Technical Note

Hybrid Anterior Cruciate Ligament Reconstruction: Introduction of a New Technique for Anatomic Anterior Cruciate Ligament Reconstruction

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Abstract: Recently, anatomic or double-bundle reconstruction of the anterior cruciate ligament (ACL) has been presented in an effort to more accurately restore the native anatomy. These techniques create 2 tunnels in both the femur and tibia to reproduce the bundles of the ACL. However, the increased number of tunnels, particularly on the femoral side, has raised some concerns among authors and surgeons. We describe a technique to reconstruct the 2 distinct bundles of the ACL by using a single femoral tunnel and 2 tibial tunnels, the “hybrid” ACL reconstruction. The femoral tunnel is drilled through an anteromedial arthroscopy portal, which allows placement in a more anatomic position. Fixation in the femur is achieved with a novel device that separates a soft-tissue graft into 2 independently functioning bundles. Once fixed in the femur, the anteromedial and posterolateral bundles of the graft are passed through respective tunnels at the anatomic footprint on the tibia. These bundles are independently tensioned, which creates a reconstruction that is similar to the native ACL. The technique presented provides surgeons with an alternative to other double-bundle techniques involving 4 tunnels. Key Words: Anterior cruciate ligament—Double-bundle anterior cruciate ligament—Anatomic anterior cruciate ligament—Hybrid anterior cruciate ligament.

Currently, the most commonly performed anterior cruciate ligament (ACL) reconstruction uses a transtibial technique in which the ligament is reconstructed with a tendon graft passed through single tunnels in both the tibia and femur. Recently, some authors have challenged the degree to which current ACL reconstruction techniques recreate the anatomy and function of the native ligament.1,2 Anatomic studies have shown that the ACL consists of 2 distinct anatomic fiber bundles: the anteromedial (AM) and posterolateral (PL) bundles.3,4 Current techniques may only reconstruct the AM bundle of the ligament, and although it has been shown that single-bundle reconstruction restores anteroposterior stability to the knee, this technique can leave the knee unstable when subjected to rotatory loads.1,5

Anatomic or double-bundle reconstruction of the ACL has been presented as a means to more accurately restore the native anatomy of the ligament.1,2 These techniques create 2 tunnels in both the femur and tibia to reproduce the AM and PL bundles of the ACL. It has been suggested that the benefits of 2 bundle ACL reconstruction can be achieved with sin-
gle tunnels in the tibia and femur. We introduce a technique that uses the optimal aspects of single- and double-bundle techniques, the “hybrid” ACL reconstruction. This technique allows a soft-tissue graft of choice to be fixed in a single femoral tunnel, leaving 2 distal limbs that are available for anatomic reconstruction through 2 tibial tunnels placed at the tibial footprint of the ACL. The surgeon is able to separately tension the reconstructed bundles, which allows for a construct that is biomechanically similar to the native ACL.

**SURGICAL TECHNIQUE**

**Positioning and Arthroscopy**

The patient is positioned supine on the operating table. Diagnostic arthroscopy is performed and excess fat and synovium debrided from the notch. This is particularly important adjacent to the anteromedial arthroscopy portal because the graft will be passed into the femur through this portal.

**Graft Preparation**

This technique uses a folded soft-tissue graft to reconstruct the ACL. We prefer to use autograft or allograft hamstrings tendons, but an allograft tibialis anterior tendon can be used as well. The semitendinosus and gracilis tendons are harvested and prepared on the back table. A sturdy nonabsorbable suture is whip stitched on each of the 4 limbs. All 4 limbs of the graft are separately whip stitched, with 2 limbs used for the AM bundle and 2 limbs for the PL bundle. The graft is sized and placed through the femoral fixation device and then tensioned and conditioned.

**Femoral Tunnel**

The knee is then hyperflexed to at least 120°. The femoral tunnel is drilled by placing the over the top guide into the notch through the anteromedial portal. Using this portal for drilling the femoral tunnel, combined with knee flexion to 120°, allows for placement of the tunnel in a more inferior position in the notch than is traditionally preferred with a single-bundle transtibial technique. For a right knee, the guidewire is drilled at the 10 o’clock position, whereas for a left knee, the 2 o’clock position is preferred. This femoral tunnel position is within the anatomic footprint of the femoral insertion. When the guidewire is in a satisfactory position, the femoral tunnel is drilled.

**Tibial Tunnel**

Once the femoral tunnel is prepared, attention is directed to the tibial tunnels. Two convergent tibial tunnels are drilled in the ACL footprint at the position of the anteromedial and posterolateral bundle insertions. The tunnel for the PL bundle is started on the anteromedial tibial surface, at least 2 cm distal to the joint line, just at the leading edge of the medial collateral ligament. The tunnel for the AM bundle is started at the same level, just medial to the tibial tubercle (Fig 1). These guidewires are usually 2.5 cm apart. The guide pins are placed by using a standard tibial guide, and placement of the pins intra-articularly is confirmed arthroscopically. The more anterior guide pin is positioned approximately 8 mm anterior to the posterior cruciate ligament in the center of the ACL footprint. The anterior horn of the lateral meniscus is a reliable intra-articular landmark for correct positioning of this tunnel. The second Steinman pin exits 10 mm posterolateral to the first pin, approximately 2 to 3 mm from the posterior horn of the lateral meniscus. With a 7-mm drill, the 2 convergent tunnels are created obtaining an approximately 2-mm osseous bridge between the 2 tunnels intra-articularly and a 2.5 cm on the tibial cortex (Fig 2).

**Graft Passage and Fixation**

One suture loop is placed in a retrograde fashion through each of the tibial tunnels, retrieved intra-articularly, and brought through the anteromedial portal. Once all tunnels are drilled, and the retrieval loops are passed through the femoral tunnel, the graft is placed within the femoral fixation device and then tensioned and conditioned.
passed, the graft is introduced. The technique involves the use of a novel femoral fixation device, the Stratis ST (Scandius Biomedical, Littleton, MA). This device separates the graft into 2 independently functioning bundles, with proper anatomic orientation on the femoral footprint. It also allows a combination of interference fixation with cross pinning, allowing aperture graft fixation with the rigidity of cross pin fixation (Fig 3).

The femoral fixation device, with the attached graft, is passed into the blind-end femoral tunnel through the anteromedial arthroscopy portal. Once the graft is passed, it is secured in the femoral tunnel with a transverse locking pin. When the femoral fixation is complete, the graft bundles exit the medial portal. The posterior 2 limbs of the graft now serve as the PL bundle, whereas the anterior 2 limbs of the graft now function as the AM bundle. By using the suture loop, the PL bundle is brought through the posterior tibial tunnel, and the AM bundle is brought into the anterior tibial tunnel (Fig 4). Passing the posterior limbs of the graft first allows full visualization of graft passage.

Once the bundles of the graft have been passed into the appropriate tunnels, the knee is cycled. The design of the Stratis device allows for each bundle to act independently, and each bundle is tensioned separately. This involves tensioning anteromedial bundle at 60° of knee flexion and the posterolateral bundle at 10° of flexion while applying a posterior force on the tibia. Twenty pounds of tension is applied to each limb of the graft before fixation in the tibia. Fixation of the graft bundles in the tibia is achieved by using bioabsorbable interference screws. The result is an ACL reconstruction using 2 bundles that recreates the femoral and tibial insertions of the ligament (Fig 5).

**DISCUSSION**

Double-bundle or anatomic ACL reconstruction has been proposed to more accurately reconstruct the native ligament. Described techniques involve passing 2 hamstring grafts through 2 distinct pairs of bone tunnels, with 2 tunnels in both the lateral femoral condyle and the tibial plateau. This technique has been proven in vitro to restore both anteroposterior and rotatory stability to the knee. However, this technique does raise some questions. The creation of 2 bone tunnels within the lateral femoral condyle may compromise vascularity as well as structural integrity of this region of the distal femur. There is a theoretical risk of devascularizing the lateral femoral condyle with a
2-tunnel technique. Furthermore, fracture of the lateral femoral condyle has been reported after single-tunnel techniques.\textsuperscript{9} The risk of this complication would seem to increase with a double-tunnel technique. Increased tunnel expansion using hamstring graft with endobutton fixation has also been described.\textsuperscript{10} Tunnel expansion of 2 femoral tunnels containing hamstring graft with endobutton fixation could lead to tunnel coalescence and graft failure. Finally, having 2 tunnels in the relatively small area of the lateral femoral condyle leaves few options should revision surgery be necessary.

We describe an alternative technique for reconstructing the anatomic bundles of the ACL by using a hybrid tunnel design. A single 10-mm femoral tunnel is created through the anteromedial arthroscopy portal, facilitating placement of the tunnel in a position that is closer to the insertion of the PL bundle on the femur. This graft position has been shown to more effectively resist rotatory loads as well as anteroposterior loads in full extension.\textsuperscript{6} By using the femoral fixation device as described, the AM bundle and PL bundle are brought through separate tunnels on the tibia and tensioned independently. This technique recreates the native ACL anatomy and bundle tension.

The technique presented may provide surgeons who wish to perform double-bundle ACL reconstruction with an alternative to other previously described techniques. Further clinical follow-up and studies of this technique, as well as others, will provide insight into the continued improvement of ACL reconstructive procedures. The benefits and complications of such new procedures need to be defined before they attain more widespread acceptance among surgeons.

\textbf{REFERENCES}


