THE ACUTE EFFECT OF RADIOFREQUENCY ENERGY ON BIOMECHANICAL PROPERTIES OF THE ANTERIOR CRUCIATE LIGAMENT

INTRODUCTION

Previous studies have shown that radiofrequency (RF) energy produces significant shrinkage of joint capsular tissues [1, 2]. Therefore, this effect has been clinically applied to glenohumeral joint stabilization [3]. Recently, a few clinical reports have dealt with an application of the thermal shrinkage using RF energy to the chronically relaxed anterior cruciate ligament (ACL) [4, 5]. Amazingly, however, no basic studies have been conducted to evaluate the degree of reduction in biomechanical properties of the ACL after the shrinkage treatment. The purpose of this study is to clarify the acute effect of RF energy on biomechanical properties of the ACL.

MATERIALS AND METHODS

Fifty fresh femur-ACL-tibia complexes harvested from fully matured LWD pigs weighing approximately 100 kg were used in this study. Previous studies demonstrated that the porcine ACL is similar to the human ACL, and that it is an acceptable model for experimental studies [6]. In each specimen, the posterolateral segment of the ACL was resected. The femur-anteralmedial (AM) bundle-tibia complex specimens were randomly divided into 5 groups of 10 specimens each. In each group, RF energy set at non-ablative levels was applied to the AM bundle with a bipolar RF generator (Arthrocare, Sunnyvale, CA). In Groups I and II, the shrinkage treatment was applied for 30 seconds using 28-Watt (W) and 45-W power, respectively. In Groups III and IV, the shrinkage treatment was applied for 60 seconds, using 28-W and 45-W power, respectively. In Group V, no treatment was applied to the AM bundle in order to obtain the normal control data. During the RF treatment, each specimen was hung from a testing jig in physiological saline solution of 37 degrees Celsius, applying a constant load of 1 N. An orthopaedic surgeon performed the RF treatment simulating arthroscopic surgery. Namely, the surgeon approached to the mid-substance of the AM bundle with a bipolar RF probe from only the anterior direction. The treatment was applied to the anterior, medial, and lateral aspects of the AM bundle. In each group, 8 out of the 10 specimens were used for biomechanical evaluation, and the remaining 2 were used for histological observation with light and polarized light microscopy. In biomechanical evaluation, the cross-sectional area and the length changes of the ACL were measured with a non-contact optical method using a video dimension analyzer (VDA) before and after the treatment. The structural properties of the femur-AM bundle-tibia complex were determined in tensile testing at a cross-head speed of 50 mm/min. Statistical analyses were performed using the ANOVA with the Fisher’s LSD test for post-hoc multiple comparisons.

RESULTS

The length of the AM bundle was significantly reduced by 8%, 14%, 18% and 26% of the original length in Groups I, II, III, and IV, respectively (p<0.0001) (Fig 1). In tensile testing, the stiffness of the AM bundle was 126, 115, 116, 92, and 151 N/mm in Groups I, II, III, respectively (p<0.0001). The ANOVA showed a significant difference among the groups (p<0.0008). Groups II, III, and IV were significantly lower than Group V, respectively (p<0.02) (Fig 2). Concerning failure modes, all specimens were avulsed from the insertion in Group V, while 1, 3, and 4, and 8 out of the 8 specimens failed at the treated portion within the bundle in Groups I, II, III, and IV, respectively (Table 1). The maximum load of the femur-AM bundle-tibia complex was 894, 840, 840, 734, and 914 N in Groups I, II, III, IV, and V, respectively. The ANOVA showed a significant difference among the groups (p<0.0156). Group IV was significantly lower than Group V (p<0.0017). Histological examination showed diffuse collagenous denaturation (hyalinization) and pyknotic nuclear changes in fibroblasts at the RF treated portion within the bundle. The collagen striations (crimp pattern) were not present in treated area (Fig 3-a, b).

DISCUSSION

This study showed that the application of bipolar RF energy significantly reduces the length of the AM bundle of the ACL, dependent of its magnitude. This study also demonstrated that the application of RF energy deteriorated the structural properties of the AM bundle, dependent of its magnitude. When the AM bundle was shortened into 74% of the original length, the stiffness was reduced into 61% of the original value. Such magnitude of shortening is commonly required as a clinical treatment. Therefore, this study warned against too optimistic clinical application of RF energy to the ACL shrinkage before the database on the RF treatment for the ACL will be increased by in vivo studies to be conducted in near future.

REFERENCES