Ultrasound-Guided Percutaneous Reconstruction of the Anterolateral Ligament: Surgical Technique and Case Report

Alan M. Hirahara, MD, FRCS(C), and Wyatt J. Andersen, ATC

Abstract

The first noted description of the anterolateral ligament (ALL) is often attributed to Dr. Paul Segond (1879). Segond described a “fibrous, pearly band showing extreme amounts of tension during forced internal rotation” that was responsible for an avulsion at the lateral aspect of the proximal tibia. In 2013, Dr. Steven Claes confirmed the presence of the ALL as the band of tissue detailed by Segond. Recent biomechanical studies have shown that the ALL is a vital stabilizer during internal rotation of the knee. Its contribution to stability during rotational kinematics has been proven to exceed that of the anterior cruciate ligament (ACL). Using the concept of the wheel and axle biomechanical formulas, the ACL endures 6 times greater forces during internal rotation in an ALL-deficient knee.

With the recent anatomic and biomechanical findings, the necessity of a technique for reconstruction of the ALL has become increasingly important. The novel use of ultrasound intraoperatively allows for the exact anatomic reconstruction of the lost ligament by identifying the exact anatomic location of both the origin and insertion of the ALL. This article describes a technique for an ultrasound-guided percutaneous reconstruction of the ALL and a case report on one of our patients who required the reconstruction of his ALL.

R

estoring native kinematics of the knee has been a primary goal of anterior cruciate ligament (ACL) procedures. Double-bundle ACL reconstruction, compared to single-bundle, has been hypothesized to more effectively re-establish rotational stability by re-creating the anatomic ACL, but has not yet proven to result in better clinical outcomes.1

In 1879, Dr. Paul Segond described a “fibrous, pearly band” at the lateral aspect of the knee that avulsed off the anterolateral proximal tibia during many ACL injuries.2 The role of the lateral tissues in knee stability and their relationship with ACL pathology has attracted noteworthy attention in recent time. There have been multiple studies presenting an anatomical description of a structure at the anterolateral portion of the knee with definitive femoral, meniscal, and tibial attachments, which helps control internal rotational forces.3-7 Claes and colleagues4 later found that band of tissue to be the anterolateral ligament (ALL) and determined its injury to be pathognomonic with ACL ruptures.

The ALL is a vital static stabilizer of the tibio-femoral joint, especially during internal tibial rotation.8-10 In their report on ALL and ACL reconstruction, Helito and colleagues11 acknowledge the necessity of accurate assessment of the lateral structures through imaging to determine the presence of extra-articular injury. Musculoskeletal diagnostic ultrasound has been established as an appropriate means to identify the ALL.12

Ultrasound can accurately determine the exact

Authors’ Disclosure Statement: Dr. Hirahara reports that he receives support from Arthrex as a consultant, royalties, and research support. Mr. Andersen reports no actual or potential conflict of interest in relation to this article.
The anatomic location of the origin and insertion of the ALL. Reconstruction of the ALL could yield better patient outcomes for those who experience concurrent ACL/ALL injury. Here we present an innovative technique for an ultrasound-guided percutaneous method for reconstruction of the ALL and report on a patient who had undergone ALL reconstruction.

**Surgical Indications**
All patients undergo an ultrasound evaluation preoperatively to determine if the ALL is intact or injured. Our experience has shown that when ultrasound evaluation reveals an intact ALL, the pivot shift has never been a grade III. Our indications for a combined ACL and ALL reconstruction are a positive ultrasound diagnosis of an ALL tear, and a grade III pivot shift test in an ACL-deficient knee or a grade I-II pivot shift test in an ACL-intact knee (Table 1). The ACL cannot be left insufficient if the patient is to have a successful ALL reconstruction.

**Surgical Technique**
For a demonstration of this technique, see the video that accompanies this article online at www.amjorthopedics.com.

The pivot shift test is conducted under anesthesia to determine whether an ALL reconstruction is required. The patient is placed in a supine position with the knee flexed at 30°, at neutral rotation, and without any varus or valgus stress. The knee is prepped and draped under sterile conditions. Under ultrasound guidance, the origin and insertion of the ALL are identified and marked with an 18-gauge spinal needle (Figure 1). A No. 15 blade is used to make a small incision centered on each spinal needle. The spinal needle is replaced with a 2.4-mm drill pin (Figure 2). A 90° hemostat is used to establish a plane under the iliotibial (IT) band between the 2 incisions to pass a looped FiberWire suture (Arthrex) for passage of the graft and FiberTape (Arthrex). The FiberTape acts as an internal brace. A socket 22 mm in length is drilled using a 5.0-mm cannulated reamer over each drill pin. A 4.5-mm semitendinosus graft was prepared with a collagen-coated FiberTape attached to a 5.5-mm BioComposite Vented SwiveLock.

**Table 1. Indications/Contraindications for Anterolateral Ligament Reconstruction**

<table>
<thead>
<tr>
<th>Indications</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive ultrasound diagnosis of ALL damage</td>
<td>Moderate to severe arthritic changes</td>
</tr>
<tr>
<td>Grade III pivot shift test in an ACL-deficient knee</td>
<td>Significant bone defects</td>
</tr>
<tr>
<td>Grade I-II pivot shift test in an ACL-intact knee</td>
<td>Persistent ACL insufficiency</td>
</tr>
<tr>
<td>Clinical instability</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ACL, anterior cruciate ligament; ALL, anterolateral ligament.

---

**Figure 1.** Intraoperative identification of the femoral and tibial attachments of the anterolateral ligament under ultrasound guidance. The attachments are then marked with a spinal needle for accurate, anatomic placement of the guide pins.

**Figure 2.** Intraoperative position of the femoral and tibial 2.4-mm guide pins (orange arrows). The locations of the guide pins are at the anatomic site of the femoral (yellow arrow) and tibial (white arrow) attachments of the anterolateral ligament. The 5.0-mm cannulated reamer is used to drill the sockets for anchor placement.
Ultrasound-Guided Percutaneous Reconstruction of the Anterolateral Ligament

![Image](image_url)

**Figure 3.** Intraoperative insertion of the BioComposite SwiveLock anchor (Arthrex) (white arrow) at the femoral attachment. The semitendinosus graft (red arrow) is attached to the anchor prior to fixation. The looped, passing suture (yellow arrow) is then used to pull the construct through the plane created underneath the iliotibial band for distal attachment.

The graft and FiberTape are then passed under the IT band to the distal incision. Using the length of the BioComposite SwiveLock anchor as a guide, a mark is made on the graft after tensioning the construct in line with the leg, distal to the tibial drill pin (*Table 2, Figure 4*). The second 5.5-mm BioComposite SwiveLock anchor is attached to the FiberTape and graft at the mark. The rest of the graft is resected. The BioComposite SwiveLock anchor, graft, and FiberTape are fixed into the tibial socket, completing the reconstruction (*Figure 5*). Passive range of motion should then be checked to ensure the construct is not overtensioned.

**Rehabilitation**

Rehabilitation following an ALL procedure is similar to traditional ACL rehabilitation with an added emphasis on minimizing rotational torque of the tibia in the early stages. Our protocol allows for early weight-bearing and minimal use of assistive devices (ie, immobilizer brace and crutches) because an internal brace is performed on every ALL reconstruction. The protocol emphasizes full range of motion and linear power with a progression to lateral and rotational activities. This enables the client to begin rehabilitation within 1 week and regain normal daily function quickly. Return to heavy lifting, physical activity, and sports is delayed until after 6 months to allow for the graft maturity and integration, which takes quite a while, as grafts are weakest after 6 weeks. When patients return to sports and activity, a brace is used for up to 1 year postoperatively to limit shearing forces inherent in pivoting and cutting.

**Case Report**

In January 2013, a 17-year-old male soccer player suffered an ACL rupture of his right knee. Later that spring, he had an ACL reconstruction with an allograft. Twelve months postoperatively, the patient returned, saying that he felt much better; however, anytime he tried to plant his foot and rotate over that fixed foot, his knee felt unstable. The physical examination revealed both negative Lachman and anterior drawer tests but a I+ pivot shift test. A magnetic resonance imaging (MRI) examination revealed an intact ACL graft. A diagnostic ultrasound evaluation revealed a distal ALL injury. After discussing the risks, benefits, and goals with the patient, we opted for a diagnostic arthroscopy and a percutaneous, ultrasound-guided reconstruction of the ALL.
Postoperatively, the patient did very well. One week after surgery, he returned, saying he felt completely stable and demonstrated by repeating the rotation of his knee. The patient continued to have no issues until he returned 13 months post-ALL surgery, complaining of a recent injury that had caused the return of his feelings of instability. An MRI evaluation showed an intact ACL graft and the possibility of a ruptured ALL. Fifteen months after the initial ALL reconstruction, we proceeded with surgery. At arthroscopy, the patient was found to have a pivot shift of I+ and an intact ACL graft. The ALL was reconstructed again using an allograft, internal brace, and bone marrow concentrate. At 13 months post-ALL reconstruction revision, the patient had no complaints.

**Discussion**

Reconstruction of the ALL is aimed to restore anatomic rotational kinematics. Sonnery-Cottet and colleagues have reported promising initial results in their 2-year follow-up study of combined ACL and ALL reconstruction outcomes. This surgical technique includes use of an internal brace, which negates the necessity for external support devices and allows for earlier mobilization of the joint. A reconstruction of the ALL, performed concurrently with the ACL, does not add recovery time, but could prevent postsurgical complications and improve rehabilitation by eliminating rotational instability that presents in some ACL-reconstructed patients.

Sonnery-Cottet and colleagues state that their arthroscopic identification of the ALL can help to cultivate a “less invasive and more anatomic” reconstruction. The use of musculoskeletal ultrasound allows our technique to utilize a completely noninvasive imaging tool that allows proper establishment of ALL anatomy prior to the procedure. The entirety of the ALL is easily identifiable, which has proven to be shortcoming of MRI evaluation. Accurate preoperative assessment of the lateral structures is necessary in ACL-deficient individuals. Sonography also provides a means of accurate guidance and socket creation, without generating large incisions.

If the ALL is responsible for internal rotatory stability as asserted, the structure should exhibit biomechanical properties during movement. In their study on the function of the ligament, Parsons and colleagues established the inverse relationship between the ALL and ACL during internal rotation. As their cadaveric knees were subjected to an internal rotatory force through increasing angles of

---

**Table 2. Anterolateral Ligament Reconstruction Tips/Pearls**

- Evaluate pivot shift under anesthesia prior to reconstruction
- Knee positioned at 30° flexion and neutral rotation without any varus or valgus stress
- Use ultrasound to guide placement of spinal needles
- Use 90° hemostat for establishing plane under iliotibial band and for the FiberWire (Arthrex) passing suture
- Use FiberTape (Arthrex) with graft as an internal brace
- Use length of BioComposite SwiveLock (Arthrex) as a guide to mark graft for tibial placement

**Table 3. Advantages/Disadvantages of Ultrasound-Guided Anterolateral Ligament Reconstruction**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate preoperative assessment</td>
<td>Required proficiency in ultrasound use</td>
</tr>
<tr>
<td>Easy graft passage and placement</td>
<td>Controversy over exact femoral attachment location</td>
</tr>
<tr>
<td>Re-establish normal rotational kinematics</td>
<td></td>
</tr>
<tr>
<td>Reliable and anatomic socket placement</td>
<td></td>
</tr>
<tr>
<td>Reliable graft measurement</td>
<td></td>
</tr>
<tr>
<td>Percutaneous and minimally invasive procedure</td>
<td></td>
</tr>
</tbody>
</table>
Ultrasound-Guided Percutaneous Reconstruction of the Anterolateral Ligament

flexion, the contribution of the ALL towards stability significantly increased while the ACL declined. Helito and colleagues and Zens and colleagues have demonstrated length changes of the ligament through varying degrees of flexion and internal rotation. Their reports indicate greater tension during knee movements, coinciding with the description of increasing ALL stability contribution by Parsons and colleagues. Kennedy and colleagues conducted a pull-to-failure test on the ALL. The average failure load was 175 N with a stiffness of 20 N/mm, illustrating the structure is a candidate for most traditional soft tissue grafts. The biomechanical evidence of the structural properties of the ALL confirms its importance in knee function and the necessity for its reconstruction.

With the understanding that ACL contributes to rotatory stability to some extent, the notion begs the question of how a centrally located ligament is able to prevent excessive rotation in a structure with a large relative radius. Biomechanically, with such a small moment arm, the ACL would experience tremendous stress when a rotatory force is applied. The same torque applied to a more superficial structure, with a greater moment, would sustain a large reduction in the applied force. The concept of a wheel and an axle should be considered. The equation is where we measured on a cadaveric knee the distance from the center of rotation to the ACL and the ALL, finding the radii were 5 mm and 30 mm, respectively. Taking these measurements, we would then expect the force experienced on the axle (ACL) to be 6 times greater than what would be experienced on the periphery of the wheel (ALL). The ALL (wheel) has a significant biomechanical advantage over the ACL (axle) in controlling and enduring internal rotatory forces of the knee. This would imply that if the ALL were damaged and not re-established, the ACL would experience a 6 times greater force trying to control internal rotation, which would result in a significantly increased chance of failure and rupture.

While there is a degree of dissent on the presence of the ALL, a number of studies have classified the tissue as an independent ligamentous structure. While there is disagreement on the precise location of the femoral attachment, there is a consensus on the location of the tibial and meniscal attachments. Claes and colleagues originally outlined the femoral attachment as anterior and distal to the origin of the fibular collateral ligament (FCL), which is the description this technique follows. Since Claes and colleagues report, many have investigated the ligament’s femoral origin with delineations ranging from posterior and proximal to anterior and distal.

The accurate, noninvasive nature of the musculoskeletal ultrasound prior to any incisions being made makes this technique innovative and superior to other open surgical techniques or those that require fluoroscopy. This is the greatest advantage of the procedure (Table 3). Not only does the use of ultrasound make this specific operation exceptional, but its practice is widely applicable. To date, this is the only ultrasound-guided reconstruction of any kind and can serve as a template for not only ALL procedures, but many other procedures as well.

Conclusion
The ALL has been determined to play an integral role in the rotational stability of the knee. In the setting of instability and insufficiency, reconstruction will lead to better patient outcomes for concurrent ACL/ALL injuries and postsurgical rotatory instability following ACL procedures. This innovative technique utilizes ultrasound to ascertain the precise anatomical attachments of the ALL prior to the operation. The novel nature of this ultrasound-guided reconstruction has the potential to be applicable in many other surgical procedures.

References


5. Dodds AL, Halewood C, Gupte CM, Williams A, Amis AA.
Ultrasound-Guided Percutaneous Reconstruction of the Anterolateral Ligament

Continued from page 422