One-stage Revision Anterior Cruciate Ligament Reconstruction With Impacted Bone Graft After Failed Primary Reconstruction

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Abstract: Revision anterior cruciate ligament reconstruction can be performed in a 1- or 2-stage procedure. Restoration of bone stock using bone grafting is often required for good results. The authors performed 1-stage revision surgery with a more lateral and oblique femoral tunnel and an impacted bone graft to avoid the bone defect caused by the previous screw removal from a malpositioned tunnel. No evidence existed of revision surgery failure or viral transmission in any of 17 cases at 2-year follow-up. The authors’ technique is also useful for a slightly misplaced femoral tunnel.

With the increasing frequency of primary anterior cruciate ligament (ACL) reconstruction, revision ACL reconstruction is becoming more prevalent. Although the surgical technique for ACL reconstruction has advanced significantly during the past few decades, varying failure rates of 0% to 14% after ACL reconstruction have been documented.1-4 These patients continue to have persistent instability on functional testing and degenerative arthritic changes in radiological findings after primary ACL reconstruction.

Causes of ACL reconstruction failure include improper surgical technique, inadequate graft incorporation, postoperative trauma, and unrecognized secondary knee instability. The most common cause of failure is an error in surgical technique, such as improperly placed grafts, resulting in a vertical tunnel.5 During revision surgery, repairing an improper tunnel and correctly creating a new femoral tunnel can be technically demanding.

Revision ACL reconstruction can be performed in a 1- or 2-stage procedure. In 2-stage revision ACL reconstruction, the initial procedure consists of ACL graft removal and tunnel curettage with or without bone grafting of the tibial and femoral tunnels; the second stage is the revised ACL reconstruction. Two-stage revision ACL reconstruction imposes an economic burden and takes time. During 1-stage revision surgery, the challenge is to overlap the improper tunnel and correctly create a new one. Bioabsorbable screws or other space-occupying materials have been used to accomplish this. However, these methods fail to restore normal bone stock in the lateral femoral condyle, which may result in serious consequences, such as later rerupture of the revised reconstruction.

The current authors used a 1-stage revision ACL reconstruction technique using an impacted morselized bone graft to avoid the bone defect of the previously malpositioned femoral tunnel. In this technique, a bone graft was used to restore the bone stock while maintaining strong initial fixation strength with dual femoral fixations.

This study followed protocols approved by the institutional review board.

Materials and Methods

Between November 2006 and July 2010, seventeen consecutive patients with ACL reconstruction failure underwent 1-stage revision ACL reconstruction with impacted bone graft. Inclusion criteria for the study were ACL reconstruction failure due to a vertical femoral tunnel, where the existing vertical femoral tunnel overlapped the desired new femoral tunnel, and follow-up longer than 2 years. Twelve men and 5 women had a mean age of 32.6±9.9 years. The clinical results
were evaluated by Lysholm score, International Knee Documentation Committee (IKDC) subjective knee score, and KT2000 (MEDmetric, San Diego, California) side-to-side difference.

**Surgical Technique**

In cases of a diagnosed ACL reconstruction failure and planned revision, the tibial and femoral tunnel widening were assessed using simple radiography preoperatively. Computed tomography was used to delineate the tunnel position, especially the femoral tunnel, and the extent of the bone defect. Magnetic resonance imaging provided graft direction and meniscal and articular cartilage pathology.

The surgical technique involved a standard knee arthroscopic evaluation and treatment for any concomitant intra-articular pathology, as indicated. In the current study, a torn ACL was confirmed in 17 patients, and the previous graft was located in a vertically positioned femoral tunnel with a metal interference screw (Figure 1). The existing femoral tunnel was widened to more than 12 to 13 mm. The existing torn graft was removed, and a notch was prepared using the remaining screw. Soft tissue was debrided with an arthroscopic shaver to ensure better vision in the operative field. A mark for the new femoral tunnel was made in the 10- or 2-o’clock direction. After achieving a tibial tunnel, a guide pin was inserted free-hand via the tibial tunnel to a premarked intended position. Reaming was begun with the smallest-sized instrument (4 mm) to make room for passing the graft with the EndoButton CL (Smith & Nephew, Andover, Massachusetts) through the lateral femoral condyle. When possible, the previous femoral interference screw remained indwelled (Figure 3), which prevented the new femoral tunnel from slipping into the previous tunnel. The new femoral tunnel was gradually increased manually with serially larger reamers. The femoral screw was removed if a previous screw was struck against the reamers of the new tunnel. After reaming, the aperture of the planed femoral tunnel overlapped with the previous femoral defect, and the previous and new femoral tunnels were shaped like a figure-8. (Figure 4). Although the orifices of the 2 tunnels overlapped, the directions of the tunnels were different (Figure 5).

The Achilles tendon allograft incorporated with the EndoButton CL was inserted through the previous tibial tunnel after preparing the guide for a RigidFix (Mitek, Norwood, Massachusetts) to the new tunnel. Dual femoral fixation with an EndoButton CL and a RigidFix created a strong attachment, although the orifices of the previous and new tunnels were overlapped and widened like a figure-8. The EndoButton CL provided excellent pullout strength, and the RigidFix prevented the windshield wiper effect and graft motion in the widened femoral tunnel. This 1-stage revision ACL reconstruction using an impacted bone graft to fill the widened previous tunnel allowed early rehabilitation after revision surgery without long-term immobilization, owing to dual fixation of the femoral tunnel and insertion of a calcaneal cancellous bone block attached to the Achilles tendon allograft into the previous tunnel. Several bullet-shaped bone blocks were also inserted into the widened bony tunnel of the tibia (usually superior to the graft). Finally, the tibia was fixed with bioabsorbable interference screws on the opposite side of the bone graft (usually inferior to the graft) and reinforced with post-ties or staples.

Tolerable weight bearing was allowed with a locked brace in full extension 3 weeks postoperatively. After 6 weeks, partial weight bearing with crutches was permitted, followed by a gradual increase in knee range of motion up to 90°. Straight running was allowed at 3 months, and plyometric functional exercise was allowed 6 months postoperative-
ly. Usually, the patient returned to previous sports activities 9 months after revision surgery.

**RESULTS**

No graft failure occurred in any case at an average 32-month follow-up. Mean postoperative Lysholm and IKDC subjective knee scores were 90.4±7.8 and 84.8±12.5, respectively. Mean side-to-side difference decreased from 6.1±1.9 mm preoperatively to 1.6±1.4 mm postoperatively using the KT2000 arthrometer. The impacted bone allograft appeared to be well incorporated on follow-up magnetic resonance imaging. All patients reported excellent results at final follow-up (Figure 7) and returned to their preinjury activity level (Table).

**DISCUSSION**

Although surgical techniques for ACL reconstruction continue to improve with time, graft failure rates remain relatively high, and the number of revision surgeries is rapidly increasing. Revision ACL reconstruction can be performed as a 1- or 2-stage procedure, with considerable controversy regarding which is best. Two-stage revision ACL reconstruction involves bone grafting into the previous tunnel, followed by revision ACL reconstruction after the initial bone graft has healed; this has been regarded as the standard method for repairing misplaced bone tunnels leading to graft failure. However, the current authors believe that 2-stage revision is disadvantageous to the patient in terms of the money and time required before returning to previous activities.

It is important to manage femoral bone deficiency during revision ACL reconstruct-
tion. Bone defects caused by previous femoral interference screw removal, malpositioned primary reconstruction tunnels, or tunnel enlargement present challenging problems. Bone defects can lead to severe complications such as a lateral femoral condylar fracture. Therefore, restoration of the bone stock using bone grafting is vital for good results. Several treatment options for femoral bone defects have been proposed. Said et al described the use of an iliac crest autograft with osteochondral autologous transfer system (OATS) harvesters to fill femoral tunnel defects as the first stage of a 2-stage revision reconstruction. Franceschi et al used autogenous bone from the medial tibial metaphyseal safe zone to manage femoral bone deficiency. They harvested via an OATS tube harvester and reconstructed 3 months after bone grafting.

In some studies, revision ACL reconstruction has been performed as a 1-stage procedure. Battaglia and Miller used allograft bone dowels with a central axial hole to graft the femoral tunnel adjacent to the newly placed femoral tunnel. Barrett and Brown described a 1-stage revision ACL reconstruction with a synthetic dowel graft to fill femoral tunnel defects. The current authors performed a morselized bone graft using allograft bone during ACL revision, based on previous studies using morselized bone grafts for managing acetabular bone defects in total hip arthroplasty, to minimize the time and money required.

Debate exists as to whether autogenous bone grafts or allografts lead to better results. An autogenous bone graft has the advantage of good graft incorporation without the risk for viral transmission. However, donor site morbidity may increase with an additional graft harvest. In the current study, all patients underwent 1-stage revision ACL reconstruction with a bone plug from an Achilles tendon allograft. No evidence existed of graft incorporation failure or viral transmission at a minimum 1-year follow-up.

Getelman and Friedman suggested that widely misplaced tunnels made it easy to avoid tunnel overlapping. However, slightly misplaced tunnels could cross the path of a properly placed revision tunnel, causing large bone deficits that make graft fixation difficult. The current authors believe that their technique is useful for slightly misplaced femoral tunnels because it allows the orifices of the previous and new femoral tunnels to overlap, with the tunnels having different directions. Furthermore, the windshield wiper effect is minimized with dual fixation using an EndoButton CL and a RigidFix to improve pullout strength and avoid intratunnel motion. Early accelerated rehabilitation was allowed after rigid dual fixation of the femur and tibia.

**CONCLUSION**

The 1-stage revision ACL reconstruction technique described in this study is a useful treatment method that reduces time and money requirements.

**REFERENCES**


