All Epiphyseal ACL Reconstruction Improves Knee Kinematics

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INTRODUCTION

Treatment of ACL injuries in skeletally immature patients is complicated by the fact that adult reconstruction techniques violate the growth plate, potentially leading to leg length discrepancies and angular deformities in skeletally immature patients. ACL injuries are commonly treated conservatively until growth plate closure; however, cartilage damage, meniscal injuries, and early osteoarthritis are common. The Anderson technique for pediatric ACL reconstruction utilizes all epiphyseal tunnels adjacent to the growth plate [1]. ACL injury leads to increased anterior translation, internal rotation, medial shift and valgus orientation of the tibia, with the largest changes occurring with the knee near full extension [2, 3]. The current study was performed to determine if all-epiphyseal reconstruction can reverse the kinematic changes caused by ACL injury.

METHODS

The ACL of ten cadaveric knees was cut, and then reconstructed with a 4-strand semitendinosus and gracilis tendon autograft using the all-epiphyseal technique. The graft was fixed to the femur with an endobutton. On the tibial side, the graft exited the tibia within the epiphysis and was secured back down into a hole distal to the physeal scar with a screw and washer. Each reconstructed knee was secured to a testing frame at 0°, 15°, 30° and 45° of flexion (Fig. 1). Loads were applied to the quadriceps with a total force of 596 N. The hamstrings were loaded with 200 N split between the medial and lateral hamstrings. Loading cables connected to weights over pulleys were clamped to the muscles at their insertion sites. Tests were performed with the ACL reconstructed and after sectioning the graft, to represent the post-injury condition, without removing the knee from the frame.

Tibiofemoral translations and rotations were quantified for each test. A sensor from a magnetic tracking system (trakSTAR, Ascension Technology) was used to digitize landmarks to establish reference axes for the femur and tibia. A sensor was also attached to the tibia to track the motion of the reference axes on the tibia during testing. Tibiofemoral translations and rotations were quantified using the floating axis coordinate system [4]. Paired t-tests were performed at each flexion angle to identify statistically significant (p < 0.05) differences between the ACL cut and reconstructed conditions.

The tibiofemoral pressure distribution was measured for both the lateral and medial compartments with a pressure sensor (K-Scan, Tekscan). The sensor was inserted between the meniscus and the cartilage on the tibia, and secured to the tibia. The anterior-posterior and medial-lateral coordinates of the center of pressure for each compartment were quantified based on the pressure distribution.

RESULTS

The anterior translation, medial translation, internal rotation, and valgus orientation of the tibia tended to be larger with the ACL cut than with the ACL reconstructed. The average difference in anterior translation was approximately 6 mm (Fig. 2A), and was significant at 0°, 15°, and 30°. The difference in medial translation was approximately 4 mm, and was significant at 45°. The difference in valgus alignment was less than 2°, and was significant at 30° and 45° (Fig. 2B). The difference in internal rotation was approximately 2°, but was not significant at any flexion angle.

Reconstructing the ACL shifted the center of pressure anteriorly on the tibia (Fig. 3). The center of pressure moved posteriorly on the tibia as the flexion angle increased. The difference in center of pressure between the ACL cut and reconstructed conditions was typically larger within the medial compartment of the tibia than the lateral compartment.

DISCUSSION

ACL reconstruction using the all epiphyseal technique primarily decreased anterior tibial translation, but also tended to decrease internal rotation, medial translation and valgus orientation of the tibia, all of which have been shown to increase following ACL injury [2, 3]. The center of pressure data further showed the posterior translation of the tibia with respect to the femur due to reconstruction, resulting in the pressure moving anteriorly on the tibia. The pressure shift was typically larger on the medial plateau than the lateral. The changes may effectively restore stability since previous in vivo studies indicated that the posterior shift in contact on the tibia related to ACL injury is larger on the medial plateau than the lateral plateau [5, 6]. At the immediately post-operative time point, all-epiphyseal ACL reconstruction seems to improve kinematic abnormalities caused by ACL rupture.

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REFERENCES


Figure 1: Schematic diagram of in vitro testing.