Review Article

Surgical Procedures for Chronic Lateral Ankle Instability

Youichi Yasui, MD

Yoshiharu Shimozono, MD

John G. Kennedy, MD, MCh, MMSc, FFSEM, FRCS (Orth)

Abstract

Surgical procedures for managing chronic lateral ankle instability include anatomic direct repair, anatomic reconstruction with an autograft or allograft, and arthroscopic repair. Open direct repair is commonly used for patients with sufficient ligament quality. Reconstruction incorporating either an autograft or an allograft is another promising option in the short term, although the longevity of this procedure remains unclear. Use of an allograft avoids donor site morbidity, but it comes with inherent risks. Arthroscopic repair of chronic lateral ankle instability can provide good to excellent short- and long-term clinical outcomes, but the evidence supporting this technique is limited. Deterioration of the ankle joint after surgery is also a concern. Studies are needed on not only treating ligament insufficiency but also on reducing the risk of ankle joint deterioration.

From the Department of Orthopaedic Surgery, Teikyo University School of Medicine, Tokyo, Japan (Dr. Yasui) and the Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, NY (Dr. Shimozono and Dr. Kennedy).

Dr. Kennedy or an immediate family member serves as a paid consultant to and has received research or institutional support from Isto Biologics, and serves as a board member, owner, officer, or committee member of the American Orthopaedic Foot and Ankle Society, Arthroscopy Association of North America, European Society of Sports Traumatology, Knee Surgery and Arthroscopy–Ankle and Foot Associates, and the International Society for Cartilage Repair of the Ankle. Neither of the following authors nor any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article: Dr. Yasui and Dr. Shimozono.

J Am Acad Orthop Surg 2018;26: 223-230

DOI: 10.5435/JAAOS-D-16-00623

Chronic lateral ankle instability (CLAI) is a common source of ankle dysfunction.[1] This pathology may involve mechanical and/or functional instability. The anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) are the major static lateral ligamentous stabilizers.[2] The ATFL is the primary constraint to inversion stress in plantar flexion. Most patients experiencing mechanical instability have either an ATFL injury alone or combined ATFL and CFL injuries.[2]

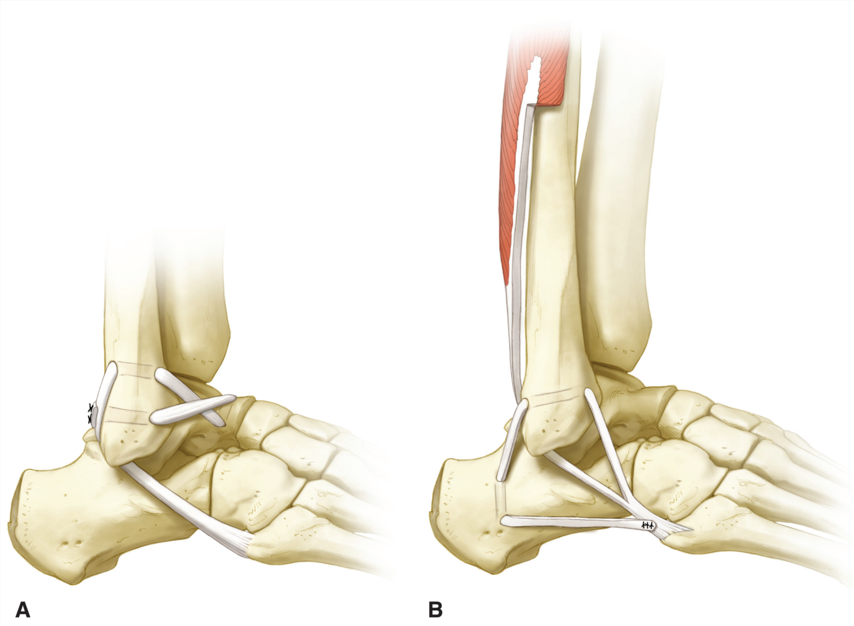
Nonsurgical treatment is often successful in patients with CLAI. When symptoms persist despite an adequate trial of nonsurgical management, surgical treatment aimed at restoring ankle stability is typically indicated. A variety of surgical techniques has been described, including anatomic direct repair with or without local tissue augmentation, anatomic ligament reconstruction using either an autograft or an allograft, and arthroscopic repair. Anatomic direct repair with or without inferior extensor retinaculum (IER) augmentation remains the first-line surgical treatment of CLAI, except in the setting of malalignment or in a patient with global laxity or in whom robust soft tissue is absent. Nevertheless, a 2011 Cochrane review concluded that clinical evidence is insufficient to determine the optimal surgical strategy for this instability.[3]

An up-to-date assessment of the evidence regarding CLAI indicates that short- and long-term outcomes and complication rates vary depending on the surgical procedure. Additional studies, including comparative trials of these techniques, are needed.

Surgical Management

Historically, surgical management of CLAI has been classified as nonanatomic or anatomic. Nonanatomic procedures, which typically involve tenodesis of the peroneus brevis tendon, include a variety of techniques aimed at stabilizing the talocrural joint[1] (Figure 1). Although

Figure 1



Illustrations showing nonanatomic procedures for managing chronic lateral ankle instability. **A,** Watson-Jones procedure, demonstrating the peroneal brevis tenodesis to the fibula. **B,** Chrisman-Snook procedure, demonstrating the tenodesis of a split peroneal brevis tendon to the fibula and the calcaneus.

nonanatomic procedures can provide successful short-term outcomes, their use is controversial.

Biomechanical studies have shown impairment of ankle and subtalar joint function subsequent to nonanatomic procedures.[4,5] In one prospective study comparing the Chrisman-Snook and the modified Broström procedures in 40 patients with CLAI, several patients treated with a nonanatomic procedure reported that their ankles felt "too tight," a sensation not reported by those undergoing anatomic procedures.[6] In addition, follow-up studies have shown that patients undergoing nonanatomic surgery, such as a Watson-Jones tenodesis or an Evans procedure, experienced unsatisfactory long-term outcomes.[7,8] Finally, Sammarco[9] found that wound complication rates were higher among patients undergoing nonanatomic tenodesis than in those undergoing anatomic procedures.

As a result of these concerns, the use of nonanatomic procedures has declined. Nevertheless, the technique is still considered in patients requiring total ankle arthroplasty or cavovarus reconstruction and in patients in whom the hindfoot has been realigned, necessitating a more robust lateral ligament reconstruction.

Anatomic procedures aimed at replacing the deficient ATFL and CFL are broadly categorized as either direct repair of the injured ligament or ligaments, or anatomic reconstruction with an autograft or allograft. Direct repair is indicated for patients with adequate ligamentous remnants, whereas anatomic reconstruction is indicated for those with obesity, generalized ligamentous laxity, prior unsuccessful stabilization procedures, and poor or insufficient ligamentous remnants.[10]

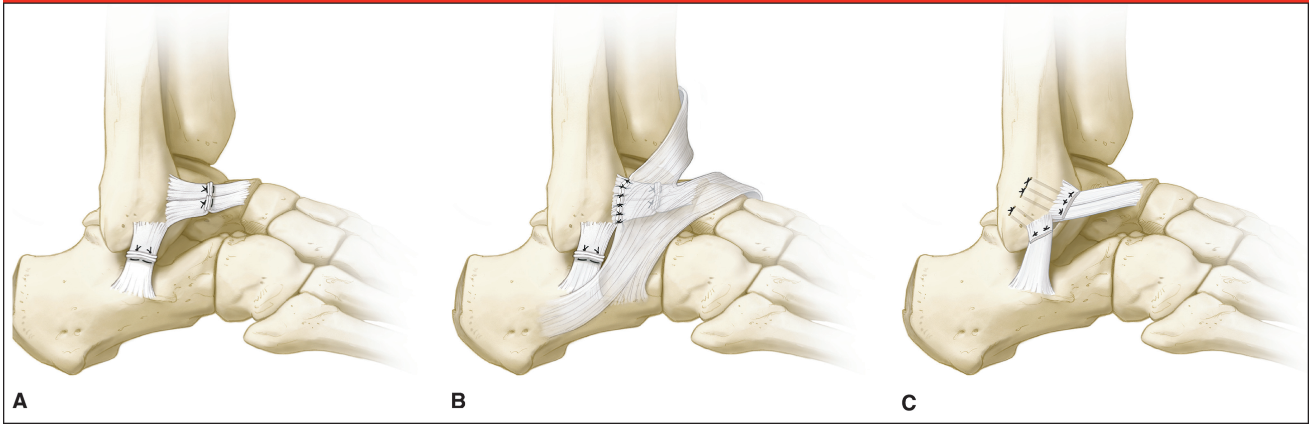
In patients with concomitant ATFL and CFL injuries, surgical treatment of the CFL is not always indicated. The CFL has been proposed as a primary stabilizer of the subtalar joint, and injury to the ligament has been associated with progression of subtalar instability. In addition, accurate clinical and radiologic diagnosis of CFL tears is challenging.[11] Furthermore, the role of the CFL in this process remains controversial.

For example, Wang et al[12] found that sectioning the CFL had no effect on the stability of the subtalar joint subsequent to open reduction and internal fixation for calcaneal fractures. Maffulli et al[13] recently assessed isolated ATFL repairs in 42 patients with CLAI whose CFL injury had been repaired. In 38 of those patients, the mean American Orthopaedic Foot and Ankle Society ankle-hindfoot score improved from 51 preoperatively to 90 postoperatively (mean follow-up, 8.7 years). Therefore, the authors suggested that surgery may not be required to manage a CFL injury.

The IER has been incorporated in surgical management of CLAI to augment the strength of anatomic ATFL procedures and confer long-term stability to the subtalar joint.[1] Good to excellent outcomes with low complication rates have been reported with this modification.[1,14,15] Similarly, Aydogan et al[16] reported that IER augmentation protected the primary ATFL repair in a cadaver study. In contrast, Behrens et al[17] reported no significant biomechanical difference in initial ankle stability with or without IER augmentation. Recent anatomic and clinical studies also suggest that incorporation of the IER may not provide clinical and radiologic advantages over traditional anatomic repair.[18,19]

The use of concomitant arthroscopy with CLAI reconstruction has recently increased, as the result of the limited ability of MRI to accurately show the intra-articular lesions frequently involved in CLAI.[20] A large

Figure 2



Illustrations showing methods of anatomic direct repair for managing chronic lateral ankle instability. **A,** Broström procedure, demonstrating the suture of the ruptured ligament ends. **B,** Broström-Gould procedure augmented with the extensor retinaculum. **C,** Karlsson technique, involving anchoring of the proximal ligament ends through the drill holes.

database study demonstrated that although concomitant arthroscopy produced a higher revision rate, it was associated with a lower incidence of subsequent invasive procedures, including ankle arthrodesis.[21]

Anatomic Direct Repair

As stated previously, anatomic direct repair is generally accepted as the first-line surgical treatment of CLAI. This procedure involves the use of native ligament remnant(s) with or without local tissue for reinforcement. The most common types of anatomic direct repair are the Broström procedure, the Gould modification, and the Karlsson modification[1,2] (Figure 2). These reparative techniques are appealing because of their low cost, minimal invasiveness, procedural simplicity, and low complication rates. However, anatomic direct repair is not recommended for patients with insufficient ligamentous tissue, prior unsuccessful stabilization procedures, high body mass index, or generalized ligamentous laxity.[10,13,22]

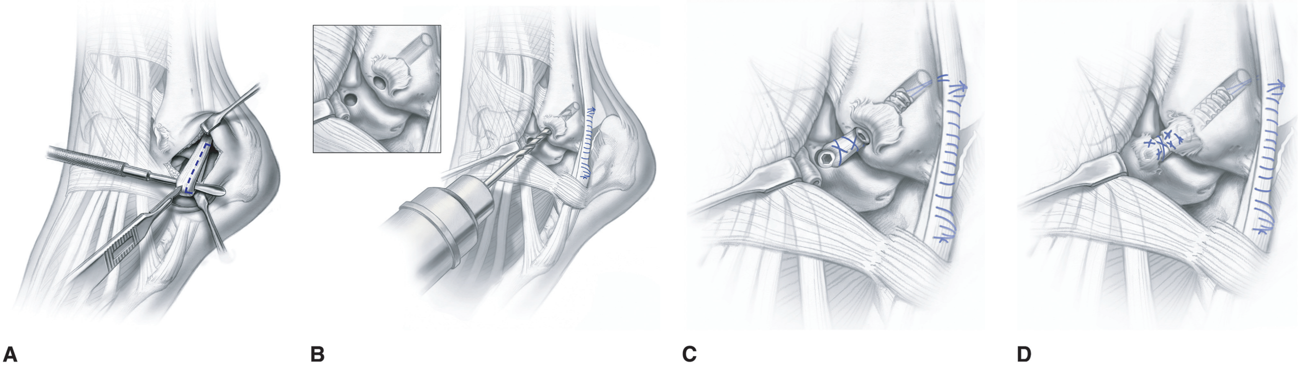
Direct repair has shown promising functional outcomes, with most patients demonstrating good to excellent results.[1,23-25] Bell et al[23] performed the Broström procedure on 31 patients. In the 22 patients evaluated at a mean follow-up of 26.3 years, the mean overall numeric ankle function score was 91.2 (out of 100; standard deviation, 10.2). Tourné et al[24] reported long-term results in 150 patients after ligamentous retensioning and reinforcement with the use of the extensor retinaculum. After a mean follow-up of 11 years, 93% of the patients had satisfactory results, with no deterioration of the articular surface detected on radiographs. A 2009 retrospective case series by Li et al[25] investigated outcomes after anatomic direct repair in an athletic population and found that 49 of the 52 high-demand athletes assessed had returned to their preinjury level of performance 2 years postoperatively.

Technical variations in anatomic direct repairs have been reported. In a prospective study by Karlsson et al,[26] 60 patients were randomly assigned to receive direct repair with either IER reinforcement or bone-tunnel techniques. At a mean follow-up of 3.1 years, no significant difference was found between the treatment groups in terms of either functional outcome or mechanical instability.

Biomechanical studies have similarly revealed no significant differences in tensile strength and stiffness between direct repair techniques and suture anchor stabilization.[27] Cho et al[28] compared 20 patients treated with bone-tunnel techniques with 20 patients treated with suture-anchor techniques in a prospective randomized study. The mean time to follow-up was 28.4 months in the bone tunnel group and 29.2 months in the suture anchor group. No significant difference was observed between these techniques after evaluation with the Karlsson scale, the Sefton grading system, and stress radiographs.

Recently, direct repair has been augmented with ligament tape. In a biomechanical study using cadaver specimens, Viens et al[29] compared suture tape augmentation alone, direct repair with suture tape augmentation, and an intact ATFL. The ATFL with suture tape augmentation was found to be at least as strong as the native ATFL. Similarly, in a study comparing tape augmentation with a native ATFL in a cadaver model, Willegger et al[30] determined that the two had similar degrees of biomechanical stability. In a biomechanical study, Schuh et al[31]

Figure 3



Illustrations of the hybrid anatomic reconstruction technique using a peroneus longus autograft with interference screw fixation, as described by Kennedy et al,[22] for management of chronic lateral ankle instability. **A,** A single incision is made, and a 4.5-cm split peroneus longus autograft (blue dashed line) is harvested. **B,** At the anatomic footprint of the anterior talofibular ligament, two drill holes are created for the tendon graft and interference screws. *Inset,* Appearance of the drill holes. **C,** The graft is first fixed in the talus. The graft is then passed through the fibular drill hole, tensioned, and held by an interference fit with a bioabsorbable screw. **D,** The fibers of the anterior talofibular ligament are secured over the reconstruction to facilitate recovery of functional stability after surgery. (Copyright John G. Kennedy, MD, New York, NY.)

compared direct repair, suture anchor, and suture anchor combined with ligament tape augmentation. They found that the ligament tape augmentation technique provided statistically superior performance in terms of angle at failure ($P = 0.02$) and failure torque ($P = 0.04$) compared with the traditional Broström and suture anchor techniques.

A prospective study by Cho et al[32] evaluated clinical outcomes of the internal brace technique[29] using suture tape in 34 patients with chronic ankle instability. At the final follow-up (>2 years), the mean foot and ankle outcome scores had significantly improved from a mean of 63.1 preoperatively to 93.2 ($P < 0.001$). In addition, both "talar tilt angle and anterior talar translation had significantly improved to an average of 4.5° and 4.1 mm, respectively" ($P < 0.001$).

Currently available evidence indicates that anatomic direct repair in patients with CLAI has the potential to provide good to excellent short- and long-term clinical outcomes. Modifications in technique are expected to improve functional outcomes; however, because of the novelty of the procedures, definitive conclusions regarding their use are premature.

Anatomic Reconstruction

Anatomic reconstructions fall into two general categories: those using autografts and those using allografts. Currently, these surgical strategies are indicated for patients with poor-quality ligament remnants, a previously unsuccessful lateral ankle repair, a high body mass index, or generalized ligamentous laxity or patients for whom direct repair may not be an option.[10] For example, Dierckman and Ferkel[10] reported that approximately 20% of patients with CLAI were not suitable candidates for anatomic repair, instead requiring anatomic reconstruction with a graft.

Autograft

The advantage of using autografts for tendon reconstruction is superior tissue quality. However, an inherent disadvantage of this strategy is the possibility of donor site morbidity. Options include local grafts (ie, peroneal longus, extensor digitorum longus) and free grafts (ie, Achilles tendon, plantaris, palmaris longus, bone-patellar tendon, hamstrings).[1]

Several authors have reported good short-term clinical outcomes after anatomic reconstruction using autograft.[1,21,33] Takao et al[33] described anatomic reconstruction using an autologous gracilis tendon and an interference fit anchoring system in 21 patients with CLAI. All patients achieved mechanical stability on stress radiographs. However, although good short-term outcomes have been reported with this procedure, no study has described long-term outcomes.

Kennedy et al[22] performed a hybrid anatomic lateral ligament reconstruction technique that involved substituting a peroneus longus autograft for the native ATFL in 57 athletes (Figure 3). All patients had achieved mechanical stability at a mean of 32 months after surgery, and 91% had returned to their previous level of sports activity.

Allograft

Allografts avoid the risk of donor-site morbidity, conferring shorter surgery times and less postoperative pain. In addition, as knowledge about potential materials has evolved, allografts have become increasingly popular options for treating patients with CLAI. Several sources have been used to manage lateral ankle instability, including the toe extensor and/or flexor, fascia lata, hamstrings, plantaris, anterior tibialis, and peroneus longus tendons.[1] There are several disadvantages to allografts, however, including an inherent (albeit low) risk of disease transmission and infection associated with the graft, as well as delayed biologic healing and higher cost.[10]

Clanton et al[34] recently addressed concerns about the tensile strength of allografts in a biomechanical study. The authors investigated the strength and stiffness of intact ATFLs and allograft reconstructions of the ATFL and found that the allografts demonstrated strength and stiffness similar to that of the native ligament.

Similar to the use of autografts, anatomic reconstructions using allografts in the management of CLAI can provide good to excellent short-term outcomes.[1,35-37] In the largest case series to date, Jung et al[35] prospectively reviewed 70 patients (72 ankles) treated with anatomic reconstruction using semitendinosus tendon allografts. At an average of 22.1 months postoperatively, they evaluated 64 of these patients (66 ankles) and found that the mean American Orthopaedic Foot and Ankle Society score improved from 71 to 91 ($P < 0.05$) and the mean Karlsson-Peterson score increased from 55 to 90, whereas talar tilt decreased from 15° to 4°. Xu et al[36] retrospectively compared allograft reconstruction with autograft procedures and found no significant difference in clinical outcomes, talar tilt, or talar shift between treatment groups at a minimum follow-up of 12 months. Dierckman and Ferkel[10] retrospectively described outcomes with an anatomic reconstruction technique in an athletic population. In their cohort, 71% of athletes were either one level below their preinjury Tegner activity level or had returned to their previous level of play at a mean follow-up of 38 ± 30 months. Matheny et al[37] compared anatomic repair involving IER reinforcement with allograft reconstruction and reported that "allograft reconstruction produced similarly favorable outcomes, including high patient satisfaction [and] high function and activity levels."

On the basis of current evidence, anatomic reconstruction using autografts and allografts in patients with CLAI provides good to excellent short-term outcomes. However, surgical techniques vary, and it remains unclear which procedures are most beneficial in the long term. Further research, including comparative studies between techniques, is warranted.

Arthroscopic Repair

Arthroscopic repair for CLAI is becoming increasingly popular.[38] This minimally invasive procedure is performed using primarily suture anchors and is thought to reduce postoperative pain and complications while hastening recovery. A strong ligamentous remnant of high quality is an important indicator for arthroscopic repair.

Biomechanical studies have demonstrated no significant differences in the amount of load to joint failure between arthroscopic and standard open procedures in matched ankles.[39] In addition, studies of arthroscopic repair for CLAI have reported good to excellent clinical outcomes.[1,40-42] Nery et al[40] conducted the longest follow-up study of arthroscopic ligament repair of CLAI to date, in which 94.7% of patients had good to excellent clinical results at a mean follow-up of 9.8 years. Acevedo and Mangone[41] reported that, in 73 patients who underwent arthroscopic ligament repair for the treatment of CLAI, Karlsson-Peterson scores improved from a mean of 28.3 preoperatively to a mean of 90.2 at a mean follow-up of 28 months; 69 of 73 patients were satisfied with the results.

To our knowledge, only two clinical studies have compared the outcomes of arthroscopic repair with those of open anatomic repair in the treatment of CLAI. Matsui et al[42] retrospectively reviewed 55 ankles and found that patients in the arthroscopic group had less pain 3 days after surgery and returned to daily activities quicker than patients in the open repair group. However, the authors also found no significant difference in clinical scores between the groups at 1 year postoperatively. In a randomized controlled trial, Yeo et al[43] reported no difference in clinical or radiologic outcomes between arthroscopic anatomic repair and open anatomic repair groups.

On the basis of the current evidence, arthroscopic repair in the treatment of CLAI may provide good to excellent short- and long-term clinical outcomes. However, arthroscopic repair is more technically demanding than an open procedure.[38] In addition, few studies have compared arthroscopic repair with open procedures. In a recent systematic review, Matsui et al[44] found that quality evidence was insufficient for recommending the use of a minimally invasive procedure.

Other Considerations in Patients With CLAI

Despite providing adequate ankle stabilization, standard open procedures may not prevent joint deterioration. In a retrospective study of nonaugmented anatomic direct repair of lateral ankle ligaments for CLAI involving 21 patients, Muijs et al[45] reported that grade I osteoarthritis was observed at a mean follow-up of 13 years in 7 of the 15 patients who did not have preexisting arthritis. After another 6 years of follow-up, five of these seven patients also developed grade I osteoarthritis in the contralateral ankle, with one patient progressing to grade II osteoarthritis. In a case series of 38 patients followed for a mean of 8.7 years after a Broström procedure, 5 patients had grade I arthritic changes and 3 had grade II arthritic changes.[13]

The reasons for these degenerative arthritic changes have been explored in multiple studies.[46-48] Prisk et al[46] demonstrated in cadaver specimens that the lateral ankle ligament reconstruction technique does not completely restore native contact mechanics of the ankle joint or hindfoot motion patterns. Two subsequent studies by Huebner et al[47,48] reported that catabolic reactions after acute injury increase the risk of degenerative changes, even in a mechanically stable joint.

Current evidence indicates that CLAI may be a precursor to posttraumatic osteoarthritis of the ankle.[49,50] Therefore, some surgeons advocate concomitant ankle arthroscopy with ankle ligament reconstruction. This practice is somewhat controversial, however, and data supporting its use are insufficient.

A correlation between cavovarus foot deformity and CLAI has been documented.[51] In 20 ankles requiring revision of lateral ligament reconstruction, Strauss et al[52] demonstrated that the most commonly associated condition was hindfoot varus alignment (28%). Irwin et al[53] reported good clinical outcomes in 22 patients who underwent lateral ankle ligament reconstruction and realignment osteotomy for cavovarus foot deformity.

In patients with CLAI and foot deformities, simultaneous correction of the deformity may be necessary for the success of an ankle stabilization procedure. In the professional athlete, mechanical realignment may best be deferred until the end of his or her playing career because recovery times can be prolonged.

Complications

In a comprehensive review of lateral ankle stabilization procedures, Sammarco[9] reported that complication rates after nonanatomic and anatomic procedures were 9.7% and 3.8%, respectively, for nerve injuries and 4.0% and 1.6%, respectively, for wound problems. Recurrent instability, meanwhile, may be the result of four principle causes: inadequate anatomic reconstruction, functional instability, reinjury, and predisposing factors.[9] Predisposing factors include ligamentous laxity, long-standing instability, high functional demand, and cavovarus deformity.[9,51] As noted, anatomic reconstruction procedures were associated with lower rates of recurrent instability than were nonanatomic procedures and anatomic direct repair procedures.[9]

Arthroscopic procedures for CLAI have been associated with relatively high complication rates.[38] In a systematic review, Wang et al[38] reported that 31 of 178 patients with ATFL who were treated with arthroscopic suture anchor placement experienced complications, mostly comprising nerve damage, but the relatively high complication rate may be the result of variations in technique. The high rate of sensory nerve injury may be the result of the presence of a communicating branch between the superficial peroneal and sural nerves inferior to the fibula. In one cadaver study, this communicating branch was observed in 58% of specimens examined, and the average distance from this branch to the crest of the lateral malleolus was 4.7 cm.[54]

However, Acevedo et al[55] defined a so-called safe zone at a distance of 1.5 cm from the tip of the fibula, which is not near the communicating branch reported in their anatomic study. Awareness of this safe zone may help surgeons avoid nerve injuries during arthroscopic procedures.

Summary

Several topics regarding the surgical management of CLAI are under debate. Successful outcomes of these procedures may depend on ligament quality and patient characteristics. Because of issues inherent in nonanatomic procedures, use of this technique is decreasing. Standard open direct repair has had continued widespread use in patients with sufficient ligament quality. This procedure can provide good to excellent clinical outcomes, potentially lasting >20 years. Reconstruction techniques incorporating autografts are another promising option for CLAI in the short term, although the longevity of this procedure is unclear. In contrast, anatomic reconstructions using allograft can provide equivalent outcomes without the risk of donor-site morbidity but with potential inherent risks and costs. Interest in arthroscopic repair has also grown. Although arthroscopy may provide good to excellent clinical outcomes in both the short- and long-term, evidence supporting its use is limited.

References

Evidence-based Medicine: In this article, references 6, 26, and 28 are level I studies. References 11 and 12 are level II studies. References 21, 36, 37, 42, and 43 are level III studies. References 2, 7, 8, 10, 13-15, 19, 20, 22-25, 32, 33, 35, 40, 41, 45, and 51-53 are level IV studies.

References printed in **bold type** are those published within the past 5 years.

1. **Yasui Y, Murawski CD, Wollstein A, Takao M, Kennedy JG: Operative treatment of lateral ankle instability. *JBJS Rev* 2016;4(5):01874474-201605000-00006.**

2. Broström L: Sprained ankles: VI. Surgical treatment of "chronic" ligament ruptures. *Acta Chir Scand* 1966;132(5):551-565.

3. de Vries JS, Krips R, Sierevelt IN, Blankevoort L, van Dijk CN: Interventions for treating chronic ankle instability. *Cochrane Database Syst Rev* 2011;8(8): CD004124.

4. Rosenbaum D, Bertsch C, Claes LE: NOVEL Award 1996: 2nd prize tenodeses do not fully restore ankle joint loading characteristics. A biomechanical in vitro investigation in the hind foot. *Clin Biomech (Bristol, Avon)* 1997;12(3):202-209.

5. Bahr R, Pena F, Shine J, Lew WD, Tyrdal S, Engebretsen L: Biomechanics of ankle ligament reconstruction: An in vitro comparison of the Broström repair, Watson-Jones reconstruction, and a new anatomic reconstruction technique. *Am J Sports Med* 1997;25(4):424-432.

6. Hennrikus WL, Mapes RC, Lyons PM, Lapoint JM: Outcomes of the Chrisman-Snook and modified-Broström procedures for chronic lateral ankle instability: A prospective, randomized comparison. *Am J Sports Med* 1996;24(4):400-404.

7. van der Rijt AJ, Evans GA: The long-term results of Watson-Jones tenodesis. *J Bone Joint Surg Br* 1984;66(3):371-375.

8. 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(3):476-480.

9. Sammarco VJ: Complications of lateral ankle ligament reconstruction. *Clin Orthop Relat Res* 2001;391:123-132.

10. **Dierckman BD, Ferkel RD: Anatomic reconstruction with a semitendinosus allograft for chronic lateral ankle instability. *Am J Sports Med* 2015;43(8): 1941-1950.**

11. **Lee BH, Choi KH, Seo DY, Choi SM, Kim GL: Diagnostic validity of alternative manual stress radiographic technique detecting subtalar instability with concomitant ankle instability. *Knee Surg Sports Traumatol Arthrosc* 2016;24(4): 1029-1039.**

12. **Wang CS, Tzeng YH, Lin CC, Huang CK, Chang MC, Chiang CC: Radiographic evaluation of ankle joint stability after calcaneofibular ligament elevation during open reduction and internal fixation of calcaneus fracture. *Foot Ankle Int* 2016;37 (9):944-949.**

13. Maffulli N, Del Buono A, Maffulli GD, et al: Isolated anterior talofibular ligament Broström repair for chronic lateral ankle instability: 9-year follow-up. *Am J Sports Med* 2013;41(4):858-864.

14. Gould N, Seligson D, Gassman J: Early and late repair of lateral ligament of the ankle. *Foot Ankle* 1980;1(2):84-89.

15. 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(2):153-157.

16. Aydogan U, Glisson RR, Nunley JA: Extensor retinaculum augmentation reinforces anterior talofibular ligament repair. *Clin Orthop Relat Res* 2006;442: 210-215.

17. Behrens SB, Drakos M, Lee BJ, et al: Biomechanical analysis of Brostrom versus Brostrom-Gould lateral ankle instability repairs. *Foot Ankle Int* 2013;34(4): 587-592.

18. **Dalmau-Pastor M, Yasui Y, Calder JD, Karlsson J, Kerkhoffs GM, Kennedy JG: Anatomy of the inferior extensor retinaculum and its role in lateral ankle ligament reconstruction: A pictorial essay. *Knee Surg Sports Traumatol Arthrosc* 2016;24(4):957-962.**

19. **Jeong BO, Kim MS, Song WJ, SooHoo NF: Feasibility and outcome of inferior extensor retinaculum reinforcement in modified Broström procedures. *Foot Ankle Int* 2014; 35(11):1137-1142.**

20. **Staats K, Sabeti-Aschraf M, Apprich S, et al: Preoperative MRI is helpful but not sufficient to detect associated lesions in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc* 2017; May 15 [Epub ahead of print].**

21. **Yasui Y, Murawski CD, Wollstein A, Kennedy JG: Reoperation rates following ankle ligament procedures performed with and without concomitant arthroscopic procedures. *Knee Surg Sports Traumatol Arthrosc* 2017;25(6):1908-1915.**

22. Kennedy JG, Smyth NA, Fansa AM, Murawski CD: Anatomic lateral ligament reconstruction in the ankle: A hybrid technique in the athletic population. *Am J Sports Med* 2012;40(10):2309-2317.

23. 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(6): 975-978.

24. 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(12): 1079-1086.

25. Li X, Killie H, Guerrero P, Busconi BD: Anatomical reconstruction for chronic lateral ankle instability in the high-demand athlete: Functional outcomes after the modified Broström repair using suture anchors. *Am J Sports Med* 2009;37(3): 488-494.

26. Karlsson J, Eriksson BI, Bergsten T, Rudholm O, Swärd L: Comparison of two anatomic reconstructions for chronic lateral instability of the ankle joint. *Am J Sports Med* 1997;25(1):48-53.

27. **Brown CA, Hurwit D, Behn A, Hunt KJ: Biomechanical comparison of an all-soft suture anchor with a modified Broström-Gould suture repair for lateral ligament reconstruction. *Am J Sports Med* 2014;42 (2):417-422.**

28. Cho BK, Kim YM, Kim DS, Choi ES, Shon HC, Park KJ: Comparison between suture anchor and transosseous suture for the modified-Broström procedure. *Foot Ankle Int* 2012;33(6):462-468.

29. **Viens NA, Wijdicks CA, Campbell KJ, Laprade RF, Clanton TO: Anterior talofibular ligament ruptures: Part 1. Biomechanical comparison of augmented Broström repair techniques with the intact anterior talofibular ligament. *Am J Sports Med* 2014;42(2):405-411.**

30. **Willegger M, Benca E, Hirtler L, et al: Biomechanical stability of tape augmentation for anterior talofibular ligament (ATFL) repair compared to the native ATFL. *Knee Surg Sports Traumatol Arthrosc* 2016;24(4):1015-1021.**

31. **Schuh R, Benca E, Willegger M, et al: Comparison of Broström technique, suture anchor repair, and tape augmentation for reconstruction of the anterior talofibular ligament. *Knee Surg Sports Traumatol Arthrosc* 2016;24(4):1101-1107.**

32. **Cho BK, Park KJ, Kim SW, Lee HJ, Choi SM: Minimal invasive suture-tape augmentation for chronic ankle instability. *Foot Ankle Int* 2015;36(11):1330-1338.**

33. 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(6):814-823.

34. **Clanton TO, Viens NA, Campbell KJ, Laprade RF, Wijdicks CA: Anterior talofibular ligament ruptures: Part 2. Biomechanical comparison of anterior talofibular ligament reconstruction using semitendinosus allografts with the intact ligament. *Am J Sports Med* 2014;42(2): 412-416.**

35. **Jung HG, Shin MH, Park JT, Eom JS, Lee DO, Lee SH: Anatomical reconstruction of lateral ankle ligaments using free tendon allografts and biotenodesis screws. *Foot Ankle Int* 2015;36(9):1064-1071.**

36. **Xu X, Hu M, Liu J, Zhu Y, Wang B: Minimally invasive reconstruction of the lateral ankle ligaments using semitendinosus autograft or tendon allograft. *Foot Ankle Int* 2014;35(10): 1015-1021.**

37. **Matheny LM, Johnson NS, Liechti DJ, Clanton TO: Activity level and function after lateral ankle ligament repair versus reconstruction. *Am J Sports Med* 2016;44(5):1301-1308.**

38. **Wang J, Hua Y, Chen S, Li H, Zhang J, Li Y: Arthroscopic repair of lateral ankle ligament complex by suture anchor. *Arthroscopy* 2014;30(6):766-773.**

39. **Drakos MC, Behrens SB, Paller D, Murphy C, DiGiovanni CW: Biomechanical comparison of an open vs arthroscopic approach for lateral ankle instability. *Foot Ankle Int* 2014;35(8):809-815.**

40. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N: Arthroscopic-assisted Broström-Gould for chronic ankle instability: A long-term follow-up. *Am J Sports Med* 2011;39(11):2381-2388.

41. **Acevedo JI, Mangone P: Ankle instability and arthroscopic lateral ligament repair. *Foot Ankle Clin* 2015;20(1):59-69.**

42. **Matsui K, Takao M, Miyamoto W, Matsushita T: Early recovery after arthroscopic repair compared to open repair of the anterior talofibular ligament for lateral instability of the ankle. *Arch Orthop Trauma Surg* 2016;136(1):93-100.**

43. **Yeo ED, Lee KT, Sung IH, Lee SG, Lee YK: Comparison of all-inside arthroscopic and open techniques for the modified Broström procedure for ankle instability. *Foot Ankle Int* 2016;37(10):1037-1045.**

44. **Matsui K, Burgesson B, Takao M, Stone J, Guillo S, Glazebrook M; ESSKA AFAS Ankle Instability Group: Minimally invasive surgical treatment for chronic ankle instability: A systematic review. *Knee Surg Sports Traumatol Arthrosc* 2016;24(4):1040-1048.**

45. Muijs SP, Dijkstra PD, Bos CF: 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(1):50-56.

46. Prisk VR, Imhauser CW, O'Loughlin PF, Kennedy JG: Lateral ligament repair and reconstruction restore neither contact mechanics of the ankle joint nor motion patterns of the hindfoot. *J Bone Joint Surg Am* 2010;92(14):2375-2386.

47. Huebner KD, Shrive NG, Frank CB: New surgical model of post-traumatic osteoarthritis: Isolated intra-articular bone injury in the rabbit. *J Orthop Res* 2013;31(6):914-920.

48. **Huebner KD, Shrive NG, Frank CB: Dexamethasone inhibits inflammation and cartilage damage in a new model of post-traumatic osteoarthritis. *J Orthop Res* 2014;32(4):566-572.**

49. **Onur TS, Wu R, Chu S, Chang W, Kim HT, Dang AB: Joint instability and cartilage compression in a mouse model of posttraumatic osteoarthritis. *J Orthop Res* 2014;32(2):318-323.**

50. McKinley TO, Tochigi Y, Rudert MJ, Brown TD: The effect of incongruity and instability on contact stress directional gradients in human cadaveric ankles. *Osteoarthritis Cartilage* 2008;16(11):1363-1369.

51. Fortin PT, Guettler J, Manoli A II: Idiopathic cavovarus and lateral ankle instability: Recognition and treatment implications relating to ankle arthritis. *Foot Ankle Int* 2002;23(11):1031-1037.

52. Strauss JE, Forsberg JA, Lippert FG III: Chronic lateral ankle instability and associated conditions: A rationale for treatment. *Foot Ankle Int* 2007;28(10):1041-1044.

53. Irwin TA, Anderson RB, Davis WH, Cohen BE: Effect of ankle arthritis on clinical outcome of lateral ankle ligament reconstruction in cavovarus feet. *Foot Ankle Int* 2010;31(11):941-948.

54. Drizenko A, Demondion X, Luyckx F, Mestdagh H, Cassagnaud X: The communicating branches between the sural and superficial peroneal nerves in the foot: A review of 55 cases. *Surg Radiol Anat* 2004;26(6):447-452.

55. **Acevedo JI, Ortiz C, Golano P, Nery C: ArthroBroström lateral ankle stabilization technique: An anatomic study. *Am J Sports Med* 2015;43(10):2564-2571.**