Biomechanical Comparisons between Clinically Available Anatomic Double-bundle and Single-bundle Procedures for Anterior Cruciate Ligament Reconstruction

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Introduction: Single-bundle anterior cruciate ligament (ACL) reconstruction has been the standard option to treat ACL-deficient knees. However, biomechanical studies have shown that normal rotational laxity cannot be restored with single-bundle reconstructions [1]. Recently, anatomic reconstruction of the anteromedial (AM) and posterolateral (PL) bundles has been introduced [2]. However, it remains controversial whether the anatomic double-bundle procedure is superior to single-bundle procedure [3]. Biomechanical studies found that anatomical attachment of the AM and PL bundles on the tibia and the femur, respectively, were created using a specially designed guide-wire navigator [2]. In the single-bundle reconstruction, the tibial tunnel that passed through the posterior aspect of the normal ACL attachment was created with clinical double-bundle procedures in patients are different from those created with experimental double-bundle procedure, because it is not easy to create tunnels with a specific device in clinical conditions. Therefore, it is required to biomechanically compare the various clinical double-bundle procedures with single-bundle procedures, using cadaver knees. However, such studies have not yet been conducted. The aim of this biomechanical study was to test the hypothesis that a clinically available anatomic double-bundle procedure with the trans-tibial tunnel technique [2] is significantly better in anterior and rotational laxity and stability than a single-bundle procedure.

Methods: Eight fresh-frozen cadaveric knees were used. The knee was mounted in a 6 degree of freedom rig and laxity testing was performed using following [6]: 90-N anterior and posterior tibial loads, 5-Nm internal and external tibial torques, and simulated pivot-shift test (50-N iliotibial tract loading, 5-Nm valgus moment, and 1-Nm internal tibial torque). The kinematic data were analyzed by using a two-way repeated-measures analysis of variance. Significance was set at p<0.05.

Results: With internal tibial torque, the internal rotation-versus-flexion curves were significantly different between the ACL-deficient, the double- and single-bundle reconstruction (p<0.0001) (Fig. 1). The rotational laxity in double-bundle reconstruction was significantly less than in the ACL-deficient and single-bundle reconstruction (p<0.0001). There were no significant differences between the ACL-deficient and single-bundle reconstruction. In response to anterior load, the anterior laxity-versus-flexion curves were significantly different among 3 groups (p=0.0068) (Fig. 2). The anterior laxity in single- and double-bundle reconstruction were significantly less than in the ACL-deficient (p<0.0235). There were no significant differences between the double- and single-bundle reconstructions. Regarding the pivot-shift loading, the anterior translation-versus-flexion curves were significantly different between the 2 procedures (P<0.0005) (Fig. 3). The anterior laxity was significantly less in double-bundle reconstruction than in single-bundle reconstruction. With posterior tibial loads, and external tibial torque, there were no significant differences between the 2 procedures. The centre of the AM tunnel outlet was located primarily in zone 1 (Table 1). The centre of the PL tunnel outlet was found primarily in zone 7. Using a measurement grid defined as starting anteriorly at 0% at the high, deep corner, and ending at 100% at the shallow, low corner, then the AM bundle was found at a mean of 22% shallow and 20% down from the notch roof, and the PL bundle at 31% shallow and 70% down from the roof.

Discussion: This study showed that internal rotational laxity and pivot-shift were significantly less after anatomic double-bundle reconstruction than after single-bundle reconstruction. However, there were no significant differences between the two procedures with anterior and posterior tibial loads, and external tibial torque. Furthermore, tunnel positions were found to be comparable to ‘normal’ attachment sites of the AM and PL bundles [7]. Anatomic double-bundle reconstruction may produce a better biomechanical outcome, especially during the pivot-shift test and tibial internal rotational load.