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ORIGINAL ARTICLE

Comparison of anterior cruciate ligament reconstruction methods between reverse "Y" plasty reconstruction and traditional single-bundle technique—A cadaveric study

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Anterior cruciate ligament reconstruction;
reverse "Y" plasty anterior cruciate ligament reconstruction;
Double bundle reconstruction;
Single bundle reconstruction

Summary *Background:* In 2009, a reverse "Y" plasty anterior cruciate ligament (ACL) reconstruction technique was proposed, with double-tibial tunnel and single-femoral tunnel, and the result obtained proved that the reverse "Y" plasty technique was satisfactory. This cadaveric study was designed to compare the reverse "Y" plasty reconstruction method with the conventional single-bundle technique for the first time.
Methods: In this study, 30 cadaveric knees were used and were randomly divided into five groups with six knees each. Six cadaveric knees with intact ACL were treated as the control group, and another six knees with ruptured ACL were treated as the rupture group. In group A, the single-bundle technique was used. In groups B and C, reverse "Y" plasty technique was used, and the grafts were fixed with absorbable biointerference screws in tibiae and absorbable biointerference screws (Group B) or Endobutton (Group C) in femora. Five groups were tested with an MTS material testing machine (MTS-858) by the use of a cyclic loading of 134 N at 15°, 30°, 60° and 90° of knee flexion and a combined 7-Nm valgus torque and 5-Nm internal tibial rotation torque at 15°, 30°, 45° and 60° of knee flexion.
Results: Both single-bundle and reverse "Y" plasty groups demonstrated similar anterior–posterior stability compared with the control group, whereas the single-bundle group showed

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inferior rotational stability tested at 30° and 45° of knee flexion than the reverse "Y" plasty group and control group. These two different fixation methods at the femoral site (Group B and C) showed no difference in anterior—posterior and rotational stability.
Conclusions: The new reverse "Y" plasty ACL reconstruction method may restore normal knee stability, especially rotational stability, better than single-bundle reconstruction.
The translational potential of this article: This study provides strong support for the new reverse "Y" plasty ACL reconstruction technique and is expected to propose a new surgical approach with good biomechanical features.

Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common injuries in the knee [1], and it may result in many secondary injuries, such as torn meniscus and cartilage damage, which lead to knee degeneration [2]. ACL reconstruction, with a success rate >90% [3], has been the most effective way to treat ACL rupture. Surgeons refined surgical approach with many reconstructive techniques over the past years, such as the single-bundle technique, anatomic double-bundle reconstruction technique [4,5], triple-bundle reconstruction technique [6,7], plasty reconstruction technique [8], etc.

In 2009, Ping et al [18] proposed a reverse "Y" plasty ACL reconstruction technique with double-tibial tunnel and single-femoral tunnel by using the hamstrings as autografts and fixing graft with absorbable biointerference screws or Endobutton in the femora and with absorbable biointerference screws in the tibiae. This study derives from the previous result that the new technique is reliable and satisfactory, and the clinical efficacy of both kinds of fixation in the femur is similar. The purpose of this study is to further evaluate the new technique and compare it with the traditional single-bundle technique. In addition, we hypothesised that there would be no significant differences in anterior—posterior stability among the single-bundle technique, double-bundle techniques and the intact knee, but the reverse "Y" plasty reconstruction technique may be superior in rotational stability than single-bundle reconstruction technique.

Materials and methods

Specimen preparation

In the study, 30 human cadaveric knees were dissected. The specimens were stored in the refrigerator at −80°C and then were allowed to defrost in isotonic saline (0.9% NaCl solution) for an hour before the test.

All were male with a mean age of 38.5 years (range: 18—55 years). Each knee was removed with all tissues, except skin and subcutaneous tissues, of 15—25 cm proximal and distal to the joint. In this study, specimen preparation and surgical operation were performed by one experienced surgeon. All specimens were dissected by removing muscles, vasa and nerves, but all ligaments, including medial collateral ligament, lateral collateral ligament, anterior collateral ligament, posterior collateral ligament, medial patellafemoral ligament and the capsules, were preserved. X-ray and magnetic resonance imaging were used for scanning the specimens to ensure the absence of osseous and soft tissue abnormalities or deformity that might affect ACL reconstructive surgery and testing results. The distal tibia and the proximal femur were fixed to the embedding cassette with the polymethyl methacrylate bone cement. To secure the knee activity, the vertical axis of the embedding cassette must be kept parallel (Fig. 1). Specimens were then randomly divided into five groups with a sample size of n = 6 for each group. The ACLs of the three experimental groups and rupture group were resected for ACL reconstruction surgery. The ACLs of the control group remained intact. At the same time, 36 flexor tendons were obtained from the same cadaveric upper limbs for ACL reconstruction. The grafts were prepared according to the grouping and then were left to defrost in isotonic saline (0.9% NaCl solution) for an hour before the test (Fig. 2). A tensile load of 70 N was applied to the grafts for 15 minute for preconditioning and used as an initial graft tension. The specimen preparation protocol had been approved by the ethics committee of Sun Yat-Sen Memorial Hospital, Sun Yat-Sen University, Guangzhou, China.

Figure 1 The cadaveric knee of 15—25 cm, proximal and distal to the joint centre, was prepared and fixed to the embedding cassette with the polymethyl methacrylate bone cement.