Chronic ankle instability can be a disabling condition requiring surgical correction. The Brostrom procedure is the most common repair technique used for primary repair of the lateral ankle ligaments. Infrequently, this procedure fails and requires revisional surgery. Revisional cases necessitate augmentation to strengthen the repair. High-demand athletes, patients with high Body Mass Indexes, and patients with conditions associated with ligamentous laxity may also require augmentation during the primary surgical procedure. Augmented repair techniques include use of xenografts, allograft repair techniques, and proprietary kits that use suture anchors, non-absorbable tape, and non-absorbable sutures to repair the ankle construct. Augmentation offers superior repair strength beyond the typical construct of a Brostrom repair and is indicated for use in revisional procedures and in patients with physically demanding lifestyles.

Prior ankle injury increases the chance of ankle sprain recurrence, which has been shown to lead to loss of proprioception and further weakening of the lateral ankle ligaments [6]. Many studies have demonstrated that ankle injuries can lead to altered postural control, defined as the ability of an individual to maintain his or her center of mass over a single supporting foot [6-8]. Rehabilitation protocols focusing on balance and proprioception lead to an increase in postural stability [9].

After exhausting conservative management, surgical repair of the lateral ankle ligaments may be warranted, especially in patients with recurrent sprains and patients who have had significant periods of interrupted activity, or when pain and weakness persist. A large number of surgical procedures have been described, and most patients requiring surgery respond well to primary anatomic repair of the damaged lateral ankle ligaments. Some cases require further augmentation and strengthening of the primary surgical repair and will be the focus of this article.

**Evaluating chronic ankle instability**

When evaluating a patient with chronic ankle instability, a systematic work up should be employed. This includes a careful history and physical examination to prevent overlooking critical related pathologies. A common cause of failure of primary surgical ankle repair is the failure to address associated pathologies. Physical examination should evaluate for concomitant subtalar joint instability and for pathology of the peroneal tendons. Subtalar joint instability can be challenging to diagnose; preoperative diagnostic blocks may prove useful. One should evaluate for possible intra-articular pathology such as osteochondral defect of the talus or tibia. Chronic injury to...
the ankle syndesmosis may also be present. It is essential to recognize a cavus or rear foot varus foot type [10]. A Coleman Block test will reveal if a lateraizing calcaneal wedge osteotomy is necessary to reduce lateral ankle ligament stress. Additionally, the surgeon must evaluate for a forefoot driven cavus deformity that may require a dorsiflexory first metatarsal osteotomy [10]. In adolescent patients, consider the presence of a tarsal coalition as a contributing factor to the instability or pain [11]. Familial disorders associated with hypermobility such as Ehlers-Danlos syndrome and Marfan’s syndrome should be ruled out [12]. One must assess the patient’s physical and occupational demands. Athletes, patients with ligamentous laxity, and patients with elevated Body Mass Indexes may require procedures that offer additional strength to traditional repair techniques.

MRI and stress radiographs such as the anterior drawer and the stress inversion tests will help reveal the condition of the native ligaments [13]. These imaging studies are particularly important in cases of revisional surgery to provide the surgeon with information on the quality of the endogenous ligaments and tissue.

More than 70 surgical procedures have been described to address lateral ankle instability [14]. Surgical options include direct repair of the lateral ankle ligaments, the use of tendon allografts and autografts, and arthroscopic ligament repair. Surgical repairs can be classified as anatomic or non-anatomic repairs. Anatomic repairs, such as the one described by Brostrom, use endogenous ligamentous structures to restore the lateral ankle ligaments [15]. Non-anatomic repairs use additional tissue to stabilize the lateral ankle ligaments when inadequate native tissue precludes direct repair.

The surgical techniques can be further classified as augmented or non-augmented repairs. Non-augmented repairs are surgical techniques that use only native tissue for restoration of the lateral ankle ligaments. In contrast, augmented repairs refer to surgical techniques involving use of tendon allografts or autografts to strengthen the repair. Multiple techniques have been described in including peroneous longus, peroneous brevis, and harvested hamstring to reconstruct the lateral ankle complex [16]. In addition to tendon grafting techniques, other forms of augmented repair include proprietary kits that contain suture anchors and suture tape that can be used in conjunction with anatomic repair techniques, such as the Brostrom procedure, to strengthen the surgical repair. Theoretically, augmented procedures offer additional strength and stability to the construct and may be beneficial in patients with physically demanding lifestyles, patients with conditions associated with ligamentous laxity, and patients with failed primary non-augmented repairs [16].

Anatomic Repairs

Currently, the “work-horse” lateral ankle stabilization procedure is the Brostrom-Gould procedure. The Brostrom procedure was first described in 1966 and involved repair of ruptures of the anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) [15]. In 1980, Gould modified the procedure, describing a primary ligament repair strengthened with the use of the inferior extensor retinaculum after incision of the ATFL and CFL [17]. The Brostrom-Gould procedure is a popular procedure for anatomic repair of the lateral ankle ligaments because it is technically easy to perform and closely restores the kinematics of the ankle. Bell et al. found that 91% of patients who underwent the Brostrom-Gould procedure described their ankle function as good or excellent at a mean time of 26 years [18]. Karlsson et al. reported on 180 Brostrom-Gould procedures and reported 89% with good to excellent outcomes [19].

The Brostrom-Gould procedure involves a curvilinear or straight linear incision anterior and inferior to the distal aspect of the fibula. The peroneal tendon sheath is identified and can be examined for possible injury to the peroneal tendons. The ATFL is identified and examined for attenuation or frank tearing. The CFL is examined and periosteum of the fibula. Sutures are tied with the foot slightly dorsiflexed and everted. While the Gould modification is used to strengthen a traditional Brostrom repair, it is not considered a form of augmented repair, as only endogenous nearby tissue is utilized to strengthen the surgical repair.

Non-Anatomic Repair Procedures

Typically, non-anatomic repairs involve the sacrifice or split transfer of the peroneal tendons [20]. A multitude of non-anatomic repair techniques have been described including Chrisman-Snoek [21], Watson-Jones [22], and Evans [23]. These cases most commonly involve splitting the peroneal tendons and routing them through a drill hole in the fibula. In some cases, the tendon is embedded into the talus and/or calcaneus. These procedures are indicated for cases of ligamentous laxity and extreme obesity, and are currently reserved for cases of revisional repair. These repairs can be technically challenging and may alter subtalar and ankle joint motion. Normal anatomy is not replicated, potentially leading to stiffness and degeneration by non-anatomical forces across the ankle joint [24]. Additionally, these type of repairs are associated with reduced eversion strength secondary to altered peroneal tendon function [25]. These type of procedures typically require longer incisions, creating greater incisional concerns and potential for nerve injury.

Allograft Techniques

In recent years, non-anatomic procedures have become less routine and have largely been overtaken by newer reconstructive procedures due to the advancements in allograft and augmentation techniques. Allograft techniques are becoming more popular as they allow augmentation and restoration of the normal anatomic insertion of ligamentous structures. Unlike non-anatomic procedures, they do not alter ankle anatomy and do not sacrifice normal tissues. Allograft techniques have been shown to lead to good functional outcomes, although with their own limitations and concerns [25].

Various allograft techniques have been reported in the literature, varying by the graft insertion site, choice of allograft, and anchoring technique [25]. Techniques have been described...
utilizing the peroneal tendons, plantaris, gracilis, fascia lata and semitendinosus tendons [14]. Ellis et al. described a method involving the creation of two bone tunnels in the fibula and utilizing an anterior tibial tendon allograft [25]. All patients showed good to excellent activity levels postoperatively [25]. Grambart described a procedure involving a peroneus longus allograft secured proximally in the fibula with a bio-tenodesis screw [26]. Distally, the graft is split longitudinally with the anterior arm of the graft inserted into the talus and the posterior arm into the calcaneus [26]. Additional reconstructive techniques include the use of a hamstring allograft or autograft secured into the talus, fibula, and calcaneus by bio-tenodesis screws [27].

Risks associated with allografts include host rejection, avascular tissue implantation, chance of disease transmission, and higher cost [25]. Need for precise proper physiologic tensioning and “bunching” of the allograft can make these cases technically demanding. However, allograft repairs can be appropriate surgical options in cases of failed prior repair attempts, when the degree of ligamentous degeneration precludes direct repair, and in cases of hyperlaxity.

**Arthroscopic Procedures (Arthrobrostrom)**

Arthroscopy for direct ligament repair has also become increasingly popular in recent years. Arthroscopy is performed on many patients who undergo lateral ankle stabilization, in large part due to the mechanism of injury. With lateral ankle injuries, there is a high number of patients with symptomatic impingements, capsulitis, synovitis, and osteochondral defects of the tibiotalar joint. Arthroscopy allows for joint debridement, subchondral drilling of osteochondral defects, excision of loose bodies, and synovectomy. After arthroscopic debridement of the ankle joint, it is typical to perform an open Brostrom-Gould technique using bone anchors to augment the repair.

A proprietary company has developed an all-inside arthroscopic system utilizing a Micro Suture Lasso to perform the Brostrom-Gould procedure. In this technique, known as the Arthrobrostrom, suture anchors are placed arthroscopically through the anterolateral arthroscopic portal. Early results, such as those by Cotton and Rigby, have shown a promising reduction in painful patient symptoms and an earlier return to weight-bearing [28]. At this time, no evidence-based results for arthroscopic lateral ankle repair have been reported for revisional cases. Rather, arthroscopy of the ankle joint is recommended as an adjunctive procedure with open repair of the lateral ankle ligaments in revisional cases.

**Augmented Repairs**

Manufacturers have developed new technologies to further augment lateral ankle ligament repair. These techniques may be useful alternatives to surgical techniques using tendon allografts and autografts. Several proprietary kits are available to provide additional stability to lateral ankle ligament repair. These systems use Fiber Tape or a similar suture material attached to bone via knotless anchors or swivel locks. Commonly, one anchor is placed in the fibula and one in the talus. Anchors are essential if there is paucity of the ligamentous structures on the fibular or talus side of the construct. Between manufacturers there are minor variations in the insertion sites of the anchors and the non-absorbable material used, but all share a similar philosophy in that their devices serve to augment anatomic repairs. The repair can be exceptionally strong; there is a potential risk of overtightening the ligaments, leading to an overly-rigid repair. Controlled studies are necessary to determine the benefit and long term results of these systems.

Waldrop et al., conducted a study using 24 cadaver specimens divided into four groups [29]. One group consisted of a control group with intact ATFLs, and in a second group, a traditional Brostrom was performed. In another group, a Brostrom augmented with a suture anchor in the talus was performed, and in the final group a Brostrom with a suture anchor into the fibula was performed. Load-to-failure testing was done for each group. No statistically significant difference was found between the three repair groups in the amount of force required to produce failure of the surgical repair, and all three repair types were much weaker than the uninjured ATFL group. Suture anchors did not appear to offer superior strength over the traditional Brostrom procedure. This study, however, only evaluated strength immediately after the operation. The repair may strengthen over time as the ligament repair heals. Further studies are necessary to determine repair strength over time.

In contrast to Waldrop’s study, Viens et al. conducted a study on 18 cadaver limbs [30]. The three study groups consisted of one group with intact ATFL, one group with suture tape repair of the ATFL, and one group with suture tape augmentation in conjunction to a traditional Brostrom procedure. Unlike Waldrop, Viens found that in the suture tape group, the mean ultimate load-to-failure of suture tape augmentation (315.5±66.8 N) was significantly higher than that of the intact ATFL (154.0±63.7 N). Additionally, the mean ultimate load of the Brostrom repair with suture tape augmentation was not significantly different from that of the intact ATFL control group. They concluded that suture tape alone, or in conjunction with a Brostrom repair, offers superior strength to the Brostrom repair alone. They theorized that suture tape augmentation may be beneficial in cases of revisional surgery, in cases of ligamentous laxity, and in obese patients.

Other modifications to augment deficient ligaments include dermal graft products and xenografts. Parks described the satisfactory results and absence of recurrent instability in thirty-five lateral ankle stabilization procedures that were performed using acellular human dermal graft to augment repair [31]. Xenografts can additionally be used to strengthen repairs and may be derived from bovine, equine, and porcine sources. Xenografts avoid pitfalls such as the need for a longer incision or issues with the harvesting of an autograft altering the dynamic stability of the foot [16]. Xenografts may offer strength similar to autografts and may be a promising alternative in lateral ankle stabilization procedures [32].

Augmented repair techniques may be particularly useful in cases of revisional surgery. Revisional cases after a failed previous direct repair are particularly challenging. It is critical to determine the etiology of the initial repair’s failure. An index of suspicion should be raised for a condition of ligamentous laxity, a component of hind foot varus, subtalar joint instability,
or recurrent high-grade ankle sprains. Revisional cases can achieve optimal outcomes with specialized augmentation of an anatomical repair. Tissue quality may be poor and the lateral ankle ligamentous tissue may deteriorate over time. Simply repeating a Brostrom-Gould repair without using a supplementary form of augmentation can lead to less than optimal outcomes.

The precise clinical role of tendon allografts, xenografts, suture anchors, and suture tape in lateral ankle stabilization surgery is yet to be determined. Additional strength to the Brostrom repair may be necessary in elite athletes, patients with high Body Mass Indexes, and in patients with ligamentous laxity. Further research is necessary before definitive surgical recommendations can be made on when to use which type of augmentation and which augmentation technique provides the greatest repair strength.

**CONCLUSION**

Most lateral ankle sprains resolve uneventfully with conservative treatment. In spite of this, some cases require surgical repair. The large majority of patients have successful outcomes with a primary anatomic repair such as the Brostrom-Gould procedure. Cases of revisional lateral ankle repair are particularly challenging. Success requires a thorough understanding of common surgical pitfalls. It is also essential to determine why the primary repair failed. The surgeon must attend to concomitant deformities such as rear foot varus or subtalar joint stability, and be cognizant of neuromuscular and collagen disorders. After a failed primary Brostrom-Gould, one should choose a procedure that offers further augmentation to the surgical repair. Athletes, patients with physically demanding occupations, and patients with high Body Mass Indexes are also excellent candidates for augmented primary repairs with either proprietary products using suture anchors and non-absorbable sutures, tendon allografts, or biologic xenografts.

Long-term clinical results are not yet available on which augmentation method provides the best outcomes, and there are no studies comparing allograft reconstructions with proprietary technologies such as suture tape and suture anchors. Despite this, there is a role for augmentation of a primary lateral collateral ligament repair in cases of hyperlaxity, patients with physically demanding life-styles, and in secondary-type procedures.

**REFERENCES**

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