Case Report

Novel Application of a Rounded-Rectangular Bone Tunnel in Revision ACL Reconstruction

A Report of 2 Patients

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Revision anterior cruciate ligament (ACL) reconstruction remains a technical challenge because surgeons have to manage preexisting tunnels, bone loss, and tunnel expansion.[1] This case study presents a novel 1-stage technique for revision ACL reconstruction that uses rounded-rectangular bone tunnels. Previous studies have shown that primary ACL reconstruction with a rounded-rectangular tunnel can restore the biomechanical insertion of the ACL, theoretically avoid iatrogenic injury to the anterior horn of the lateral meniscus, and produce better clinical outcomes than those achieved via a conventional round tunnel.[2,7,8] In an animal study, Zhao et al[9] reported that a flattened bone tunnel could accelerate tendon-to-bone healing in the early period after ACL reconstruction. However, no studies have focused on the potential use of such a tunnel in revision ACL surgery.

We describe 2 patients with ACL graft failure. The first patient experienced left knee instability after revision ACL surgery, while the second had restricted range of motion of the left knee after primary ACL reconstruction. Both patients underwent revision ACL reconstruction with our adjustable rounded-rectangular bone tunnel technique.

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PATIENT 1

A 24-year-old man was seen at our clinic 2 years after primary ACL reconstruction. He experienced persistent left knee instability as well as anterior knee pain after his first operation. He underwent revision ACL reconstruction 1 year following the initial procedure. However, symptoms of left knee instability persisted despite the revision surgery. When he was transferred to our hospital, he had positive results on Lachman and anterior drawer tests. A computed tomography (CT) image showed remarkable widening of the preexisting tibial tunnel (major axis, 17 mm; minor axis, 13 mm) in addition to malposition of the femoral tunnel (Figure 1). We performed a repeat revision ACL reconstruction for this patient.

The patient was placed in the supine position under lumbar anesthesia. The contralateral hamstring tendons (semitendinosus tendon and gracilis tendon) were harvested to serve as the ACL graft, which had an 8-mm diameter. The anteromedial and anterolateral portals were used for instruments and arthroscope, respectively. By carefully removing the remnant ACL graft fibers, we could fully expose the tibial and femoral insertion sites of the ACL.

New bone tunnels were then reamed on both the tibia and the femur. For the tibial side, we used a tip-to-elbow aimer (Acufex) set at 45° to guide aim at the ACL insertion site, posterior to the preexisting tunnel. To avoid confluence with the preexisting tunnel, we used a custom arthroscopic ruler to measure the distance between the preexisting tunnel and the center of the aimer (Figure 2A). The exit of the new tibial tunnel was placed medially to the preexisting tunnel so that the new tunnel would not become confluent with the preexisting tibial tunnel (Figure 3C). We first reamed a small tunnel using a conventional 5-mm reamer and then expanded the tunnel step-by-step with a bone rasp (Figure 2, B and C). The new tibial tunnel had a rounded-rectangular shape, with a diameter of 12 mm in the major axis and 5 mm

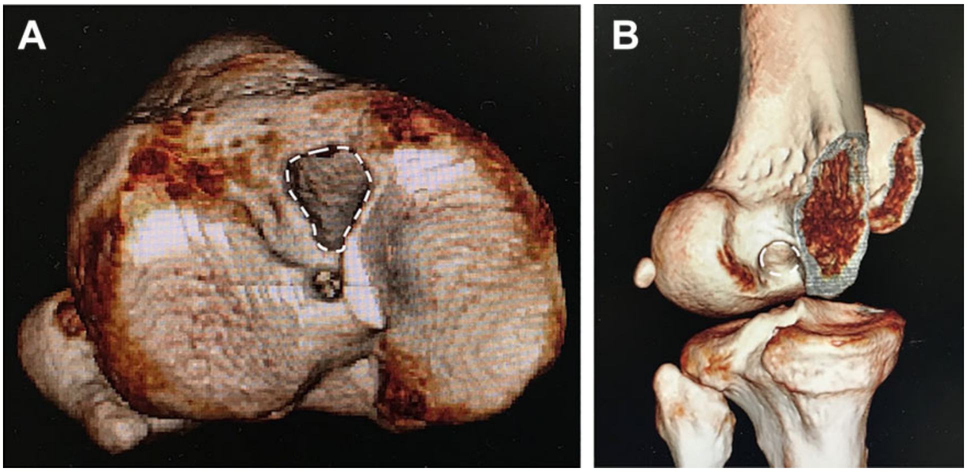

Figure 1. Preoperative computed tomography scans showing preexisting (A) tibial and (B) femoral tunnels in patient 1. White dashed lines represent the outline of the tunnels.

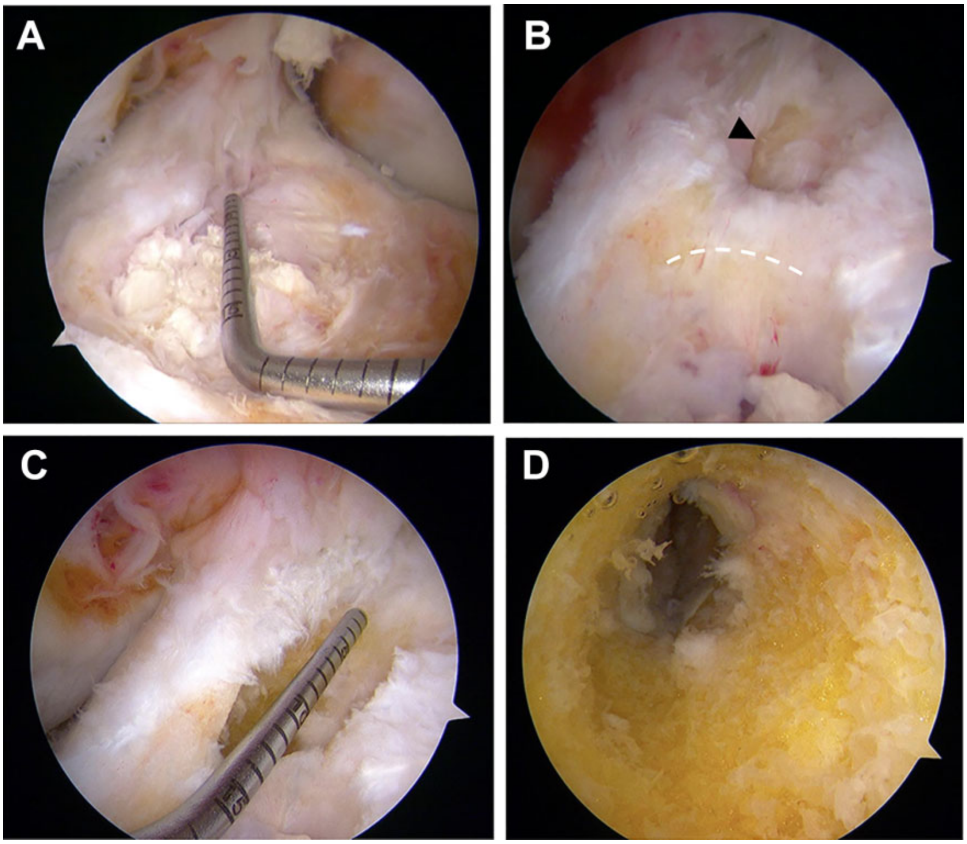

Figure 2. Arthroscopic views in patient 1. (A) Custom arthroscopic ruler. (B) Small tunnel (black arrowhead) was reamed using a 5 mm–diameter reamer. The posterior boundary of the preexisting tibial tunnel (white dashed line) was used as an anatomic landmark. (C) The diameter of the rounded-rectangular tunnel was confirmed by the arthroscopic ruler. (D) New tibial tunnel walls were made of fresh cancellous bone.

in the minor axis. Moreover, it had the same cross-sectional area as an 8 mm–diameter round tunnel,[7] as confirmed by use of the arthroscopic ruler. The new tibial tunnel walls were made of fresh cancellous bone under arthroscopic view (Figure 2D). Then the new femoral bone tunnel was reamed within the ACL femoral insertion site via a transtibial technique. The femoral bone tunnel was first reamed with a 6 mm–diameter reamer and then dilated to be a

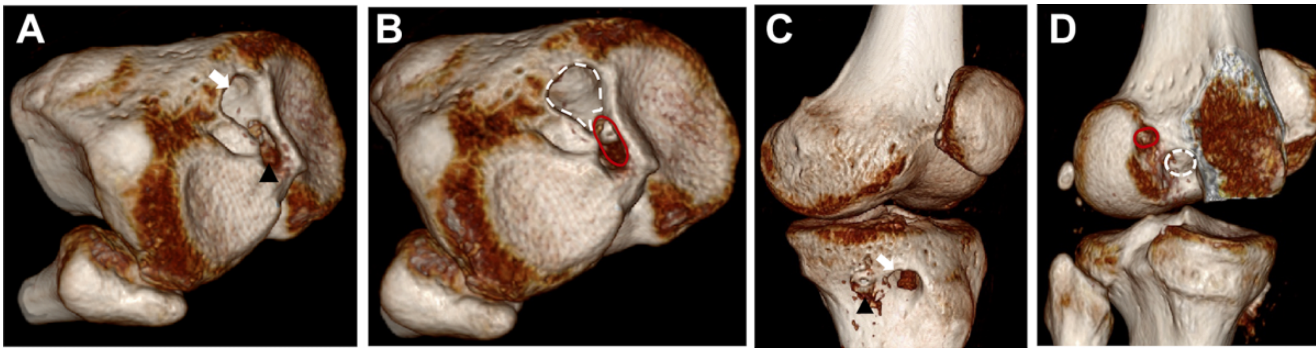

Figure 3. Postoperative computed tomography scans in patient 1. (A) Preexisting and (B) new tibial tunnels. (C) The exit of the new tibial tunnel was placed medially to the preexisting tunnel. (D) Preexisting and new femoral tunnels. Black arrowhead, new tibial tunnel; white arrow, preexisting tibial tunnel; red solid line, outline of new tibial and femoral tunnels; white dashed line, outline of preexisting tibial and femoral tunnels.

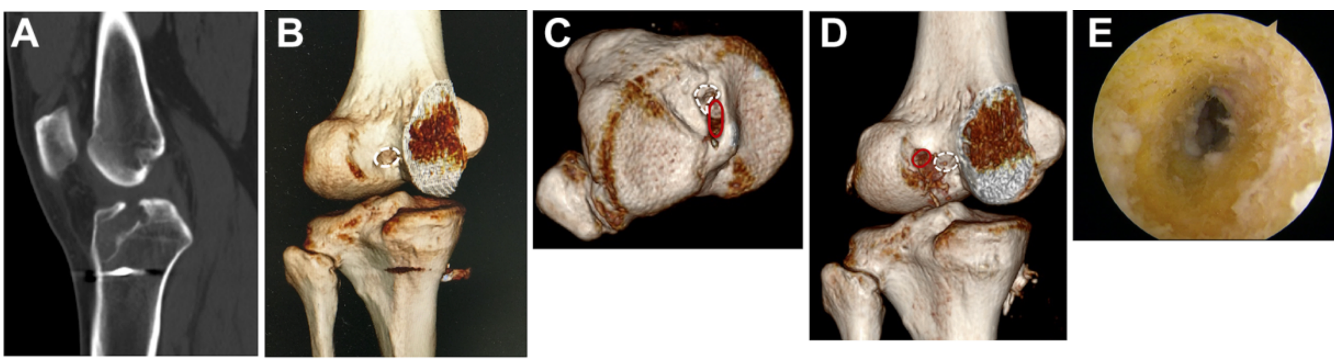

Figure 4. Pre- and postoperative computed tomography scans and arthroscopic view in patient 2. Preexisting (A) tibial and (B) femoral tunnels. New (C) tibial and (D) femoral tunnels were in good locations. (E) All of the new tibial tunnel walls were fresh cancellous bone. Red solid line, outline of new tibial and femoral tunnels; white dashed line, outline of preexisting tibial and femoral tunnels.

rounded-rectangular shape by use of the bone rasp. The major and minor axes for the new femoral tunnel were 10 and 6 mm, respectively.

We performed femoral graft fixation using an EndoButton (Smith & Nephew). We used a bioabsorbable Intrafix screw (DePuy Mitek) to achieve tibial graft fixation.

The postoperative CT scan on the second day showed that the new tibial and femoral bone tunnels did not become confluent with the preexisting tunnels and were well located (Figure 3). The standardized postoperative rehabilitation remained unremarkable. At 1-year follow-up, the patient reported that stability of the left knee had been restored. Physical examination revealed a negative Lachman test; range of motion of the reconstructed knee was not restricted. His Tegner activity score and International Knee Documentation Committee (IKDC) subjective score were 6 and 88.5, respectively. At 1-year follow-up, the patient reported he had successfully returned to sport.

PATIENT 2

A 23-year-old man reported to our clinic with restricted range of motion in his left knee after a primary single-bundle ACL reconstruction with hamstring tendon autograft 5 years prior. Physical examination revealed positive Lachman and anterior drawer tests. A CT scan showed malposition of the femoral tunnels as well as expansion of the tibial tunnel. We performed revision ACL reconstruction using the same technique as used with the first patient.

The pre- and postoperative CT scans (Figure 4) showed good locations of the new bone tunnels, which did not become confluent with the preexisting tunnels. At 1 year after the revision surgery, range of motion had been completely restored in the reconstructed knee. The patient showed negative Lachman and pivot-shift tests. His Tegner activity and IKDC subjective scores were 6 and 90.8, respectively. At 1-year follow-up, the patient had returned to contact sports.

DISCUSSION

The purpose of revision ACL reconstruction is to restore the anatomic and biomechanical features of native ACL. However, preexisting tunnels can make the technique difficult. Previous literature reported the possible use of a

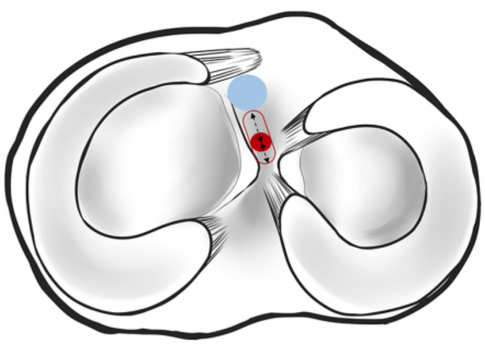

Figure 5. Diagram of the technique used in the 2 revision patients. A small tunnel was reamed first (red circle) and then shaped as a rounded rectangle by use of a rasp. The black arrow indicates the distance for rasping. Blue circle, preexisting tibial tunnel; red solid line, new tibial tunnel.

rectangular tunnel using bone-tendon-bone graft in revision ACL surgery,[3,4] but we are the first to use this ream-and-rasp technique to create rounded-rectangular tunnels using hamstring tendon graft in revision ACL surgery.

During surgery, we first reamed a small circular tunnel and then manually shaped it to achieve the correct aperture. Our idea was that the anteroposterior position of the small tunnel could be adjustable, as long as the small tunnel was within the ACL tibial attachment. Then, by using a bone rasp, we could manually achieve the correct shape and location of the new tunnel (Figure 5). The new tunnels were flattened by our technique, which was consistent with the anatomic and biomechanical properties of the native ACL insertions.[5,6,8]

Our technique showed several advantages in revision ACL surgery. First, by using a small-diameter reamer, with the assistance of an arthroscopic ruler, we decreased the possibility of tunnel confluence. As was shown in these 2 patients, the small tibial tunnel could be reamed posteriorly to the preexisting tunnel, which would create a space for the rasping procedure. In some cases, if the preexisting tibial tunnel had been placed too posteriorly, the small tunnel could be reamed anteriorly to avoid the old tunnel. Second, the risk of tunnel confluence was further reduced as the tunnel was rasped meticulously, step-by-step, under direct arthroscopic visualization. The limit of the preexisting tibial tunnel could serve as a useful anatomic landmark throughout the surgery, so that the new tunnel was in close proximity to the old tunnel rather than breaking into it. Third, the exit of the new tibial tunnel was placed medially to the preexisting tunnel, which ensured that the tunnels inside the tibia would not become confluent with each other (Figure 3C). As a result, our technique enabled better contact between the ACL graft and fresh cancellous bone, allowing for better graft incorporation inside the tunnels. Fourth, our technique was a 1-stage operation, thus avoiding the need for staged surgeries that are commonly used in severe tunnel expansion.

CONCLUSION

We successfully applied the rounded-rectangular bone tunnel ACL reconstruction in 2 patients undergoing revision ACL reconstruction. The arthroscopic imaging, postoperative CT scanning, and early follow-up assessments showed satisfactory results. Although long-term follow-up assessments are needed for further clinical evaluation, our novel concept and technique overcame the difficulties of revision ACL reconstruction and have prospects for wide application.

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