In Vivo Effects of Shrinkage with Radiofrequency Energy on the Anterior Cruciate Ligament: An Experimental Study with a Rabbit Model

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Introduction

Effects of radiofrequency (RF) energy on the anterior cruciate ligament (ACL) have not been sufficiently clarified. Our previous in vitro study (Arthroscopy 2004) demonstrated that the RF energy drastically reduced structural properties of the ACL immediately after surgery, while the RF energy significantly reduces the length of the ACL. Recently, a few studies have shown that RF energy significantly deteriorates structural properties of the whole ACL under in vivo conditions. However, these studies have ignored the existence of the untreated intact portion in a cross-section of the RF-treated lesion. In addition, these studies have not determined the mechanical properties of the RF-treated ligament, distinguishing it from those of the intact ligament tissue. No studies have been conducted thus far to clarify the in vivo effect of RF energy, quantitatively distinguishing the RF-treated portion from the untreated portion. The purpo! se of this in vivo experimental study is to clarify whether the mechanical properties of the ACL reduced by the RF shrinkage are then restored over time, when a sufficient volume of ligament tissues remains intact around the treated portion.

Material and Methods

Thirty skeletally mature rabbits were used in this study. In each animal, the right ACL was treated using the following quantitative technique. After the antero-medial (AM) and postero-lateral (PL) bundles of the ACL were identified, separation was then performed by a blunt probe between the two bundles. In each knee, RF energy set at a non-ablative level was applied to the whole PL bundle of the ACL with a bipolar RF generator (ArthroCare). The RF treatment was applied using 28-Watts for 5 seconds. Then, all the animals were randomly divided into 3 groups, Groups S0, S6, and S12, with 10 rabbits in each group. In these groups, 10 animals were sacrificed at 0, 6, and 12 weeks after surgery, respectively. Ten knees (Control group) randomly harvested from all left knees were used to obtain normal control data. As to the biomechanical evaluation, the anterior-posterior (A-P) translation of the knee was measured using a tensile tester! with a 5-DOF fixture under 10N forces at 30, 60, and 90 degrees of knee flexion. The cross-sectional area (CSA) of the whole ACL was measured with a non-contact optical method using a video dimension analyzer. Then, after the AM bundle was resected, the CSA of the treated PL bundle was measured, and the mechanical properties of the PL bundle were determined in tensile testing at a cross-head speed of 20 mm / min. Statistical analyses were made using the ANOVA with the Fisher's PSLD test for post-hoc multiple comparisons.

Result

Concerning the A-P translation of the knee, the ANOVA showed a significant difference among all the groups at each angle of knee flexion ($p < .0265$). The post?hoc test demonstrated that, at 60 degrees of knee flexion, there was a significant difference between Group S0 and the other groups. In tensile testing, the ANOVA demonstrated a significant difference in the tangent modulus among the groups ($p < .0001$). Groups S0, S6, and S12 were

significantly lower than the control group, respectively ($p < .0003$). In addition, Group S12 was significantly lower than Group S0 ($p = .0413$). Concerning the tensile strength, the ANOVA demonstrated a significant difference among the groups ($p < .0005$). Groups S0, S6 and S12 were significantly lower than the control group, respectively ($p < .0129$). In histological examination of Group S12, granulation-like tissues with numerous plump fibroblasts and inflammatory cells were predominantly found in t! he mid?substance of the PL bundle, where collagen fibers were loosely woven without the crimp pattern.

Conclusion

This study clearly demonstrated that, even when a sufficient volume of ligament tissues remains intact around the treated portion, the mechanical properties of the ACL reduced by the RF shrinkage are not restored in vivo, but the properties significantly deteriorate over time. This result indicated that the intact ligament tissue around the treated portion does not protect the RF-treated ACL tissue from the material deterioration. This study also showed that the application of RF energy to the PL bundle significantly reduced the A-P translation of the knee immediately after surgery, but that this shrinkage effect disappeared at 6 weeks. This result suggested that the ACL tissue shortened with the RF shrinkage treatment is elongated gradually over time. In the clinical field, many orthopaedic surgeons have the expectation that the ACL properties which are reduced by the RF shrinkage may be gradually restored over time, when some of! the ligament tissues remain intact around the RF-treated portion. This study cautioned against being too optimistic over a clinical application of RF energy to the ACL shrinkage.

Key word: Anterior cruciate ligament, Shrinkage, Radiofrequency, Mechanical properties

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