Re-Tensioning Technique to Cover the Graft With Remnant in Anterior Cruciate Ligament Reconstruction

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Abstract: A number of remnant-preserving techniques to restore proprioceptive function in anterior cruciate ligament reconstruction have been described. However, they might not cover the significant amount of the graft with the synovium of the remnant in many cases. We introduce a simple technique that can cover nearly the entire graft with the synovium by re-tensioning the remnant, which might enhance synovialization of the graft and restoration of proprioception.

The anterior cruciate ligament (ACL) is one of the primary stabilizers of the knee and the main restraint against anterior tibial translation. ACL reconstruction is one of the most widely performed orthopaedic surgical procedures around the world. The goal of ACL reconstruction has focused on the restoration of anteroposterior stability and rotational stability so far. Many surgical techniques have been introduced to completely restore the mechanically stabilizing function of the ACL before injury. However, interest in proprioception related to the mechanoreceptors of the ACL has been growing recently. Aside from the position of the femoral and tibial tunnels, types of grafts, and rehabilitation programs, restoration of proprioceptive function is important for the graft in ACL reconstruction to function. On the basis of the fact that most mechanoreceptors exist in the subsynovial layer near the tibial attachment, many authors have introduced surgical techniques to save the remnant of the ruptured ACL. However, most of these techniques are about preserving remnant, not covering the graft more with remnant.

We introduce a remnant-preserving and re-tensioning technique to easily cover most of the graft.

Surgical Technique

Stability was examined with the patient under anesthesia using the Lachman test and pivot-shift test. The diagnosis of ACL rupture was confirmed by arthroscopic examination. Only 2 portals, anteromedial and anterolateral, were used for the entire procedure (Video 1). The meniscal injury and articular cartilage lesion were evaluated, and if necessary, meniscectomy or meniscal repair and treatment for a cartilage lesion (chondroplasty or microfracture) were performed.

By use of a 45° or crescent suture hook (Linvatec, Largo, FL) with No. 1 polydioxanone (PDS; Ethicon, Somerville, NJ), 2 suture strings were placed through the proximal part of the remnant (Fig 1). The sutures of No. 1 PDS were retrieved out of the anteromedial portal. With medial traction of the remnant using sutures, the posterolateral portion of the tibial attachment of the ACL was partially released with Metzenbaum scissors to obtain a better view of the tibial footprint for tibial tunneling (Table 1). Remaining tissue attached to the lateral wall of the intercondylar notch was debrided to view the femoral footprint better for femoral tunneling.

The diameters of the femoral and tibial tunnels were 9 mm. The tibial tunnel was made on the tibial footprint at an angle of 45° to the tibial shaft. The remnant and covering synovium were retracted anteromedially.
using sutures during reaming to avoid being damaged. An offset guide was not used for femoral tunneling. With knee flexion of 120° or more, a guide pin was placed on the center of the femoral footprint or just proximal to the lateral bifurcate ridge adjacent to the posterior articular margin. The length of the femoral socket, in which the graft would be seated later, was set at 20 to 30 mm. The rest of the femur was reamed with a 4.5-mm reamer.

Fresh-frozen Achilles tendon allograft was thawed at room temperature. A calcaneal bone block was removed with the attached tendon preserved. It was usually separated by manual tension without difficulty. The free tendon was folded into a 2-strand graft and was trimmed to a thickness of 9 mm. The length of the 2-strand graft was 9.5 to 10.0 cm. The graft was looped over the EndoButton CL (Smith & Nephew, Andover, MA) of an appropriate length, and 20 mm of the looped end of the graft was whipstitched with No. 1 Vicryl (Ethicon). Three centimeters of each of the 2 free ends was whipstitched with No. 2 FiberWire (Arthrex, Naples, FL), and each of 2 strings on each free end of the graft was retained for post-tie fixation. The looped end was marked at the position at which it was to be seated in the femoral socket to ensure that the graft became completely seated in the femoral socket by arthroscopy.

No. 1 Vicryl, which would be the guiding suture, was inserted into the femoral tunnel through the anteromedial portal out of the lateral thigh using an eyelet guide pin. Holding the femoral end of the guiding suture with a hemostat, the surgeon (J.H.N.) retrieved the anterior end of the guiding suture with 4 strings tethered to the remnant out of the anterior aperture through the tibial tunnel using an arthroscopic suture retriever. The looped end of the graft with EndoButton CL was inserted into the femoral tunnel by use of a guiding suture of No. 1 Vicryl through the tibial tunnel. Just before the loop of EndoButton CL entered the tibial tunnel, all 4 tethering strings of No. 1 PDS were looped over the EndoButton CL anteroposteriorly. Care should be taken so that the ends of the 4 strings of No. 1 PDS do not become entangled with the graft into the tibial tunnel during insertion of the graft (Fig 2). After the

![Fig 1. Arthroscopic view of ACL-injured right knee through anterolateral portal. The suture hook pierces the ACL remnant to pass No. 1 PDS suture through the anteromedial portal.](image1)

**Table 1. Surgical Pearls and Key Points**

- Release of the synovium covering the ACL remnant from the PCL and lateral wall of the intercondylar notch using Metzenbaum scissors is helpful to retract the remnant tissue using sutures.
- After femoral tunneling with a 9-mm reamer, care must be taken not to injure the medial femoral condyle during removal of the reamer. After removal of the 9-mm reamer, a shaver is inserted along the eyelet passing pin through the anteromedial portal to remove debris to obtain a clear view.
- The passing suture of No. 1 Vicryl, with which the eyelet passing pin is replaced, should be as long as possible to facilitate retrieval of the 4 strings of No. 1 PDS out of the tibial tunnel with it later.
- Before looping over the EndoButton loop of the 4 strings of No. 1 PDS, making the lengths of the 4 strings equal is helpful for re-tensioning the remnant later.
- Tying the 4 strings of No. 1 PDS together after re-tensioning of the remnant may not be necessary because the strings are tight in the femoral and tibial tunnels.

PCL, posterior cruciate ligament.

![Fig 2. Technique for remnant re-tensioning ACL reconstruction. The red line represents No. 1 PDS that passes the ACL remnant and loops over the EndoButton CL.](image2)
femoral end was fixed and pre-tensioning was performed, the tethering 4 strings of No. 1 PDS were pulled one by one to re-tension the remnant under arthroscopic viewing (Fig 3). Re-tensioning was facilitated by performing cyclic motion of the knee several times. The tibial end of the graft was fixed with a post-tie method and/or 7 × 23-mm Bio-interference screw (Arthrex). The tethering sutures were fixed to the anterior tibia if they were not tight enough.

Postoperative Rehabilitation

Quadriceps strengthening exercise was performed immediately after surgery. Partial weight bearing was allowed on the second postoperative day, with full weight bearing as tolerated. A brace was applied for 3 months, which was fixed in extension for 6 weeks and allowed motion of 0° to 135° afterward. Continuous passive motion exercise was performed starting at 50° on the second day up to 120° six weeks postoperatively. Stiff stationary bicycling, proprioception exercise, and jogging were allowed 3 months after surgery. Competitive sports, except for those exercises that might involve strong contact with others, such as football or soccer, or those exercises that might impose strong external forces on the patient’s knee, such as skiing or snowboarding, were allowed 6 months after surgery. All types of exercise were allowed after 9 months.

Discussion

With the current technique, the graft could be entirely covered by the synovium of the remnant in most cases of ACL rupture in the proximal half. Preserving the remnant of the ruptured ACL might have some advantages such as preservation of proprioceptive function; enhancement of the revascularization process; reduced synovial fluid leakage, which may cause tunnel enlargement; and mechanical protection of the graft from being scratched by the intercondylar notch. In the traditional ACL reconstruction technique, the ACL remnant is usually removed to some extent for the purpose of positioning the femoral and tibial tunnels accurately. Although this technique has shown good mechanical stability, issues regarding the recovery of proprioception on the basis of potential function of the remnant tissue have recently been arising. Sherman et al. stated that most ruptures of the ACL occurred in the proximal half. Because most mechanoreceptors are located in the subsynovial layer near the tibial attachment of the ACL, it is supposed to be possible that proprioceptive function is recovered by preserving the remnant of the tibial attachment of the ACL during ACL reconstruction. Adachi et al. stated that there was correlation between the number of mechanoreceptors in the ACL remnant and the accuracy of position sense of the knee, which suggests that a remnant-preserving technique might lead to better proprioceptive function of the knee after ACL reconstruction than the conventional technique. However, to our knowledge, there are no human studies comparing the number and quality of mechanoreceptors in the reconstructed ACL with and without preservation of the remnant.

In traditional remnant-preserving ACL reconstruction, second-look arthroscopy has shown that the regenerated synovium covering the graft is thin and friable in many cases. With our technique, the healed synovium could be expected to be thicker and more stable. Moreover, the risk of a cyclops lesion is assumed to be much lower compared with traditional remnant-preserving ACL reconstruction, although it is not yet clear whether cyclops lesions will develop at a much higher frequency when using the remnant-preserving technique compared with the conventional technique. We also hope that the time for healing of the synovium would become shortened, although further investigation is needed.

We have introduced the described technique with femoral fixation using EndoButton CL. This technique might also be applicable to other suspension fixation methods and expansion fixation methods. However, it might be difficult to apply this technique to compression fixation techniques such as interference screw fixation. We believe that this technique allows better synovialization and remodeling of the graft after ACL reconstruction.

References


