Functional Results of Open Broström Ankle Ligament Repair Augmented With a Suture Tape

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Abstract

Background: The Broström procedure is the most commonly used lateral ligament repair for chronic instability, but there is concern about the strength of the repair and the risk of reinjury. Currently, the InternalBrace™ ligament augmentation repair is an accepted augmentation method for management of a Broström procedure. Our hypothesis was that augmentation of the Broström repair with an InternalBrace™ would allow accelerated rehabilitation and return to activity and would aid in stability of the repair without a tendency to stretch.

Methods: Eighty-one patients with lateral ankle instability procedures repaired with a Broström and InternalBrace™ augmentation were evaluated at a one-time postoperative visit between 6 and 24 months. Outcomes included demographics, surgical time, the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot score, Veterans Rand 12-Item Health Survey (VR-12), Foot and Ankle Ability Measure (FAAM), Visual Analog Scale (VAS), satisfaction, and objective clinical measurements. Eighty-one patients were analyzed including 30 males and 51 females. Median age was 34 years (range, 18-62 years) with a median return for follow-up of 11.5 months (range, 6-27 months).

Results: Average postoperative VAS and satisfaction were 0.8 ± 1.4 and 9.1 ± 1.6, respectively. Mean return to sport (n = 68) was 84.1 days. Average AOFAS Ankle-Hindfoot score was 94.3. A score of 90 or higher on the FAAM Sports subscale was seen in 79.0% of the subjects. The single-leg hop test (Limb Symmetry Index %) showed that 86.4% of patients returned to normal or near normal function. The tape measure method and ankle dorsiflexion comparisons showed a significant difference: 9.2 ± 3.3 cm (operative side) and 10.4 ± 3.7 cm (contralateral side) (P = .034). Ankle plantar flexion comparison (goniometer) was 48.5 ± 11.5 degrees (operative side) and 49.7 ± 11.9 degrees (contralateral side), showing no difference (P = .506).

Conclusion: These results suggest that InternalBrace™ augmentation of a Broström procedure is a safe and efficacious procedure that produces favorable outcomes in patients in terms of preventing recurrent instability in the ankle in the short term.

Level of Evidence: Level IV, case series.

Keywords: ankle instability, Broström, lateral ligament repair

Lateral ankle sprains remain the most common injury in most sporting activities at any level. Appropriate initial conservative care yields a high rate of recovery, but 10% to 20% of people will develop chronic ankle instability. If this constitutes a functional instability that limits the ability to participate at the highest level, surgical repair is indicated. Over the past decade or two, the Broström procedure has become the mainstay for surgical repair of the lateral ankle ligament complex. Since a standard Broström relies on maturation of the native tissue, the ankle must be immobilized for 6 weeks before rehabilitation starts. It usually takes 4 to 6 months for the tissue to mature before an athlete can return to play without a higher risk of reinjury.

The goal of this study was to determine whether it would be possible to accelerate rehabilitation while at the same time protect the ligament repair in short-term follow-up. The hypothesis was that augmentation of the Broström...
repair with an InternalBrace™ (Arthrex, Naples, FL) would allow accelerated rehabilitation and return to activity and would enhance lasting stability of the repair without a tendency to stretch.

Methods

After appropriate institutional review board (IRB) approval was obtained, a chart review was conducted at 2 centers to determine which patients had undergone lateral ankle instability repair with a Broström and InternalBrace™ augmentation procedure (ie, augmented Broström). Patients provided consent and were evaluated at a one-time postoperative visit between a minimum of 6 months through 24 months after their initial date of surgery. Inclusion and exclusion criteria included the following:

Inclusion criteria:

1. Age between 18 and 65 years.
2. Prior augmented Broström procedure.
3. Willing and able to complete the study.
4. Able to understand, complete, sign, and date the informed consent form.

Exclusion criteria:

1. Significant secondary procedures done at the time of repair, including microfracture, or any other treatment of osteochondral lesions of the talus or tibia. Minor debridements, synovectomies, and bone spur removals were not excluded.
2. Concomitant deltoid ligament insufficiency.
3. Any worker’s compensation case.
4. Any subject with a history of infection of the ankle predating the ankle repair.
5. Current orthopedic issues, not related to the ankle, that prevented the patient from performing the functional tests.

Most patients had undergone magnetic resonance imaging (MRI) prior to surgery to confirm the lateral ligament injury, but the determination of instability was made by a combination of objective clinical findings and complaints of subjective instability by the patients.

Data collection included patient demographics; surgical history, information, and complications; postoperative adverse events; and patient-reported outcomes. Patient-reported outcomes were determined by the Veterans Rand 12-Item Health Survey (VR-12) (which has a physical score and a mental score),9-11,24 Foot and Ankle Ability Measure (FAAM),16 Visual Analog Scale (VAS)25 for pain, and patient satisfaction. The American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot score13 and objective measurements (range of motion [ROM], anterior drawer, functional single-leg hop test, and calf strength [standard heel-rise test and calf girth measure]) were documented and compared with the contralateral ankle. Each patient was given a patient satisfaction question with standard 0-10 numeric rating scale, where 0 denoted not satisfied at all and 10 indicated completely satisfied.17

Eighty-one patients were analyzed: 30 males and 51 females. The median age was 34 years (range, 18-62 years) and the median return to follow-up was 11.5 months (range, 6-27 months); 90.1% of the patients were nonsmokers, whereas 4.9% were former smokers and 4.9% were current smokers. The average body mass index was 27.6 ± 5.3 (range, 18.8-43.8).

Surgical Procedure

Surgery was done on an outpatient basis. A standard arthroscopy was performed in all but 2 patients to allow visualization and debridement of the joint, including osteophyte removal and synovectomies as needed. The arthroscopy also served to clinically confirm the lateral instability and deltoid ligament integrity. The scope was then removed, and a 5-cm curvilinear incision was made laterally over the ankle to expose the lateral ligament complex (Figure 1).

A standard Broström repair was performed to imbricate and reattach the anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) to the fibula. Depending on the tissue quality and individual situation, traditional Broström3 with a pants-over-vest repair was done, or in some cases the ligaments were reattached to the fibula with suture anchors of choice.5 The Broström-Gould modification was also used as a standard procedure.5

After the Broström repair, the InternalBrace™ was inserted. The first drill hole was made at the footprint of the

Figure 1. A curvilinear incision was made starting over the middle of the distal fibula, aiming for the sinus tarsi. This was located in the interval between the superficial peroneal nerve and the sural nerve.
ATFL on the talus (Figure 2a). Once the hole was prepared, the 3.5-mm SwiveLock® anchor with FiberTape® was inserted. The second drill hole was then made at the footprint of the ATFL on the fibula (Figure 2b). The InternalBrace™ was anchored into the fibula with a 4.75-mm SwiveLock® anchor. Care was taken to insert the FiberTape under adequate tension. There should be 1 to 2 mm of play in the brace to allow normal physiological movement of the repaired lateral ligament complex. If the FiberTape of the brace is too tight, it could limit the normal development and maturation of the repaired ligament complex (Video 1, available online).

An accelerated rehabilitation program was used for all patients (Table 1). Postoperatively, a short leg cast was applied and the patients were sent home with crutches. They were instructed to be weight bearing as tolerated (WBAT) right away and could be full weight bearing (FWB) without crutches as soon as they were comfortable.

At 2 weeks after surgery, the cast was removed and the patients were placed in a short-leg, controlled ankle motion (CAM) walking boot for ambulation, again WBAT to FWB. They could remove the boot as often as they wanted and start active ROM. At 4 weeks postoperatively, the official rehabilitation started and an accelerated program was used. A laced-up ankle brace was recommended for the first 3 months following surgery. Of note, patients were also seen clinically at 6 weeks, 3 months, and 1 year after surgery.

**Results**

The average surgical time was 33.5 ± 8.3 minutes (range, 16-60 minutes). Use of the InternalBrace™ added between 5 and 10 minutes to the overall surgical time. The average AOFAS Ankle-Hindfoot score was 94.3 ± 9.3. Forty-five patients (56%) reported an ideal maximum score of 100. The VR-12 mental score averaged 54.8 (range, 27.4-63.3) and the physical score averaged 48.7 (range, 20.6-57.6). The FAAM (ADL and Sports subscales), which is an appropriate outcome instrument to quantify functional limitations in patients with varying leg, foot, and ankle disorders, was used at the return visits for this cohort.6,16 The median scores showed values commensurate with preferable outcomes (Table 2). Figures 3 and 4 show the distribution of numerical data as they fell at the postoperative report for both ADL and Sports subscale scores.

Also using the FAAM, patients compared their current level of function in sport-related activities versus their level of function before their foot and ankle problem. To do so, the patients rated their current level of function as 0% to 100% (with 100% being the preinjury level); 79.0% of patients reported their current level of function as 90% or greater. The average postoperative VAS and satisfaction scores were 0.8 ± 1.4 and 9.1 ± 1.6 (range, 0-10), respectively.

The functional single-leg hop test was used to compare the operated leg with the normal leg (Video 2, available online).18 Testing was conducted as follows:

1. Subject begins with the nonoperative ankle.
2. One practice trial is given for each ankle.
3. Two alternating trials are performed on each ankle.
4. Subject starts by standing on one leg with toe behind the marked line.

**Statistical Analysis**

Two-sample t tests were used to determine differences in outcome scores over time. Statistical analyses were performed using Sigma Plot 11.0 (Systat Software, Chicago, IL) with significance set at an alpha level of .05.
5. Measurements are taken from toe of starting point to where the heel lands.
6. Landing position must be held for 3 seconds with no loss of balance or extra steps.
7. A failed jump is marked by loss of balance, touching the floor with arms or opposite leg, or an additional short hop on landing.
8. The Limb Symmetry Index is calculated by taking the average operative ankle measurement divided by the average nonoperative ankle measurement. Multiply by 100 to determine percentage.

To perform the single-leg hop for distance, the subject performs a maximal hop horizontally, landing on the same foot.

The results of the single-leg hop test are reported in Table 3 and Figure 5.

**Table 1. Accelerated Rehabilitation Protocol.**

<table>
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<tr>
<th>Phase</th>
<th>Weeks</th>
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<th>10+</th>
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<tr>
<td><strong>Phase I: Weeks 1-2</strong></td>
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<td>✓</td>
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<td>Control pain. Rest and elevation to control swelling.</td>
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<td>WBAT to FWB in cast or CAM boot. Most people can ambulate without crutches within 3-4 days.</td>
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<td>Sutures removed at 10-16 days.</td>
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<td>CAM boot—out of the boot to shower.</td>
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<td>Start active ROM (ankle PF/DF).</td>
<td>✓</td>
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<td>Ride stationary bike, walk, use elliptical trainer, etc, in the boot.</td>
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<td>Hip AROM and strength: clam, side lift, gluteus maximus, SLR.</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td>Knee AROM and strength: SLR, TheraBand*b press, or leg machine.</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td><strong>Phase II: Weeks 3-6</strong></td>
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<td>✓ ✓ ✓</td>
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<td>All should be FWB by 3 weeks.</td>
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<td>Start official rehabilitation with physical therapist.</td>
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<td>Start using ankle brace.</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td>Can bike, walk, use elliptical trainer, etc, without the boot.</td>
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<td>Core exercises: abdominal recruitment; bridging on ball; ball reach; arm pulleys or TheraBand using diagonal patterns.</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td>Stretching: gluteus maximus, gluteus medius, piriformis, rectus femoris, hamstrings.</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
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<td><strong>Phase III: Weeks 6-8</strong></td>
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<td>Full rehabilitation without restrictions as long as pain/discomfort is ≤3 out of 10.</td>
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<td>Continue AROM ankle PF/DF and start inversion/eversion.</td>
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<td>Proprioception activities/agility training (can start at 4 weeks if pain is minimal, ROM is good), single-leg stance on even surface.</td>
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<td>Muscle stimulation: intrinsics, invertors/evertors if required, gait training.</td>
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<td>If required, manual mobilization to joints (not part of ligament reconstruction).</td>
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<td><strong>Phase IV: Week 8-9</strong></td>
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<td>Proprioceptive training: single-leg stance on even surface with resistance to arms or weight-bearing leg; double-leg stance on wobble board, Sissel,c Fitter;d single-leg stance on wobble board, Sissel, Fitter, with resistance to arms or non-weight-bearing leg.</td>
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<td>Strength: toe raises, lunges, squats</td>
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<td><strong>Phase V: Week 10+</strong></td>
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<td>Work-specific or activity-specific training.</td>
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<td>Plyometric training.</td>
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<td>Hopping, skipping, running.</td>
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Abbreviations: AROM, active ROM; CAM, controlled ankle motion; DF, dorsiflexion; FWB, full weight bearing; ROM, range of motion; PF, plantar flexion; SLR, straight leg raise; WBAT, weight bearing as tolerated.

*aSpecific changes in the program will be made by the physician and/or physical therapist as appropriate for the individual patient.

*bTheraBand (Akron, OH).

*cSissel (Anaheim, CA).

*dFitter International Inc (Calgary, AB, Canada).
The mean time to return to sports (n = 68) was 84 days; 8 subjects did not participate in sport prior to surgery but were able to return to their preinjury ADL status very quickly. The average time to FWB (n = 81) was 16.4 days (range, 1-64 days).

Five minor adverse events (4 patients) were reported: (1) One patient had a slight dehiscence of the incision at the 2-week postoperative visit. The evaluation was not consistent with an infection and was treated with standard dressing changes. (2) One patient reported a superficial infection at 3 months postoperatively. This occurred after the incision was irritated following intensification of running. This was treated with a course of antibiotics as a precaution and resolved. (3) A patient experienced ankle inversion sprains (~1 year postoperatively) during basketball games that did not result in instability. (4) A patient experienced anterior ankle impingement (~9 months postoperatively). (5) A patient experienced extensor tendinitis in the ankle. There was no indication that the impingement or tendinitis was related to the ligament repair.

We found that 67% of the cohort was brace-free with a return to sport activity. A laced-up ankle brace was recommended for the first 3 months following surgery. Those still choosing to wear a brace did so at the recommendation of their coach or because of personal preference. Most teams on a professional or collegiate level strongly advise, if not insist, that players either brace or tape both their ankles for practices or games, irrespective of injury history. However, we could not find any evidence that this practice made a statistical difference in injury rates.

The averages for objective calf strength examination (actual girth measured in centimeters) after treatment and recovery proved almost equal to values for the contralateral limb: 38.5 ± 4.2 cm for the injured leg (operative side) and 38.4 ± 4.6 cm for the noninjured leg (contralateral side) (P = .890), respectively. At the postoperative visit, 93.8% of the cohort had a negative anterior drawer. The other 6.2% had a 1+ positive laxity seen in the drawer compared with the opposite side.

Ankle dorsiflexion was measured with a tape measure as shown in Figure 6.14 Ankle dorsiflexion was 9.2 ± 3.3 cm on the operative side and 10.4 ± 3.7 cm on the contralateral side (P = .034); even though the operative side had excellent dorsiflexion, the difference between the two sides was statistically significant. Ankle plantar flexion (measured with a goniometer) was 48.5 ± 11.5 degrees on the operative side and 49.7 ± 11.9 degrees on the contralateral side, a difference that was not statistically significant (P = .506).

| Table 2. Foot and Ankle Ability Measure (FAAM) ADL and Sports Subscale Scores. |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                | Average         | Minimum         | Maximum         | Median          |
| ADL subscale score             | 94.5            | 40.5            | 100             | 97.6            |
| Sports subscale score          | 85.5            | 29.2            | 100             | 93.8            |
Discussion

Results of Broström repairs are not widely published, and we were concerned that when we evaluated our Broström repairs, some would fail or be subject to reinjury. Waldrop et al\textsuperscript{23} in 2012 confirmed that a Broström repair is significantly weaker than the native ATFL ligament. The investigators tested anatomic suture anchor fixation versus the standard Broström technique for lateral ligament repair. Their study showed no significant difference between the 2 methods, but both proved to be only about 50% the strength of the native, uninjured ligament. Waldrop et al concluded that one has no choice but to protect the repair for an extended period to avoid premature failure. Kirk et al\textsuperscript{12} also confirmed in a cadaveric study that unprotected motion after a Broström repair was associated with a significant elongation and failure of the repair. If the same is true in live tissue, it will be impossible to conduct an accelerated rehabilitation program without compromising the repair.

Several recent studies have raised concerns about the durability of a Broström repair for lateral ankle stability. Xu et al\textsuperscript{26} showed in their follow-up study that patients who had ligamentous laxity prior to surgery did poorly in the long term. We acknowledge that this is a different patient population than normal, but it still represents a problem that needs a resolution. In a long-term follow-up study after Broström repair, Mafulli et al\textsuperscript{18} showed that 26% of patients abandoned all athletic activity after the repair and 16% decreased their activity. That study had a much longer follow-up than ours, but it shows the potential limitations of a standard Broström repair.

Viens et al\textsuperscript{22} conducted a biomechanical study that involved augmenting the Broström repair with an InternalBrace\textsuperscript{TM}; the investigators showed significant strength at time zero at 250 N compared with the native repair (150 N) or a repaired Broström with either FiberWire or suture anchors of 75 N. A recent study by Cho et al\textsuperscript{4} is the first to report on InternalBrace\textsuperscript{TM} augmentation for a Broström. The investigators reported excellent results in a cohort of 28 patients with generalized ligamentous laxity, with no tendency to stretch out over time.

Conclusion

Our large study showed very encouraging results after augmenting a standard Broström with an InternalBrace\textsuperscript{TM}. The procedure allowed us to implement a very aggressive rehabilitation program without compromising the stability of the repair. We found that motivated athletes were able to return to play at an accelerated pace, even as early as 8 weeks after surgery. Our plan is to evaluate the same cohort again in several years to see whether the results persist. We are in the process of conducting a multicenter, prospective,
randomized controlled trial to better evaluate our outcomes of standard versus augmented Broström repairs. In the short term, the addition of the InternalBrace™ allowed excellent stability and a significantly accelerated rehabilitation and return to sports.

Declaration of Conflicting Interests
The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: J. Chris Coetzee, MD, J. Kent Ellington, MD, and James A. Ronan, BS, report other from Arthrex, during the conduct of the study. ICMJE forms for all authors are available online.

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Supplemental Material
Supplemental videos are available online with this article.

References