Technical Note

The Tibial Tug Test: An Intraoperative Test to Assess Tibial Fixation During Anterior Cruciate Ligament Reconstruction

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Abstract: The anterior cruciate ligament (ACL) is commonly injured, especially in athletes performing twisting and pivoting motions. ACL reconstruction is a standard procedure; however, there is no way to intraoperatively assess one of the causes of failure: the lack of adequate graft fixation on the tibial side. Different fixation devices can be used to ensure fixation, but there is as yet no consensus on which is the most effective. Moreover, there is no reliable way to assess their strength in the intraoperative setting. The tibial tug test is meant to be an important resource to help avoid fixation failure by evaluating the tibial fixation device intraoperatively and giving the surgeon the opportunity to revise the tibial fixation if deemed inadequate. The aim of this article is to describe an empirical and simple test that can demonstrate to the surgeon adequate tibial fixation during ACL reconstruction surgery.

Anterior cruciate ligament (ACL) tears are a common knee injury typically caused during the motions of cutting and pivoting. In the United States, there are around 200,000 ACL injuries per year, with an incidence of between 35 and 69 per 100,000 persons.[1-3]

The result of this type of injury can be devastating, but arthroscopic ACL reconstruction allows patients to regain the stability and strength required for return to sport. There is as yet no single consensus on many variables, such as type of graft, tensioning, and method of fixation, that can affect the outcome of an ACL reconstruction.

In 2010, the Multicenter ACL Revision Study published a list of the most frequent causes of ACL reconstruction failure.[4] The most common cause of failure is the improper placement of the tunnels, which can be found in 70% to 80% of failed ACL reconstructions according to Temponi et al.[5] Anatomic tunnel placement is necessary to avoid rerupture of the graft.

Among the other causes of failure, and closely correlated with the tunnel placement, is improper graft fixation. The Multicenter ACL Revision Study reported that tibial graft fixation, regardless of the method of fixation, has a lower fixation strength compared with femoral fixation.[4] To address the stability of tibial fixation in ACL reconstruction, we describe a simple and reproducible technique to test tibial fixation stability. This intraoperative maneuver, called the tibial tug test, is helpful to evaluate the stability of fixation after tibial fixation of the reconstructed ACL and thereby reduce chances of graft failure. The tibial tug test is an empirical test, useful to assess the stability and determine whether tibial fixation is adequate.

Surgical Technique

Patient Setting

The patient is placed supine on a standard operative table with a padded tourniquet placed proximally on the surgical limb previously marked. A lateral post is positioned at the same height of the tourniquet to

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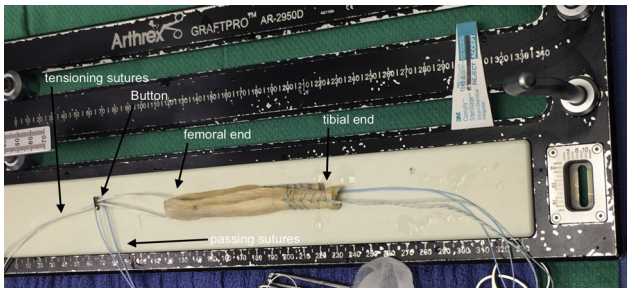

Fig 1. The allograft used for this right knee anterior cruciate ligament reconstruction. The graft is folded in half and loaded with a TightRope on the femoral side. This device has a button that is passed through the femoral tunnel and 2 pairs of sutures: the blue sutures are used to pass and flip the button outside the femoral cortex, and the white ones are used to tension it.

ensure support during the entire procedure, but at the same time the knee can be moved throughout the full range of motion during the reconstruction. The surgical site is then prepped and draped in a sterile fashion.

ACL Inside-Out Techniques

Depending on the age and level of physical activity of the patient, the graft can be either an autograft or allograft. For our autograft reconstruction, we use the gracilis and semitendinous tendons, which are harvested using a closed-ended tendon stripper. This autograft is then sized and placed on a TightRope RT (Arthrex, Naples, FL) graft fixation implant (Fig 1). The diagnostic arthroscopy is performed through the anterolateral portal. An anteromedial portal is added via needle localization in the appropriate trajectory to access the anatomic femoral footprint of the ACL on the posterior lateral femoral notch. After cleaning the ACL stump both at its origin and insertion, a femoral tunnel is drilled according to the size of the graft (Fig 2). An appropriately sized over-the-top guide is introduced from the anteromedial portal and the knee is held close to 110°/120° of flexion to allow a good visualization of the femoral notch during the drilling.

The tibial tunnel is drilled (Fig 3) using the aiming guide set at 55°, with the tip placed at the posterior aspect of the anterior horn of the lateral meniscus as a landmark and an incision made medial and distal to the tibial tubercle. The graft loaded on a TightRope is passed through the tibial and femoral tunnel, with the aid of a passing suture placed in the tunnels (Fig 2), while viewing through the anteromedial portal. The TightRope button flips on the lateral femoral cortex and serves as suspensory femoral fixation (Fig 4). The tensioning sutures of the button are pulled to dunk the graft into the socket leaving 5 mm for residual tensioning after tibial fixation.

Tibial fixation is achieved after dilation of the tibial tunnel and placement of a GraftBolt sheath (Arthrex)

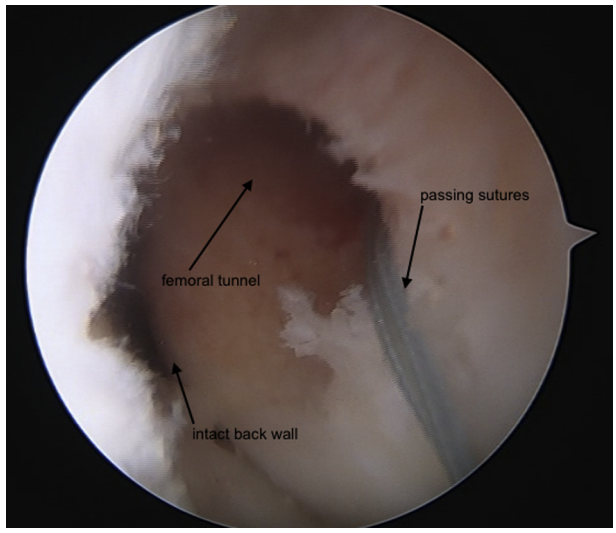

Fig 2. Left knee seen through the anteromedial portal. The drill and an offset guide, used to protect and keep the back wall intact, is introduced from the anteromedial portal. The pin is drilled through both cortexes to measure the femoral length and then a low profile reamer is introduced to make the tunnel of the same size of the graft. The second cortex must not be reamed so that the TightRope button can flip and ensure tension. In the picture there is a passing suture that will be used to shuttle the 4 limbs connected to the TightRope, and the graft itself in the tunnels previously made.

first and then a GraftBolt screw (Arthrex) with the application of a posterior drawer, which ensures knee kinematics closest to those observed in an uninjured knee (Fig 5).

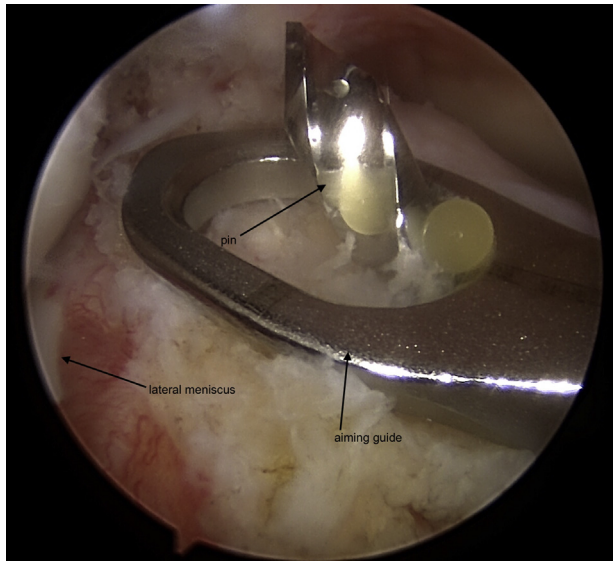

Fig 3. Right knee arthroscopy with the scope in the anterolateral portal. An aiming guide is set at 55° with the tip placed at the posterior aspect of the anterior horn of the lateral meniscus as a landmark and an incision made medial and distal to the tibial tubercle to pass the drill loaded with a pin. A reamer will be used to create an adequate tunnel size to pass the graft.

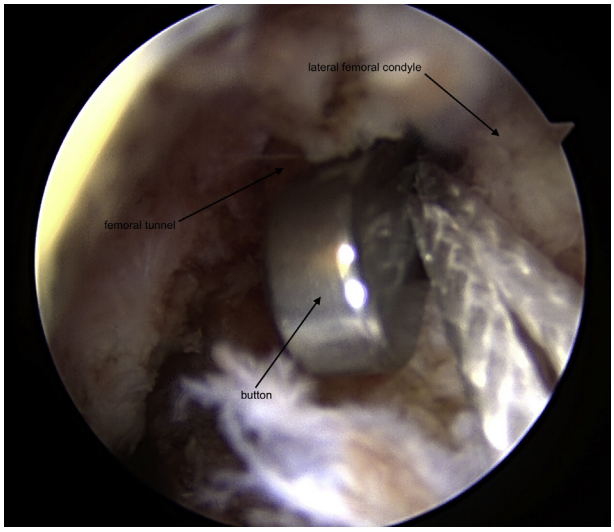

Fig 4. Left knee anterior cruciate ligament reconstruction viewed through the anteromedial portal. The graft loaded with the TightRope is being shuttle through the tunnels previously drilled. The button passes in the femoral socket with the help of a shuttling suture. Once all 4 sutures of the TightRope are pulled out from the skin, the blue sutures are pulled to make the button flip outside the femoral cortex. In the meantime, back tension is applied to the tibial end of the graft to ensure that the button is flush on the cortex.

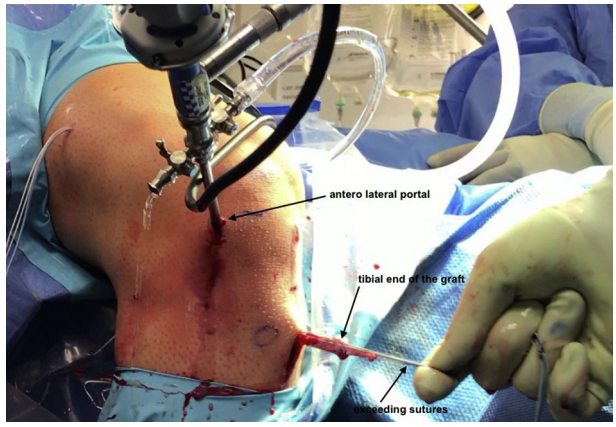

Fig 6. Right knee anterior cruciate ligament reconstruction. The arthroscope is placed in the anterolateral portal to visualize the result of the test. The tibial end of the graft and the exceeding sutures are pulled by hand to assess the tibial fixation at the end of the anterior cruciate ligament reconstruction. The actual result of the test can be verified during intra-articular visualization of the graft and tibial plateau with the arthroscope.

Tibial Tug Test

The recommended time to perform the tibial tug test is both before and after tibial fixation has been achieved with the use of the GraftBolt, as well as before trimming the excess graft from the tibial fixation site. Important anatomic landmarks to observe during the test are the graft itself and the tibial plateau.

The tibial tug test is performed by applying tension or a tug (Fig 6) on the sutures on the tibial end of the graft while viewing the graft intra-articularly (Video 1). If the graft is seen moving while the tibial plateau does not move, the test is considered positive. This result means that the tibial fixation is inadequate because the graft is not well fixed and there is graft movement. This result can predict postoperative instability of the graft, and therefore it is recommended that when the tibial tug test is positive, the tibial fixation should be removed and replaced with stronger fixation. Performing the test before tibial fixation is placed will give an example of a positive test.

A negative test is achieved only with a proper and successful tibial fixation: in this case, both the graft and the tibial plateau will be seen intra-articularly moving as a single unit when tension is applied to the sutures (Fig 7). In this case, the patient is unlikely to experience instability.

Discussion

The tibial graft fixation site has a lower fixation strength compared with the femoral side. Many fixation

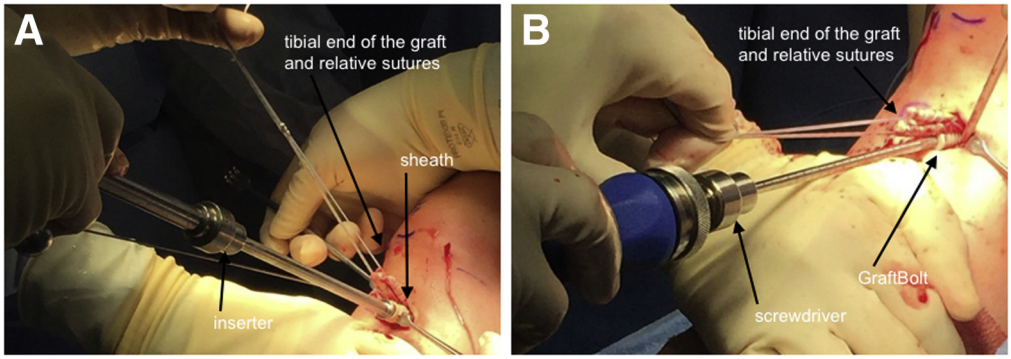

Fig 5. Right knee during anterior cruciate ligament reconstruction. A 9.0-wire pin is introduced in the tibial tunnel as a guide for cannulated dilators and the screwdriver. A posterior drawer is placed on the knee. (A) After dilation, a cannulated sheath is inserted in the tunnel and malleted down. (B) The right size cannulated GraftBolt is inserted and screwed in place to give proper tibial fixation.

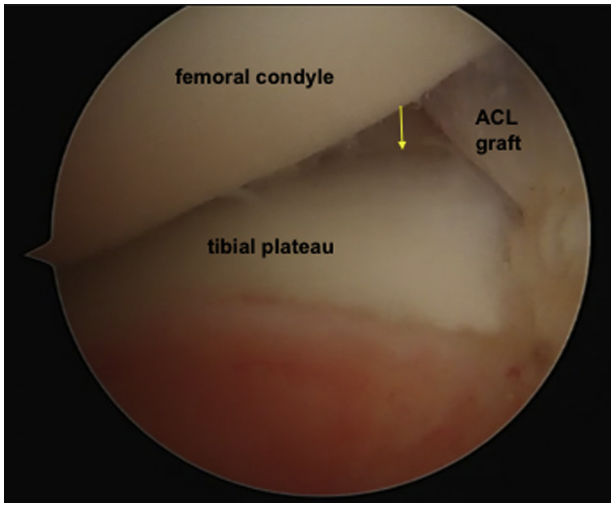

Fig 7. Arthroscopic image of a right knee anterior cruciate ligament (ACL) reconstruction. (Top) The lateral femoral condyle is visualized. (Right side) The ACL graft is already in place. (Bottom) The tibial plateau. The yellow arrow marks the space between the femoral condyle and the tibial plateau. During a negative test, the distance between these 2 anatomic structures increases owing to a simultaneous movement of the ACL graft and the tibial plateau, showing a proper tibial fixation. This finding reassures the surgeon that the patient will be less likely to experience instability.

devices are available for use and differ significantly one from another, all with consistent strength to sustain everyday activities during in vitro biomechanical studies. In vivo studies are more complex because of the biological processes involved, and it has been shown that the tibial side is the weakest link in the early postoperative phase[2,6,7] and therefore a possible reason for fixation failure. Distal fixation is considered more problematic than femoral fixation owing to the bone quality of the tibial metaphysis and also the effect of forces acting along the ACL graft and tibia.[6]

The fundamental purpose of an intraoperative test is the possibility to adjust or replace the device intraoperatively if the graft fixation is inadequate to avoid possible failure. Historically, tunnel widening was considered a possible reason for failure of the tibial end of the graft until it was disproven in recent studies.[7-9]

Table 1. Advantages and Disadvantages and Limitations of the Tibial Tug Test

Advantages	Disadvantages and Limitations
Technically straightforward	Small increase in surgical time
Simple and reproducible	Empirical test, no objective way to measure
Confirms intraoperative fixation	Not possible to perform the test if the free ends of the tibial sutures are trimmed too early
Can be used with any tibial fixation device	

Table 2. Pearls and Pitfalls of the Tibial Tug Test

Pearls	Pitfalls
Arthroscope to the anteromedial or anterolateral portal for direct visualization of the graft, femoral condyle, and tibial plateau.	This test does not guarantee adequate graft tension.
Tension is applied by hand to the sutures on the tibial end of the graft from outside the tibial tunnel.	Visualization of the graft only during the test does not ensure proper fixation.
Perform the test before and after the tibial fixation to note the difference in fixation.	

Measurements of the tibial tunnel widening on follow-up magnetic resonance imaging compared with grades of ACL laxity did not show statistical significance.[7-9] Disproof of the possibility of tibial tunnel widening led to the conclusion that nonoptimal tibial device placement was the cause in the majority of cases of failure of tibial fixation.

Other advantages of the tibial tug test are the possibility to perform it with any tibial fixation device, without a need for modifications. Both resorbable interference screws and adjustable suspensory fixation system present with a distal end to pull, allowing the surgeon to perform the test.[10] Additional advantages include its technical straightforwardness and simplicity to learn and perform to evaluate fixation on the distal part of the graft (Table 1), which is crucial for the success of an ACL reconstruction.

The best way to discern the difference between a positive and negative result of this test is to perform it before and after placement of the fixation device. Before placement of the tibial fixation device the result will be positive, meaning that only the graft moves, indicating a lack of fixation. After proper fixation, performing the test under direct visualization should show movement of both the graft and the tibial plateau as single unit (Table 2). We consider this to signify a negative test, indicating appropriate fixation of the tibial end of the graft.

The main limitation is that our technique is empirical, without any objective measurement. However, it is also a fast and simple way to demonstrate that the device has achieved adequate fixation of the tibial end of the ACL reconstruction.

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