Double-Bundle Anatomic ACL-Reconstruction with Computer Assisted Surgery: An In-Vitro Study of the Anterior Laxity in Knees with Anatomic Double-Bundle versus Isometric Single-Bundle Reconstruction

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Abstract. The current standard technique to reconstruct ruptured anterior cruciate ligament (ACL) is through an isometric single-bundle graft. However, the ACL has a two-bundled nature, with the anteromedial bundle (AMB) most tight in flexion and the posterolateral bundle (PLB) near extension. Therefore a double-bundle, anatomically placed, graft is expected to provide better stability over the complete range of motion. The anterior laxity was tested in various flexion angles in knees with anatomic double-bundle and isometric single-bundle reconstruction. Anatomic femoral graft placement was performed using Computer Assisted Surgery (CAS) with the AMB-graft fixated in 90° of flexion and the PLB in 20°. Near extension the double-bundle technique caused no significant laxity change compared to a 2.1 mm (34%) increase in single-bundle reconstructed knees. In 90° of flexion the laxity increase was nearly similar. Over the complete range of motion the anatomic double-bundle technique results in a better functional reconstruction, at the cost of a higher AP-error near extension.

1 Introduction

The anterior cruciate ligament (ACL) consists of two functional bundles, each with its anatomic insertion area. The anteromedial bundle (AMB) is most tight in flexion and the posterolateral bundle (PLB) is tighter near extension. An anatomical double-bundle graft restores the functionally two-bundled nature of the ACL in full flexion a near extension, where as an isometric single-bundle technique cannot [1].

1.1 Goal

This in-vitro study evaluates the anterior laxity characteristics in knees with double-bundle reconstruction, anatomically placed using Computer Assisted Surgery (CAS) by comparing to intact knees and the standard isometric single-bundle technique.

2 Methods

In 9 fresh cadaver knees, fixed in a knee loading system under 50N axial compression, the anterior-posterior (AP) position of the tibia relative to the femur was measured using an electromagnetic system [3Space Fastrak, Polhemus Navigation Sciences, USA]. This was done in various flexion angles for the unloaded joint and loaded with an anterior force (100N drawer test) on the tibia, whereby axial tibial rotation was restrained. Mean AP-error, as the result of the difference in AP-position between the unloaded intact and unloaded reconstructed knee was calculated. As was the anterior laxity, defined as the difference between the unloaded and loaded joint. Each knee was measured, in 6 conditions: 1) intact; 2) ACL deficient; 3) anatomic double-bundle reconstruction (4+5); 4) anatomic AMB-reconstruction; 5) anatomic PLB-reconstruction; 6) isometric single-bundle reconstruction. In the anatomic double-bundle, AMB- and PLB-reconstruction a Quadriceps Tendon-patellar Bone graft (QTB) with 1 bone block and two tendon slips was used. The AMB-graft was tensioned in 90° of flexion, the PLB-graft in 20°. A Bone-Patellar Tendon-Bone (BPTB) graft, tensioned in 20° of flexion, was used in the single-bundle reconstruction. Tibial tunnel positioning was performed using the PCL Oriented Placement Marking Hook™ [Arthrex Inc., USA]. Anatomic femoral graft placement was performed through CAS [SurgiGate, Medivision, Switzerland] with the use of an ACL-module [2, MEM Institute for Biomechanics, Switzerland] and a 3D femoral template [3]. One 11 mm-tunnel was drilled at the 3D position of the ACL-center in the template. A transtibial femoral guide™ [Arthrex Inc., USA] with a 7 mm offset, placed in the over-the-top position at 11 o'clock determined the isometric tunnel location.

3 Results

Fig. 1. Mean anterior laxity in mm, as the result of the difference between the anterior-posterior (AP) position (Y) of the unloaded joint (*lower position*) and loaded joint (*upper position*), in various knee flexion angles (X). In intact knees (*horizontal stripes*), ACL deficient knees (*white*) and reconstructed knees with AMB-graft (*upping stripes*), PLB-graft (*downing stripes*), double-bundle graft (*black*) and isometric single-bundle graft (*gray*)

4 Discussion

The slight posterior shift of the tibia (posterior AP-error) seems to be a characteristic that is common in all ACL-reconstruction using tendons, due to the tensioning at the time of fixation. The three single bundle reconstructions were not able to restore the normal laxity in the position in which they were tensioned and fixed. The increased posterior AP-error and lower anterior laxity in the double bundle technique, specifically up to 30° of flexion where both bundles are recruited, can be the result of using more tendon material in the double bundle graft of these reconstructions.

5 Conclusion

Double bundle anatomic ACL-reconstruction, placed with CAS and a 3D template, results in a good functional reconstruction having anterior laxity characteristics that are close to those of the original ACL over the complete range of motion.

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