Restoration of Lateral Ankle Stability With Augmentation: Two Variations and Results

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INTRODUCTION

The ligaments of the ankle are the most common site of musculoskeletal injury, with an incidence of 30,000 per day in the US (1-3). Prior injury to the ankle ligaments increase the risk of re-injury, and between 20% and 40% percent of ankle sprains will have residual symptoms and recurrent instability (4-9). Given the prevalence and potential negative sequelae of these injuries, accurate assessment and treatment is essential. These chronic sequelae of ankle sprains can significantly impair an athlete's ability to perform at a high level. Nearly all of these ligamentous injuries, regardless of severity, are treated conservatively with immobilization and rest followed by rehabilitation. Surgical repair of acute injuries is generally reserved for elite athletes, and even then has been controversial. With or without proper acute care, there are some patients who will present following one or more ankle injuries complaining of recurrent sprains or "giving way" during sports or even activities of daily living (1,3). Approximately 50% of these patients will respond well to bracing and physical therapy consisting of peroneal strengthening and proprioceptive training (10). The patients who do not improve functionally after a period of rehabilitation are likely to have mechanical instability secondary to a true ligamentous injury that has not healed adequately to support the ankle.

Injury to the lateral collateral ligament complex (anterior talofibular ligament [ATFL], posterior talofibular ligament [PTFL], and calcaneofibular ligament [CFL]) represents the vast majority of ankle sprains. The ATF is the first ligament to be torn in an inversion injury regardless of the position of the ankle (11). Most injuries are in the mid-substance of the ligament, as opposed to avulsions, and occur during loading or unloading of the ankle when the joint is at its least stable construct and the ligaments are susceptible to extreme forces.

The ATFL is a broad, flat ligament running from the anterior margin of the lateral malleolus to the talar body in front of the lateral articular surface (12). The ATFL is contiguous with the joint capsule as a discreet capsular thickening (3,13). The ATFL is the primary stabilizer against anterior translation of the talus in all positions of the foot; it resists varus tilting of the talus (adduction), internal rotation of the talus, and inversion stress during plantarflexion. It is structurally the weakest of the three lateral collateral ligaments and is the most frequently injured ligament. It is tested clinically with the "anterior drawer" test.

The CFL is cylindrical and lies deep to the peroneal tendons, running from the anterior margin of the lateral malleolus, just distal to the ATFL origin, to the lateral wall of the calcaneus.The CFL resists varus talar tilt and inversion in all foot positions, and assists the ATFL against anterior translation in dorsiflexion and neutral (3). It also acts as a stabilizer of the subtalar joint. The tilt test is used to clinically examine the CFL.

The PTFL runs from the posterior margin of the lateral malleolus to the talus, posterior to the lateral articular surface. It is the strongest of the lateral collateral ligaments, and the least frequently injured (3). The PTFL assists the CFL in resisting inversion stresses.

TREATMENT

Diagnosing chronic ankle instability is typically a clinical judgement, with little objective data available except for the possible benefit of a stress radiograph or magnetic resonance image scan that demonstrates ligamentous damage (14-16). Use of machines that apply a predetermined stress and measure displacement are not commonly utilized in practice. In our study, the ankle was graded 1 if the anterior translation of the talus in relation to the tibia in the anterior drawer test was less than 5 mm. Displacement of 6-9 mm was graded as level 2 and those greater than 9 mm were graded as level 3. Once the diagnosis of chronic mechanical instability of the lateral ankle that is refractory to conservative care is made, there are several types of reconstruction procedures available. These generally try to restore both stability and function to the ankle, and are successful in meeting these goals to varying degrees. The procedures are broadly divided into anatomic versus tenodesis techniques, with the selection driven by location of injury, degree of ligamentous attenuation, and surgical preference. Of the anatomic repairs, a Brostrom-type procedure is generally the most popular and successful, while the Chrisman-Snook is the most frequent tenodesis repair (17). Other tenodesis procedures include the Evans, Elmslie, Larson, and Watson-Jones techniques.

In our patients with chronic lateral ankle instability and acute traumatic rupture, the anatomic modified-Brostrom procedure has been very successful. Preservation of the peroneal muscles and tendons likely makes rehabilitation easier and restoring the tension to the ATFL and CFL ligaments may improve the proprioceptive function of the foot. Additionally, repairing the ATFL and CFL is not an impediment to later tenodesis procedures, if necessary.

In performing a Brostrom-type surgery, it is common practice to augment the imbrication of the ATFL and CFL with something to gain additional strength. This is often either a portion of the inferior extensor retinaculum or fibular periosteum. Our first series of patients have had excellent success to date with the Brostrom-type repair augmented by multiple different orthobiologic implants and attached in a technique developed by the authors. Our second series of patients also have had excellent success to date with the Brostrum-type repair augmented by fiber tape by Arthrex with the InternalBrace.

TECHNIQUE

The initial repairs of the ATFL and CFL are made in the standard fashion of the Brostrom procedure. Through a lateral incision, these two ligaments are cut in their midsubstance, shortened, and imbricated. Any available extensor retinaculum is then used to overlay the ATFL and enhance the construct, as described by Gould.

The soft tissue grafts are trimmed to approximately 1.5- to 2-cm wide and approximately 2.5 inches in length leaving a rectangular graft. In our initial patients, two Arthrex bioabsorbable suture anchors with #2 Fiberwire suture were placed along side each other into the talar neck just distal to the original insertion of the ATFL. Two corners of the soft tissue graft were then sutured to the anchors and pulled tightly against the talus. Recently, we have slightly modified this distal attachment by placing a running Krakow stitch of #2 Fiberwire up and back down one end of the graft and then utilizing a 4-mm Arthrex biotenodesis screw just distally to the ATFL insertion to anchor the graft. This modification was done mostly to decrease the amount of time required to complete the distal attachment site.

The foot is then dorsiflexed and externally rotated to place the graft in the orientation of the shortest position for the ATFL. The graft is then pulled tightly back along the talus, and one 10-mm staple is used to attach the proximal end of the graft to the lateral malleolus or an Arthrex biotenodesis screw can be used. Once the graft is in place, it is immediately strong enough to allow range of motion of the foot without damaging the repair.

Usually, the CFL is amenable to direct repair by imbrication and requires no further reinforcement. In cases where the CFL is attenuated, it can be enhanced by using a strip of soft tissue graft. A narrow piece of the inferior edge of the graft can be cut from distal to proximal, leaving it attached to the fibula just distal to the staple or biotenodesis screw. This edge can be reflected down over the CFL and attached to the calcaneus using a suture anchor. All of the free edges of the graft are then tacked down to the underlying tissues using an absorbable suture so as to keep the graft in direct contact with the reconstructed ligaments (Figure 1). The inferior arm of the extensor retinaculum is sutured to the anterior fibula. Layered closure is performed with a small absorbable suture and the skin is then closed and the patient placed into a walking boot.

The second group of patients in our study had the exact same Brostrum procedure and primary soft tissue repair. Where they differ is that the InternalBrace Ligament Augmentation Repair System (Arthrex) was used instead of the biologic graft. The internal brace is a synthetic fiber tape that replaces the biologic implant in our patients.

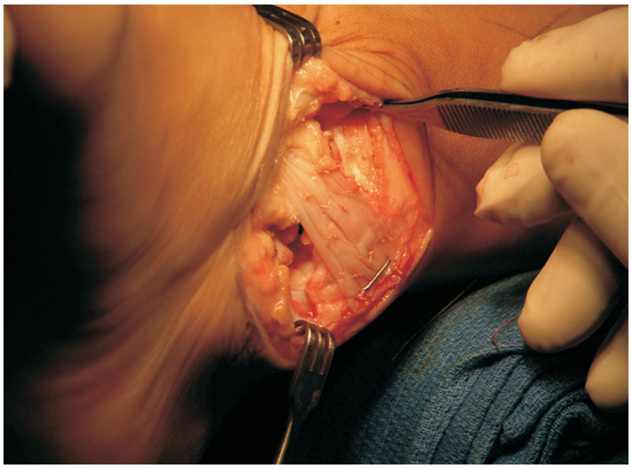


Figure 1. Biologic graft anchored and sutured to anterior talofibular ligament.

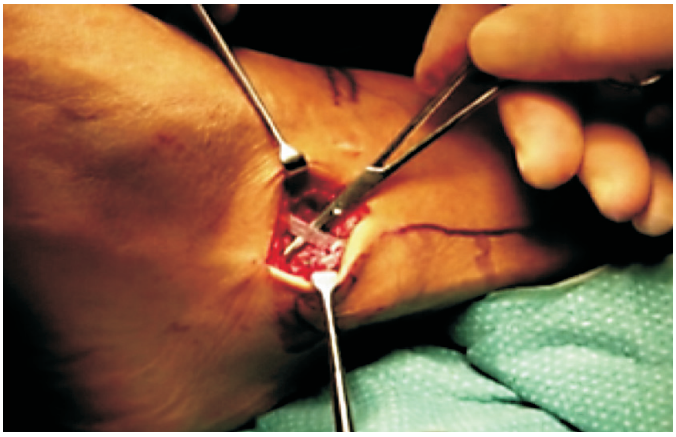


Figure 2. InternalBrace Ligament Augmentation Repair System from Arthrex anchored and in place.

Table 1. MANOVA test criteria and exact F statistics for the hypothesis*

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99383421	0.45	1	73	0.5031
Pillai's Trace	0.00616579	0.45	1	73	0.5031
Hotelling-Lawley Trace	0.00620405	0.45	1	73	0.5031
Roy's Greatest Root	0.00620405	0.45	1	73	0.5031

* Hypothesis is no no AOFAS*Variation_2 Effect. H = Type III SSCP Matrix for AOFAS*Variation
E = Error SSCP Matrix, S = 1, M = -0.5, N = 35.5.Wilk's lamda test is used to do the multivariate analysis. Since [F (1, 73) = 0.994, $P = 0.5031$] it can be concluded that any difference between AOFAS scores do not reliably depend on operative procedure in conjunction with which variation of procedure was performed.

Table 2. AOFS scores*

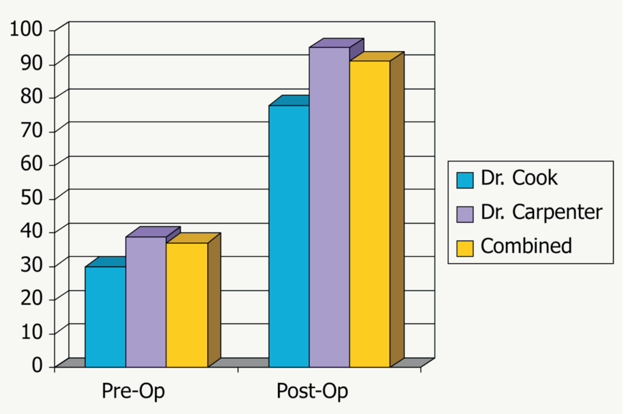
Source	DF	Type III SS	Mean Square	F Value	Pr > F
AOFS	1	20545.61678	20545.61678	149.69	<.0001
AOFS*pre_surg_grp	5	1117.47436	223.49487	1.63	0.1643
Error(aofs)	68	9333.52564	137.25773		

*Since $P < 0.001$ it can be concluded that there is significant effect of operative procedure on overall mean AOFAS scores. Since [F (1, 68) = 1.63, $P = 0.1643$] it can be concluded that operative procedure in combination with previous surgery group do not influence AOFAS scores.

It is inserted just distal to the insertion of the anterior talo fibular ligament on the lateral side of the talus with a BioComposite Swivel Lock anchor and then to the anterolateral aspect of the fibula just above the Brostrum ligament repair site. Tensioning was performed identical to the tensioning of the biologic graft (Figure 2). In cases where the CFL is attenuated, an arm of the InternalBrace Ligament Augmentation Repair System is flipped down over the CFL and is pulled tight and attached to the calcaneus using a suture anchor.

The patients in both groups were allowed immediate full weight-bearing in the boot. At the first postoperative visit in 10-14 days, the stitches were removed and the patient was instructed to begin gentle range of motion movements. At 4 weeks postoperatively, the patients increased their motion exercises and began ambulation without the boot. For most patients, home exercises (Ther-a-band, peroneal strengthening, single-leg balancing) are sufficient and they will not require formal physical therapy to regain their strength, proprioception, and motion. By 12 weeks, the patient should be back to full activities without restriction. In the case of high demand athletes, formal physical therapy, including BAPS board exercises, are begun at 6 weeks postoperatively utilizing a functional brace. The brace is worn during therapy for 4 weeks and then only during competition for the next 12 months. They are allowed to return to athletics at 10-12 weeks postoperatively.

Table 3. Preoperative and postoperative foot and ankle AOFAS scores by physician.



RESULTS

From December 2002 to March 2013, the Orthobiologic Implant procedure was performed on 34 patients with a preoperative diagnosis of lateral ankle instability. From April 2013 through July 2016, the procedure with the InternalBrace Ligament Augmentation Repair System was performed on 17 patients with a preoperative diagnosis of lateral ankle instability. The 2 groups of patients had no statistically significant difference so were combined into one data set analysis (Table 1).

Table 4. Multivariate analysis for Within Subjects Test*

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.07953754	833.23	1	72	< 0.0001
Pillai's Trace	0.92046246	833.23	1	72	< 0.0001
Hotelling-Lawley Trace	11.57267902	833.23	1	72	< 0.0001
Roy's Greatest Root	11.57267902	833.23	1	72	< 0.0001

*MANOVA Test Criteria and Exact F Statistics for the Hypothesis of no AOFAS Effect H = Type III SSCP Matrix for AOFAS; E = Error SSCP Matrix; S = 1; M = -0.5; N = 35. Since [F (1, 72) = 833.23, $P < 0.0001$] null hypothesis is rejected and concluded that AOFAS scores change after operative procedure.

There were 51 patients in this study and 7 with previous lateral ankle ligament reconstructions (Table 2). The average age was 32 years old (range 13-64 years), and the average weight was 181 pounds (range 110-350 pounds). All of the patients had clinical follow-up until they were released by the surgeon and 82% had AOFAS follow-up scores available (Tables 3, 4). The average preoperative and postoperative AOFAS scores were 37 (range 0-79) and 91 (range 10-100), respectively (Table 5). The average follow-up of the patients was 58 months (range 6-157 months).

DISCUSSION

The most common site for musculoskeletal injury is the ligaments surrounding the ankle joint, accounting for up to 40% of all athletic injuries, with even higher numbers in jumping and contact sports such as basketball and football (3). Nearly all of these ligamentous injuries, regardless of severity, are treated conservatively with immobilization and rest to limit the extent of injury, followed by physical therapy to first restore motion and then restore agility and endurance. Despite proper care, a significant number of these patients will experience residual problems, ranging from a sense of instability to multiple recurrent sprains. Approximately half of these patients with chronic ankle instability will improve their level of functioning with intense physical therapy and dynamic bracing. Special attention must be paid to both the strengthening and proprioceptive condition of the patient in order for them to achieve a good long-term result. Unfortunately, many of these patients will end up requiring surgical intervention for true mechanical instability.

Table 5. *T*-tests*

Difference	DF	t Value	Pr > |t|
postop_AOFAS - preop_AOFAS	74	29.33	<.0001

*Paired *t* test is used to assess the difference in the means of preoperative and postoperative t test scores. $P < 0.0001$ indicates that there is significant difference in the means of preoperative and postoperative AOFAS scores.

Among the procedures in use for stabilizing the lateral ankle ligaments, the anatomic-based Brostrom repair is both popular and successful. By repairing the damaged ligaments without involving other structures in the foot, static foot stability is achieved without sacrificing dynamic stability, such as is provided by the peroneal tendons. A frequent drawback to the Brostrom procedure, however, is the quality of the tissue available for repair. Often in long-standing or severe injuries, the lateral collateral ligament complex may become attenuated or scarred with fibrous tissue. The use of the Orthobiologic Implant or Internal Brace to augment the repair provides immediate strength to the repair, allowing early range of motion and immediate weight-bearing. The results have been promising, and the technique described has proven to provide a strong and properly tensioned repair. The patient outcomes between the two augmentation techniques have been very successful. The average cost of utilizing an Orthobiologic Implant/Graft is currently $2,250 and the cost of the Internal Brace kit is $1,100 at our facility. With these results and cost, the internal brace has become the procedure of choice for ligament augmentation repair at our facility.

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