The Accuracy of Bone Tunnel Position Using Fluoroscopic-Based Navigation System in ACL Reconstruction

INTRODUCTION

The most common cause of technical failure in anterior cruciate ligament (ACL) reconstruction is the bone tunnel misplacement(1). However it is technically challenging to place the bone tunnel in the anatomically correct position. The aim of this study was to prove the hypothesis that fluoro-based navigation system contribute to the accuracy and reproducibility of bone tunnel placements in single-bundle ACL reconstruction thereby potentially leading to better clinical results than those of conventional method. And its application for double-bundle ACL reconstruction, which still remains lack of reliable technique, was also discussed from the aspects of radiographic and clinical outcomes.

MATERIALS AND METHODS

This study group consisted of a consecutive series of 48 patients (21 male, 27 female) who underwent primary reconstruction of the ACL using a hamstring tendon auto graft. Among them, 17 knees in 17 patients (8 male, 9 female) underwent single-bundle ACL reconstruction using the fluoroscopic navigation system (Group 1). Another 16 knees in 16 patients (6 male, 10 female) were underwent single-bundle ACL reconstruction without this system and were served as the control group (Group 2). Double-bundle ACL reconstruction was performed by the use of navigation in other 15 patients (7 male, 8 female). All patients were followed up at least 24 months since operation was performed. The study was performed with the approval of the institutional review board, and all patients signed the consent form drafted for the study.

Navigation system :

A computer-assisted fluoroscopic-based navigation system (Vectorvision® ACL system, BrainLAB, Heimstetten, Germany) was used for this study. This system composed of a C-arm fluoroscope and a navigation system.

Surgical procedure :

We plan the femoral and tibial center of the bone tunnel positions on the navigation system according to the Quadrant methods for the femur and Staublis methods for the tibia in the lateral radiograph. When we performed single-bundle reconstruction, we placed the center of the tibial tunnel where the 43% along the tibia plateau, taking 0% as the anterior and 100% as the posterior extent. On the femoral side, a quadrant is projected onto the condyles of the femur in the lateral radiograph. The quadrant has to be positioned so that the proximal line is overlapping Blumensaat’s line, the projection of the intercondylar roof in the lateral radiograph. The center of the femoral inserton of the ACL was aimed in the quartered quadrant just inferior to the most superoposterior quadrant (Figure 1-a).

When we performed double-bundle ACL reconstruction, we placed the center of the antero-medial (AM) and postero-lateral (PM) tibial bone tunnels around where the 43% (AM:30%, PM:44%) along the tibia plateau according to the previous reports. On the femoral side, as shown in the previous cadaveric studies(2), we aimed AM femoral tunnel at 25% from the deep margin in a deep-shallow direction and at 16% from Blumensaat’s line in a high-low direction and PL tunnel at 30% in a deep-shallow direction and at 42% in a high-low direction, according to the Quadrant methods (Figure 1-b).

Radiological assessments :

In the cases of single-bundle reconstruction (group 1, 2), the position of the center of the tibial tunnel was calculated and expressed as a percentage of the total length of tibia plateau on the lateral radiograph (a/t). Placement of the center of the femoral tunnel was also assessed as a percentage of the total length of Blumensaat’s line on the lateral radiograph (b/f) (Figure 2-a). In cases of the double-bundle reconstruction (group 3), we employed the 3D-CT to assess the accuracy of the bone tunnel. Femoral tunnels were assessed on a sagittal plane and tibial bone tunnels were assessed on axial plane (Figure 2-b).

RESULTS AND DISCUSSION

Bone tunnel positions of single-bundle ACL reconstruction :

Taking 0% as the anterior and 100% as the posterior extent, the femoral tunnels were 74.18±3.27% in group 1 and 71.7±6.00% in group 2 along Blumensaat’s line, and tibial tunnels were 42.08±1.44% in group 1 and 42.98±4.63% in group 2 along the tibia plateau. The bone tunnels using navigation (group1) were located significantly more closed to the position planned pre-operatively and varied smaller in both femur and tibial side, compared with those without navigation (group 2). (P<0.05) The distributions of femoral and tibial tunnels are shown in Figure 3. Bone tunnel positions of double-bundle ACL reconstruction :

In the 3D-CT evaluation of the double-bundle ACL reconstruction, the center of AM tunnel was placed at 29,18±2.41% from the anterior edge of the tibia, and the PL tunnel at 48.34±2.35% on the tibial side. On the femoral side, the center of the femoral AM tunnel was placed at 25.73±2.77% from the deep margin in a deep-shallow direction and at 17.59±4.55% from Blumensaat’s line in a high-low direction. The center of PL bundle was found at 32.88±4.35% from the deep margin in a deep-shallows direction and 45.85±5.43% from Blumensaat’s line in a high-low direction. The dispersion of bone tunnels are demonstrated in Figure 3. 3D-CT images showed that the center of the PL tunnel of the tibia side tend to located posterior to our predicted position in order to avoid connect with AM tunnel. But other tunnels positions were placed as we planned before the operation.

DISCUSSION AND CONCLUSION

Fluoroscopic-Based Navigation system contributed to the accurate placement of the bone tunnel during single-bundle ACL reconstruction, compared with conventional technique. This innovative device renders the reconstruction more reliable, eliminating the problem of skeletal variation among patients. We can also show its potential for the application of double-bundle ACL reconstruction.

REFERENCES