

Preservation of Remnant Tissue Improves Knee Stability after Anterior Cruciate Ligament Reconstruction in Sheep

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Summary:

This laboratory study demonstrated that a ligament remnant tissue coverage significantly improved the anterior-posterior translation, the initial stiffness of the hysteresis loop, and the recovery of mechanoreceptors at 12 weeks after hamstring ACL reconstruction in sheep model.

Abstract:

INTRODUCTION

It is known the ACL-injured knee frequently has a ligament remnant tissue [1], in which mechanoreceptors and subsynovial vessels are found [2,3]. Therefore, there is a strong possibility preservation of the ACL remnant tissue may be able to restore the proprioceptive function and vascularization of the graft after ACL reconstruction. Recently, several investigators have developed ACL reconstruction with remnant tissue preservation [4,5]. However, no basic studies have shown any biological and biomechanical evidence about the utility of the remnant preservation in ACL reconstruction. We have hypothesized graft coverage by the remnant tissue may significantly improve the knee stability after ACL reconstruction. The purpose of this study was to test this hypothesis.

METHODS

Forty mature sheep were randomly divided into 2 groups of 20 animals each. In each animal, the right knee underwent ACL reconstruction using the semitendinosus tendon autograft. In Group I, the ACL was completely resected before ACL reconstruction. In Group II, the ACL was transected at the mid-substance. Then, the graft was introduced through the tibial tunnel and the ligament tissue into the femoral tunnel. In each group, the graft was placed in bone tunnels, and fixed with an Endobutton (S&N) and a post-screw at 60° of knee flexion under the initial tension of 40N. Each 10 animals were sacrificed at 4 and 12 weeks after surgery. In each group, 14 knees were used for biomechanical evaluations, and the remaining 6 were used for histological and immunohistochemical evaluations. Statistical analyses were made using the Student's t test.

Results: The cross-sectional area of the graft was significantly thicker in Group II ($p=0.014$) than in Group I at 12 weeks. Concerning the anterior-posterior (A-P) translation at 12 weeks, it did indicate significant differences between the groups at 30°, 60°, and 90° of flexion ($p<0.002$). The initial stiffness of the load-displacement hysteresis loop was significantly greater in Group II ($p=0.032$) than in Group I. In tensile testing, there were no significant differences in the maximum load and stiffness between the groups at 4 and 12 weeks. Histologically, a thin synovial tissue was covered around the graft in Group I at 4 and 12 weeks.

In Group II, a thick synovial tissue was covered at 12 weeks. The continuity between the remnant tissue and the graft was observed in Group II at 12 weeks. Morphologically, S100 positive Ruffini and Pacini mechanoreceptors were found in all graft of Group II at 4 and 12 weeks, while not identified in Group I. A smooth muscle actin positive blood vessels were found in the graft of both groups at 4 weeks. Vessels were stained thicker in Group II than in Group I without irregularity.

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DISCUSSION

This study demonstrated a remnant tissue coverage significantly improved the A-P translation, the initial stiffness of the hysteresis loop, and the recovery of mechanoreceptors at 12 weeks after surgery. These results implied the sufficient remnant tissue coverage significantly enhances healing of the tendon graft after ACL reconstruction. We consider the sufficient remnant tissue coverage of the grafts may reduce elongation or failure of the grafts in the graft-remodeling phase, resulting in better knee stability. As to clinical relevance, preservation of the remnant tissues may be of potential benefit during ACL reconstruction, as some re-innervation and the recovery of proprioceptive potential may be possible, thus improving clinical outcomes.

REFERENCES

[1] Crain et al. Arthroscopy2005 [2] Denti et al. CORR1994 [3] Ochi et al. JBJSBr1999 [4] Adachi et al. AOTS2000 [5] Ochi et al. Arthroscopy2006