

The Push-Through Sign—Making the Decision for Selective-Bundle Anterior Cruciate Ligament Surgery



Arthur R. Bartolozzi, M.D., Aashish V. Jog, M.D., and Tyler J. Smith, D.O.

Abstract: Partial anterior cruciate ligament (ACL) tears are often difficult to diagnose and treat. Recent interest in the literature has focused on performing selective-bundle ACL reconstruction in patients with symptomatic partial ACL tears when one of the ACL bundles is intact. However, the clinical examination, magnetic resonance imaging, and arthroscopic evaluation of partial ACL tears may not correlate, and proper assessment of the integrity of the intact portion of the ACL continues to be a challenge. If a selective-bundle ACL reconstruction is performed in a patient with an apparently intact but structurally damaged individual bundle, the outcome would be compromised by leaving the damaged bundle in place. This technical note provides a description of a simple and reliable arthroscopic method to aid in the diagnosis of a partial ACL tear. The use of this method to assess remaining ligamentous tissue will assist surgeons in deciding for or against selective-bundle ACL reconstruction.

Anterior cruciate ligament (ACL) reconstruction has undergone an evolution since the science and biomechanical behavior has become more understood, and there also is increasing attention to performing single-bundle ACL reconstruction as the anatomic nuances of ACL injury are better understood. Fu et al.¹ have emphasized that double-bundle ACL reconstruction is an anatomic concept, not simply a technique. Individual comparative studies as well as meta-analyses of randomized controlled trials indicate better biomechanical function of double-bundle reconstructions in comparison with single-bundle reconstructions; however, there is no consensus regarding superiority of functional outcomes or graft failures.²⁻⁸ Nevertheless, there remains interest in single-bundle ACL reconstruction. Attention to detail and focusing on anatomical restoration has prompted greater interest in restoring only the injured segment of the ligament.

However, the diagnosis and assessment of an individual-bundle disruption or a partial ACL tear is often difficult.^{9,10}

DeFranco and Bach have defined a partial ACL tear by a combination of the following factors (Table 1): (1) an asymmetric Lachman test result as compared with that of the uninjured knee; (2) a negative pivot-shift test with the patient under anesthesia; (3) a low-grade KT-1000 arthrometer measurement (≤ 3 mm); and (4) arthroscopic evidence of an ACL injury. They further indicated that an asymmetric positive pivot shift, regardless of the grade, is consistent with functional instability.¹⁰

In addition, studies have suggested that results of the clinical examination, magnetic resonance imaging (MRI), and arthroscopy may be variable, may not correlate during the assessment of a partial ACL tear, and none of these diagnostic methods can be used individually to diagnose a partial ACL tear with certainty.¹⁰⁻¹²

Furthermore, the microanatomy of the torn ACL has been documented, as has the outcome of nonoperative treatment for partial tears.¹³ The implication is that if a selective-bundle ACL reconstruction is performed in a patient with an apparently intact individual bundle, the outcome would be compromised by leaving an internally damaged but visually intact bundle in place. The purpose of this paper is to present an arthroscopic technique of identifying whether an ACL bundle that appears intact during arthroscopy is truly intact, or in other words, whether a partial ACL tear is actually partial (Table 2).

From Jefferson 3B Orthopedics, Philadelphia, Pennsylvania, U.S.A.

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Address correspondence to Arthur R. Bartolozzi, M.D., Aria 3B Orthopedics, 601, Walnut St., Suite 44L, Philadelphia, PA 19106.; E-mail: jocdoctor@gmail.com or charlotteobrien@ariahealth.org

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Table 1. Criteria for Defining a Partial ACL Tear (DeFranco and Bach¹⁰)

An asymmetric Lachman test result as compared with that of the uninjured knee
A negative pivot-shift test with the patient under anesthesia
A low-grade KT-1000 arthrometer measurement (≤ 3 mm)
Arthroscopic evidence of an anterior cruciate ligament injury

ACL, anterior cruciate ligament.

Technique

A standard operating room table with a lateral post or an arthroscopic leg holder is used for the procedure. The affected knee is prepped and draped in a standard fashion. A standard anterolateral portal is made, and a 30° arthroscope is introduced in the knee through the portal. A routine diagnostic arthroscopy is performed. After creation of a standard anteromedial working portal under direct visualization, a suction shaver is used to remove any obstructing tissue. The least possible debridement that allows inspection and evaluation of the ACL is performed using the suction shaver. The ACL can be visualized after retracting the ligamentum mucosum, when intact, medially using the probe. The ACL originates from the medial wall of the lateral femoral condyle and attaches on the anterior portion of the interspinous region of the tibia. The ACL is thus directed inferiorly, medially, and anteriorly from its attachment on the femur.

The Push-Through Sign (With Video Illustration)

To perform the push-through test, the probe is inserted through the anteromedial portal and the ACL is visualized from anterolateral portal. The tip of the probe is aligned parallel with the long axis of the visually intact bundle of the ACL, adjacent to its femoral attachment (Fig 1). Using the probe, moderate pressure is applied posteriorly in an attempt to push the probe through the ACL tissue. Care must be taken to avoid excessive or uncontrolled pressure, as the probe may pass through the ACL posteriorly and cause injury to structures of the posterior knee. If the probe passes through the tissue, it is considered a positive push through sign (Fig 2, Video 1, first part). This would indicate that although the bundle is visually intact, there is structural damage and therefore not

Table 2. Key Points

It is difficult to assess the integrity of remaining ACL fibers in the case of a partial tear.
Consideration must be given to thoroughly evaluating the remnant anteromedial or posterolateral bundle arthroscopically in the event that the MRI and/or physical examination indicates that a partial tear may be present.
The positive push-through sign is an indication of insufficient or incompetent remnant tissue to perform a selective-bundle reconstruction

ACL, anterior cruciate ligament; MRI, magnetic resonance imaging.

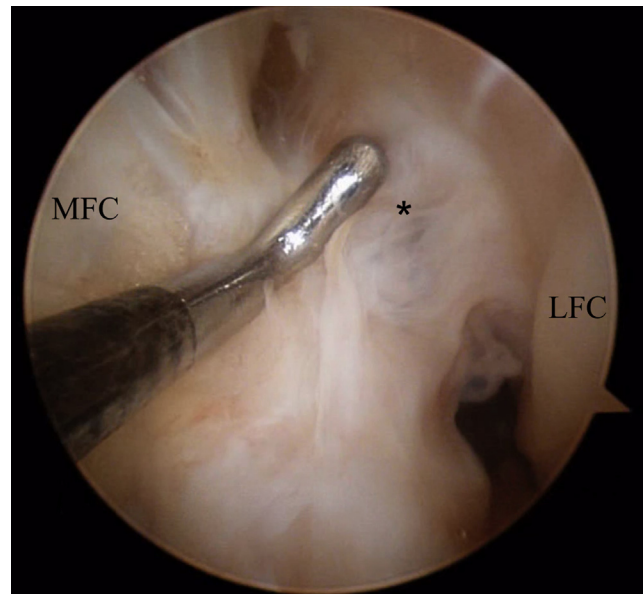


Fig 1. Left knee; anterolateral portal viewing. The ACL is visually intact. The probe is aligned parallel to the orientation of the ACL fibers at the femoral attachment. *ACL. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; MFC, medial femoral condyle.)

functionally intact. If moderate pressure applied to the probe does not result in the probe passing through the tissue, this is considered a negative push through sign (Figs 3 and 4). This would indicate that the bundle is

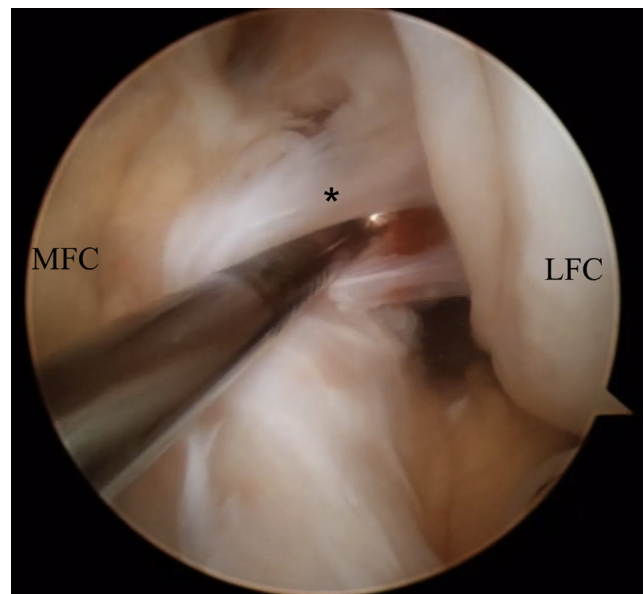


Fig 2. Left knee; anterolateral portal viewing. Moderate pressure is applied to the probe in an attempt to push the probe through the ACL tissue. The probe advances through the ACL tissue. This is considered a positive “push-through sign” and indicates that although it appears visually intact, there is structural damage to the ACL bundle. *ACL. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; MFC, medial femoral condyle.)

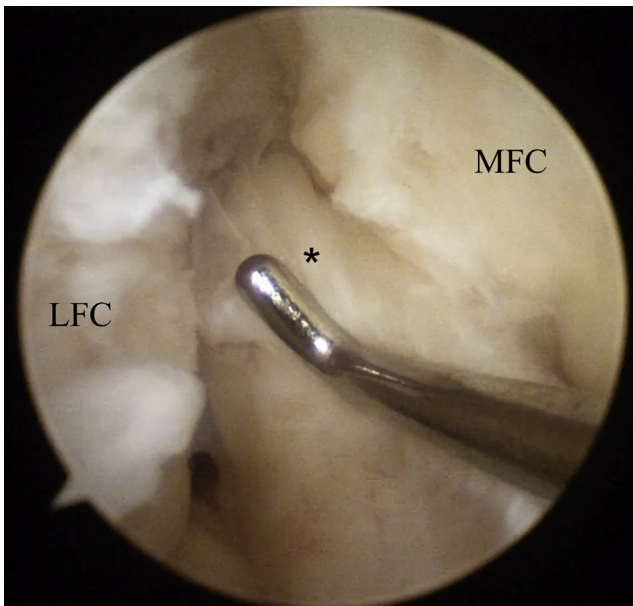


Fig 3. Right knee; anterolateral portal viewing. The ACL is visually intact. The probe is aligned parallel with the orientation of the ACL fibers at the femoral attachment. Moderate pressure is applied. *ACL. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; MFC, medial femoral condyle.)

both visually and structurally intact. It is important to keep the probe aligned parallel to the long axis of the ACL fibers, as positioning the probe perpendicularly

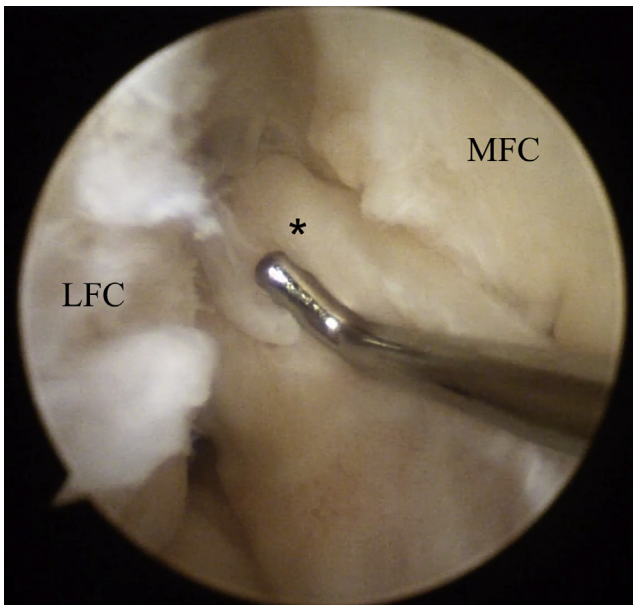


Fig 4. Right knee; anterolateral portal viewing. Moderate pressure is applied to the probe in an attempt to push the probe through the ACL tissue. The probe does not advance through the ACL tissue. This is considered a negative "push-through sign" and indicates the ACL bundle is both visually and structurally intact. *ACL. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; MFC, medial femoral condyle.)

Table 3. Tips

When the ligament remaining appears intact, it is helpful to view it from several positions such as the standard lateral and medial parapatellar portals.

Begin applying the probe pressure just adjacent to the femoral attachment, as most ACL injuries occur closer to the femoral side. When performing arthroscopy of the knee in cases in which the ACL is normal, take the opportunity to carefully probe the ACL in line with the longitudinal axis to get an appreciation of what an intact ligament feels like.

If the probe tip is pushed perpendicular to the fibers and not longitudinally, it can result in a false-negative push through sign.

ACL, anterior cruciate ligament.

may result in a false-negative sign. Additional tips regarding the push-through sign can be found in [Table 3](#). To summarize, the probe cannot be passed through the tissue with moderate pressure in a healthy, structurally intact ACL ([Video 1](#), second part).

Discussion

Selective-bundle ACL reconstruction for partial tears has gained interest in the past several years.¹⁴⁻²⁵ However, clinical examination, MRI, and routine arthroscopic evaluation may not be able to provide a detailed and proper assessment of the integrity of the ACL.^{11,12} As a result, determining which partial ACL tears truly involve only a single bundle continues to be a challenge. There are circumstances in which clinical examination, MRI, and diagnostic arthroscopy suggest there is a partial tear with one intact bundle. However, the visually intact bundle may have significant structural damage, compromising its function. If a selective-bundle ACL reconstruction is performed in this scenario, there is a high risk of failure and revision surgery.

We have developed a method that can be used during arthroscopy to evaluate the structural integrity of the individual bundles in cases of partial ACL tear. This technique presents a simple, reliable, and easily reproducible method to aid in the diagnosis of a partial ACL tear. Other advantages of the technique are that it does not add any increased cost, no special equipment is required, and it is not time-consuming or disruptive to operative workflow ([Table 4](#)). Limitations of the technique are that it cannot be used for bony avulsions of the ACL, and the test does not provide information regarding the microarchitecture of the bundle ([Table 5](#)). A positive push-through sign indicates that the visually intact bundle is weak, has structural damage, and implies that it is actually torn. A negative push-through

Table 4. Advantages of the Technique

It presents a method of assessment of ligament integrity

It is not time consuming

It does not require any special equipment

It is reliable and reproducible

It is safe and does not compromise any further surgical steps

Table 5. Limitations and Risks of the Technique

It assesses only the apparent quantity and apparent integrity of the remaining tissue but not the microarchitecture
It is useful only in cases of interstitial tears of the ACL or tears at the attachment sites of the ACL and not in cases of bony avulsions of the ACL
If the probe is pushed in an uncontrolled fashion, it may slide too posterior and cause injury
Using the push through sign is only part of a thorough assessment of the remaining ACL tissue. It is only applicable as a component of a comprehensive evaluation to assess the situation for appropriateness of selective-bundle reconstruction. A negative sign must be accompanied with a physical exam suggesting single bundle injury

ACL, anterior cruciate ligament.

sign indicates that the bundle is strong, functional, and is intact. Thus, the push-through test is a useful tool for surgeons during diagnostic arthroscopy and ACL reconstruction and may aid in the decision for or against selective-bundle ACL reconstruction.

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