5 Points on
Transtibial Anterior Cruciate Ligament Reconstruction

Adam B. Yanke, MD, Nathan A. Mall, MD, Seth L. Sherman, MD, and Bernard R. Bach Jr, MD

Surgeons perform an estimated 150,000 anterior cruciate ligament reconstructions (ACLRs) each year in the United States.[1] Most surgeons who perform ACLRs do so infrequently; American Board of Orthopaedic Surgery data suggest that about 90% of ACL surgical procedures are performed by surgeons who do fewer than 10 ACLRs annually.[2] Multiple studies have listed technical aspects as the most common reason for ACLR failure.[3-6] For this reason, it is important that surgeons focus on the technical aspects of the procedure to improve outcomes.

Seventy-six percent of ACLRs are performed using a 1-incision arthroscopy-assisted transtibial technique.[7] However, technical difficulties associated with anatomic placement of the femoral tunnel during transtibial drilling has prompted use of accessory portal and 2-incision drilling techniques. Although most ACLRs use bone–patellar tendon autografts, some surgeons prefer soft-tissue hamstring autografts. Allograft tissues, the majority of which are bone–patellar tendon–bone grafts, are also becoming more popular in revision settings, and in older athletes, who participate in fewer cutting and pivoting sports.

The goals of ACLR are to normalize the Lachman test and pivot-shift deficiencies, restore motion, provide chondral protection, improve function, and return patients to an active lifestyle. The ACL consists of anteromedial and posterolateral bundles, which contribute to sagittal translation and rotation, respectively. Regardless of the technique or graft used for ACLR, recreating the native footprint is crucial to optimizing biomechanics. The most common reason for clinical failure of the transtibial ACLR technique is vertical placement of the femoral tunnel. Such placement essentially creates an isolated reconstruction of the anteromedial bundle, which may normalize the Lachman test but does not control rotation.[6] In the correctly performed transtibial technique, both bundles are reconstructed.

Bernard R. Bach Jr, MD (BRB) has had excellent clinical results using a transtibial technique, as evidenced by elimination of Lachman tests and pivot-shift deficiencies on follow-up examinations.[8] In this article, we focus on pearls and tips that may improve the success of this widely used and effective technique.

Dr. Yanke is Resident, Department of Orthopedic Surgery; Dr. Mall and Dr. Sherman are Sports Medicine Fellows, and Dr. Bach is Professor, Department of Orthopedic Surgery, and Director, Division of Sports Medicine, Rush University Medical Center, Chicago, Illinois.

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Address correspondence to: Bernard R. Bach Jr, MD, Department of Orthopedic Surgery, Rush University Medical Center, 1611 W Harrison St, Suite 300, Chicago, IL 60612 (tel, 312-432-2353; fax, 312-942-1517; e-mail, brbachmd@comcast.net).

1 Graft Harvest and Preparation

Obtaining a graft that facilitates ACLR is crucial. Graft harvest is performed with the patient in a seated position with the knee flexed at 80° to maintain tension on the patellar tendon. A 9-cm incision is made longitudinally, paralleling the medial edge of the patellar tendon. Dissection is carried through subcutaneous tissues, which are mobilized with a finger sweep. The peritenon is then incised the length of the initial incision, and the medial and lateral edges of the tendon are defined.

Subsequently, the width of the tendon is measured, and, with proper placement of 2 Senn retractors and an Army-Navy retractor, the extensor mechanism is directly visualized for optimal graft harvest. The distal pole of the patella and the tibial tubercle are marked with a sterile pen for orientation, and a scalpel is used to outline the graft starting on the patella and extending distally to the tibial tubercle. This is repeated on the remaining side of the graft, and a No. 238 oscillating saw blade is used to make the bone cuts. BRB prefers to make these cuts initially on the tibial tubercle, creating a triangular profile graft on cross-section. The bone plug is generally about 25 mm long. On the patellar side, a graft of similar length is harvested, but the cross-sectional shape of the graft is rhomboid. For visualization of the tissues, the right side of the graft is cut with the saw blade in the right hand, and the left side of the graft is cut with the saw blade in the left hand.

To reduce the chance of an accidental drop of the graft

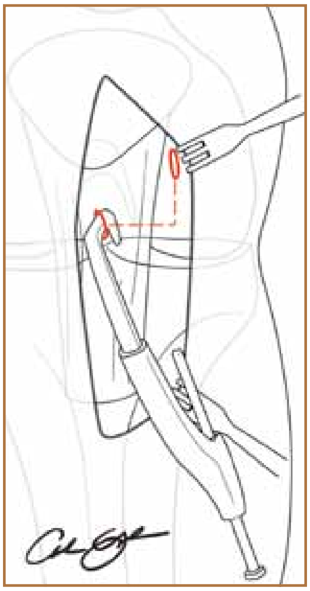

Figure 1. Advantage of midtendon accessory portal. Moving entry point more central and closer to joint line improves obliquity of tibial aimer.

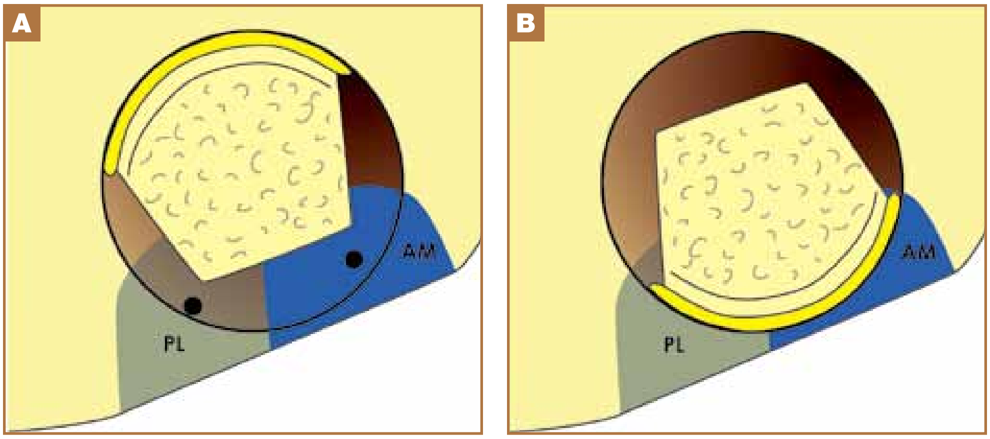

Figure 2. As demonstrated by Rue and colleagues,[9] (A) femoral tunnel covers only 50% of femoral footprint when using transtibial technique. However, (B) when the graft is placed with soft-tissue component posterior, the tendon lies almost completely within footprint.

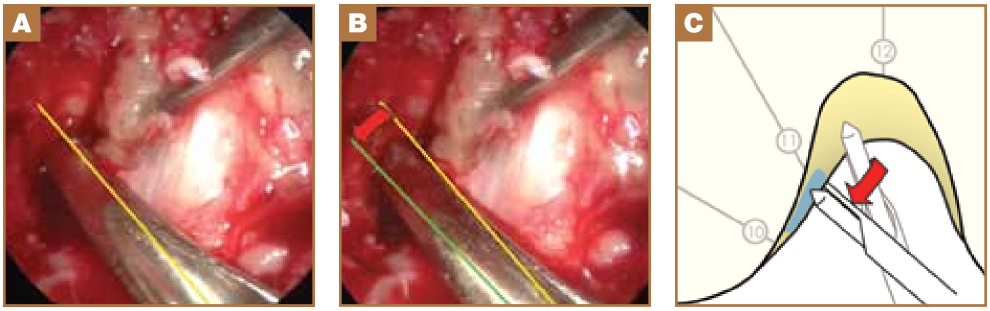

Figure 3. With femoral aimer in place (A), external rotation of guide allows for more anatomical placement of guide pin (B) and for access lower on "clock face" so femoral footprint can be overlapped (C).

during transport to the back table for preparation, the surgeon must personally carry it there. On the table, the graft is trimmed to fit a 10-mm sizing tube. Two small drill holes are placed in 1 of the bone plugs, followed by 2 No. 5 Ti.Cron sutures (Covidien, Mansfield, Massachusetts). The drill holes can be placed on the tibial or femoral side or on both sides, depending on whether a pull-through or push-in technique is planned. At this point, it is important to note the entire length of the construct, particularly the soft-tissue length, as this can affect the angle which the tibial tunnel is drilled.

2 Tibial Tunnel Creation

When a transtibial technique is used for ACLR, oblique orientation of the tibial tunnel is crucial. The distal tibial entry site is near the intersection of the superficial medial collateral ligament and the pes anserinus tendons. Tibial tunnel obliquity is optimized using an accessory transpatellar portal, allowing more central placement of the tibial aimer tip intra-articularly. This is done in contrast to using a normal inferomedial portal. This critical aspect of the procedure allows more rotational flexibility of the aiming device for a more oblique tunnel (**Figure 1**). More distal placement of the tunnel creates a longer tibial tunnel with less chance of encountering mismatch.

The intra-articular pin is aimed to enter within the intercondylar eminence region, paralleling the posterior edge of the anterior horn of the lateral meniscus in the coronal plane. As the pin emerges intra-articularly, the knee can be extended to ensure the pin is posterior to the intercondylar roof and does not impinge in extension.

Once the surgeon confirms the appropriate positioning, the pin is tapped into the lateral femoral wall for stabilization while it is overreamed with an 11-mm cannulated reamer. The tibial tunnel is oversized by 1 mm to facilitate ease of graft passage. The intra-articular aperture of the tibial tunnel creates an ellipse because of the angle of approach. Therefore, the more horizontal the tibial tunnel becomes, the more ellipsoid the intra-articular aperture becomes. Generally, the graft soft-tissue length (N)+7 or N+10 calculations for the angle of the tibial aimer are no longer used. A 55° angle is used in most cases, provided the soft-tissue length of the graft is 45 mm or less. Even when the patellar tendon is shorter (eg, 40 mm), a 55° angle is used.

If the graft recedes within the tibial tunnel, a longer tibial interference screw can be used for fixation. If the soft-tissue construct approaches 50 mm, the drill angle is typically set to 60°. If the construct is longer than 50 mm, the technique can be converted to a 2-incision technique to reduce the likelihood of significant construct mismatch. As

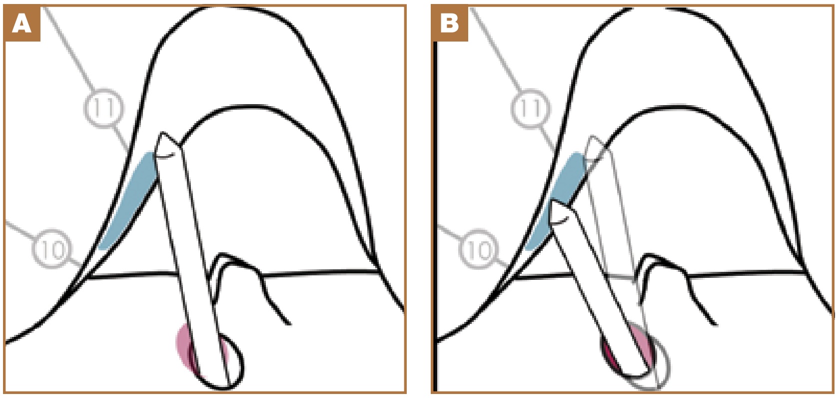

Figure 4. (A) Femoral tunnel guide pin may not reach low enough on femoral intercondylar wall for appropriate graft placement. Therefore, with wire in lowest position possible, tibial tunnel is again reamed, yielding the red area. (B) Guide pin can then be reinserted, and the surgeon can achieve lower position on intercondylar femoral wall (blue area, anterior cruciate ligament femoral footprint; red area, additional bone removed by 2-stage technique).

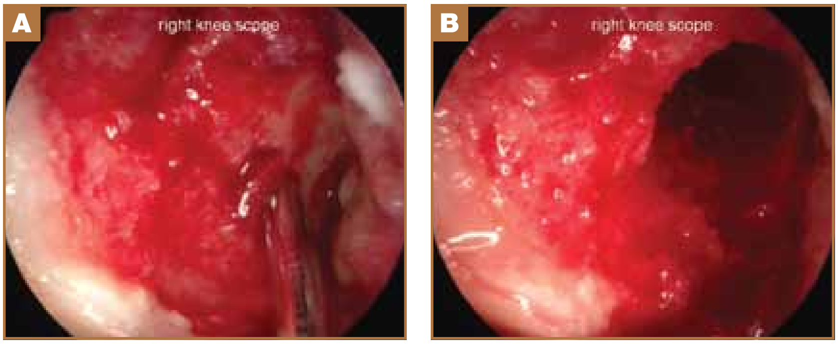

Figure 5. Femoral pin (A) and subsequent tunnel (B) viewed from anteromedial portal during anterior cruciate ligament reconstruction. (We prefer viewing from anterolateral portal.)

the tibial tunnel is created, the bone reamings are collected for grafting of the distal patella and tibial tubercle defects.

3 Femoral Tunnel Creation

The goal of femoral tunnel creation is to reconstruct a portion of the posterolateral and anteromedial bundles of the ACL. Cadaveric anatomy studies[9] performed at our institution showed that about 50% of both bundles were reconstructed using the technique being outlined here. Placement of the cortical portion of the graft posteriorly is necessary to orient the soft tissue portion of the graft at the site of the footprint (**Figures 2A, 2B**).

Clinically, our studies have shown that this technique reliably eliminates the Lachman test and pivot-shift deficincies.[8] With a 7-mm offset aimer passed retrograde through the transtibial tunnel, the femoral tunnel starting point can be determined. The guide is hooked in the over-the-top position and is rotated externally along the femoral wall to about the 10 o'clock position (right knee) or 2 o'clock position (left knee) (**Figures 3A-C**). With a pin aligned over the knee, the clockface position of this tunnel essentially can be estimated.

The $^3/_{32}$-inch Steinmann pin is drilled to a depth of about 1.5 inches using the femoral offset aimer and is then overreamed to about two-thirds of the reamer head depth using a 10-mm cannulated acorn reamer. This is surgically noted when the reamer gives through the cortex, correlating with a change in pitch. The reamer is then backed off to make sure the posterior cortical rim of the femur is maintained. Reaming is completed to a depth of 30 to 35 mm.

One advantage of using the transtibial technique is that the femoral tunnel will be longer than the tunnel obtained with an accessory portal and hyperflexion as described by O'Donnell and Scerpella.[10] Although the hyperflexion modification can reliably place the femoral tunnel in the anatomical position along the lateral wall, doing so can be more difficult, as the knee must be flexed about 120°. Difficulties in positioning and visualization may lead to complications, including a relatively shorter femoral tunnel contributing to graft-tunnel mismatch or posterior blowout. Alternatively, curved reaming systems for femoral tunnel creation are being introduced.

4 Two-Stage Femoral Drilling Technique

If the femoral guide pin ends up slightly higher than desired along the intercondylar wall, the technique can be converted to a 2-stage technique to avoid vertical graft placement. To achieve this, the guide wire is placed through the tibial tunnel as low as possible on the femoral wall with the femoral aimer. The guide is removed, and the reamer is passed through the intra-articular aperture of the tibial tunnel. As the guide pin is not collinear with the tibial tunnel, the posterior portion of the tibial tunnel is preferentially reamed (**Figure 4A**). At this point, reamer, pin, and offset aimer are removed and repositioned, which should allow access even farther down the femoral intercondylar wall (**Figure 4B**). We use this method about 10% to 15% of the time and have found it extremely reliable. Once the pin is properly positioned, it is then overreamed (**Figures 5A, 5B**), as detailed earlier.

5 Graft Placement and Fixation

Most surgeons rely on a pull-through technique by which a beath needle is drilled through the anterolateral femoral cortex. Sutures placed through the bone plug are used to pull the graft into the femoral socket. Over the past 20 years, BRB has used a push-in technique whereby an instrument is used to push the femoral bone plug intra-articularly. The plug is then grasped with a curved hemostat and guided into the femoral socket. The graft initially is left prominent, which allows placement of a nickel-titanium wire (Nitinol; Nitinol Devices & Components Inc, Fremont, California) between the bone plug and the socket. The prominent edge of the bone plug acts as a skid during increased flexion to about 100°, and the pin can be advanced to the base of the tunnel to optimize parallel placement of the femoral interference screw. The pushing device is then used to place the bone plug flush with the intercondylar notch to assess for potential construct mismatch in extension. Graft mismatch of up to 5 mm may require graft recession, while mismatch in excess of 5 mm may require a modified free bone-block technique.[11] However, graft mismatch occurs in only 10% of surgeries performed with the technique outlined in this article.

Once the graft is placed flush with the osseous margin, it is secured in hyperflexion (100°-110°) with a 7×25-mm metallic interference screw. Twisting the screw through the soft tissues may result in loss of the hyperflexed pin position; therefore, we prefer advancing the screw without twisting. After the screw is advanced to the bone–tendon interface, the knee is hyperflexed, and the screw is inserted under direct arthroscopic visualization. If the graft begins to wrap or twist around the screw, the graft or wire can be repositioned to minimize the chance of graft laceration.

After screw fixation, the "rock test" is performed by placing repeated manual tension on the sutures of the tibial bone plug to make sure the graft is rigidly fixed within the femur. Gross isometry is assessed with the sutures wrapped around the hand and the thumb at the aperture of the tibial tunnel. With the knee extended from 90° of flexion to complete extension, recession of about 2 mm should be noted relative to the distal tibial aperture during the terminal 20° of extension. After multiple cycles of the graft to eliminate any creep, the knee is brought into complete extension, and the tibial bone plug is externally rotated 180°, aligning the cortex anterior in the coronal plane. An interference screw of appropriate length is placed on the cortical surface of the tibial bone plug, with maximum manual tension on the tibial bone-plug sutures and the knee in hyperextension with the foot placed against the surgeon's chest to provide an axial load. As the femoral origin of the ACL lies posterior to the femoral center of rotation, the ligament is most tense at full extension and physiologically lax at 10° to 40° of flexion. Therefore, tensioning at midflexion could overconstrain the knee in extension, whereas tensioning while extended can lead to midflexion laxity. We prefer extension, as tensioning in flexion can lead to flexion contracture, supraphysiologic tension in extension, and increased tibiofemoral contact pressures. A 9×20-mm metallic interference screw is used in the absence of graft recession. In this setting, a longer screw can allow for adequate fixation while still providing access at the distal tibial aperture.

Conclusion

These fundamentals of transtibial ACLR have been in use for more than 20 years, and results are very reliable. BRB and colleagues have reported a personal revision rate of 1.5% after more than 2000 ACLRs performed over 25 years.[12] This rate matches the 1.5% rate in our Division of Sports Medicine (4 fellowship-trained sports knee surgeons) and parallels the rate reported at the 2010 annual meeting of the American Academy of Orthopaedic Surgeons.[13]

A transtibial technique can be reliably used along the lateral wall of the intercondylar notch to essentially perform hybrid reconstruction of the posterolateral and anteromedial bundles of the ACL. This technique reliably eliminates the Lachman test and pivot-shift deficiencies.

References

1. Gottlob CA, Baker CL Jr, Pellissier JM, Colvin L. Cost effectiveness of anterior cruciate ligament reconstruction in young adults. *Clin Orthop*. 1999;(367):272-282.
2. Fox JA, Pierce M, Bojchuk J, Hayden J, Bush-Joseph CA, Bach BR Jr. Revision anterior cruciate ligament reconstruction with nonirradiated fresh-frozen patellar tendon allograft. *Arthroscopy*. 2004;20(8):787-794.
3. Marchant BG, Noyes FR, Barber-Westin SD, Fleckenstein C. Prevalence of nonanatomical graft placement in a series of failed anterior cruciate ligament reconstructions. *Am J Sports Med*. 2010;38(10):1987-1996.
4. Trojani C, Sbihi A, Djian P, et al. Causes for failure of ACL reconstruction and influence of meniscectomies after revision. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(2):196-201.
5. Battaglia MJ 2nd, Cordasco FA, Hannafin JA, et al. Results of revision anterior cruciate ligament surgery. *Am J Sports Med*. 2007;35(12):2057-2066.
6. Markolf KL, Hame S, Hunter DM, et al. Effects of femoral tunnel placement on knee laxity and forces in an anterior cruciate ligament graft. *J Orthop Res*. 2002;20(5):1016-1024.
7. Duquin TR, Wind WM, Fineberg MS, Smolinski RJ, Buyea CM. Current trends in anterior cruciate ligament reconstruction. *J Knee Surg*. 2009;22(1):7-12.
8. Bach BR Jr, Aadalen KJ, Dennis MG, et al. Primary anterior cruciate ligament reconstruction using fresh-frozen, nonirradiated patellar tendon allograft: minimum 2-year follow-up. *Am J Sports Med*. 2005;33(2):284-292.
9. Rue JP, Ghodadra N, Bach BR Jr. Femoral tunnel placement in single-bundle anterior cruciate ligament reconstruction: a cadaveric study relating transtibial lateralized femoral tunnel position to the anteromedial and posterolateral bundle femoral origins of the anterior cruciate ligament. *Am J Sports Med*. 2008;36(1):73-79.
10. O'Donnell JB, Scerpella TA. Endoscopic anterior cruciate ligament reconstruction: modified technique and radiographic review. *Arthroscopy*. 1995;11(5):577-584.
11. Verma NN, Dennis MG, Carreira DS, Bojchuk J, Hayden JK, Bach BR Jr. Preliminary clinical results of two techniques for addressing graft tunnel mismatch in endoscopic anterior cruciate ligament reconstruction. *J Knee Surg*. 2005;18(3):183-191.
12. Frank RM, McGill KC, Cole BJ, et al. An institution-specific analysis of ACL reconstruction failure. *J Knee Surg*. 2012;25(2):143-149.
13. Cain E, Ponce B, Boohaker H, et al. Evaluation of 54 failed primary ACL reconstructions and ensuing revisions from a single institution. Paper presented at: Annual Meeting of the American Academy of Orthopaedic Surgeons; March 2010; New Orleans, LA.

This paper will be judged for the Resident Writer's Award.