Anatomical single bundle ACL reconstruction using rounded rectangular dilator: technique, clinical results, and basic research

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INTRODUCTION:

It is widely accepted that a smaller hamstring autograft size (tunnel diameter < 8 mm) is a predictor of poor knee stability and clinical outcomes. A shortcoming of conventional anatomical single bundle anterior cruciate ligament (ACL) reconstruction is that the creation of a large anatomical bone tunnel is not possible because of roof impingement or breakage of the posterior femoral bone tunnel. Based on the results of anatomical studies involving the ACL, we should create a femoral bone tunnel in a rounded rectangular shape to approximately reproduce the native tendon-bone junction of the ACL, and perform ACL reconstruction using a thick graft. Several anatomical studies have reported that the femoral insertion of ACL has a rounded rectangular shape and we found that the cross-sectional shape of the fourfold semitendinosus tendon is oval, not round (Oshima T, et al. J Exp Orthop. 2016). We designed an original femoral dilator and sizing block (Fig. 1), and developed a new ACL reconstruction technique called "rounded rectangular femoral tunnel ACLR" (RFTR). This technique reported in the AAOS 2022 in Orthopaedic Video Theater. Therefore, we report clinical results and imaging results (MRI and CT) in this year.

METHODS:

227 primary ACL reconstructions were performed. After implementation of the inclusion criteria(The patients who photographed CT and MRI at an appropriate time and completed 2 years follow-up), 80 ACL reconstructions were analyzed (anatomical single bundle ACL reconstruction, ASBR = 40 patients; 15 males, 25 females; age, 22.3 ± 8.7 years; RFTR = 40 patients, 14 males, 26 females; age, 23.6 ± 9.5 years). The parameters analyzed were the area of the femoral tunnels, anteroposterior laxity using KT-1000, pivot-shift test, Lysholm score 2 year after the surgery, and postoperative CT and magnetic resonance (MR) images. To evaluate the CT value, we compared the 1-week postoperative CT images. Using parallel slices toward the openings of the bone tunnels to a depth of 3 mm, we evaluated the CT value of eight directions in the bone tunnel wall. To evaluate the tunnel enlargement, we compared the 1-week postoperative CT images with those taken 3 months postoperatively. Using parallel slices toward the openings of the bone tunnels, we measured the bone tunnel area and calculated the tunnel enlargement ratio. To evaluate the graft shift, we compared the MR images at approximately 6 months after the surgery. We evaluated the graft bone tunnel gap by using the original scoring system with axial, oblique coronal, and oblique sagittal slices for each tunnel.

Technique of RFTR

The femoral tunnel is drilled via an additional medial portal. Rounded rectangular tunnels are created using a special dilator. Tibial tunnels are created using conventional rounded tunnels. Fixation was achieved using a suspensory device on the femur, and a plate and screw on the tibia.

The femoral tunnel positions were documented postoperatively from computed tomography (CT) scans using the quadrant method. Using the positioning ratios, the femoral tunnels were located at 25.3 ± 5.8% from the deepest subchondral contour of the lateral femoral condyle, and at 31.8 ± 4.3% from Blumensaat's line (Fig. 2). All femoral tunnels were located within the area of the anatomical ACL insertions (Nakase J, et al. Knee. 2016).

RESULTS:

There was no significant difference in the baseline data. RFTR created a bigger femoral tunnel area than ASBR (average area, 52.2 ± 4.6 mm^2 vs. 46.8 ± 5.3 mm^2, respectively; $p < 0.01$). RFTR resulted in better anteroposterior stability and Lysholm score than ASBR (average side-to-side difference for anterior tibial translation, 0.6 ± 0.8 mm vs. 1.6 ± 1.4 mm, respectively; $p < 0.01$; average Lysholm score, 98.5 ± 2.1 vs. 97.5 ± 3.5, respectively; $p < 0.01$). Differences in the rotational laxity between the groups were statistically significant (negative pivot shift, 92.3% vs. 82.5%; $p < 0.01$). RFTR had significantly high CT values compared with those of all directions in ASBR, except for the anterior-distal direction. The rounded rectangular bone tunnel areas were significantly larger immediately after the surgery; however, there were no significant differences in the bone tunnel area 3 months postoperatively (107.5 ± 26.7 mm^2 vs. 101.0 ± 25.9 mm^2; $p = 0.32$). The rounded rectangular tunnel area enlargement ratios 3 months postoperatively and immediately after the surgery were significantly lower (73 ± 37% vs. 110 ± 38%, respectively; $p < 0.01$).

The graft-bone tunnel gap scores of the tunnel shapes (1.63 vs. 2.08, respectively; $p > 0.05$) had no significant differences between RFTR and ASBR.

DISCUSSION AND CONCLUSION:

We did not experience any serious intraoperative complications during this new technique, and the resulting locations of the femoral tunnels were near the center of the ACL footprint. Thus, this technique facilitates a larger graft in anatomical ACL reconstruction (without the risk of roof impingement), which improved clinical results and decreased bone tunnel enlargement compared with the conventional technique. This technique is simple and can address the shortcomings of the conventional anatomical single bundle ACL reconstruction.