Radiofrequency Energy Effects on the Mechanical Properties of Tendon and Capsule

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Purpose: To compare the mechanical properties of tendon and capsule after radiofrequency (RF) energy treatment. **Type of Study:** An in vitro study. **Methods:** RF energy was applied to ovine extensor tendon and human cadaveric glenohumeral capsule varying in the treatment wattage and time (5, 10, or 20 W for 10 or 30 seconds). The associated tissue length changes and dynamic and failure properties of the tissues were investigated using a materials testing machine. **Results:** Length changes in the 2 tissues were comparable across the range of treatment settings used with both increases in the treatment wattage and time increasing the amount of tissue shrinkage observed. However, tendon showed greater changes in its mechanical properties after RF treatment, with significant decreases in the failure properties of the tissue as well as the dynamic and static stiffness. **Conclusions:** RF treatment shrinks collagenous tissues in a progressive manner correlated to the treatment wattage. However, it has different effects on the mechanical properties of tendon and capsule with the properties of tendinous tissues dramatically reduced. **Clinical Relevance:** RF treatment has been shown to effect the mechanical properties of different collagenous tissues differently; therefore, it must be used specifically and with caution around areas of mixed tissue origin. **Key Words:** Radiofrequency energy—Collagen—Joint stability—In vitro—Mechanical properties.

Radiofrequency energy (RF) combined with laser surgery has recently come to the attention of orthopaedic surgeons as a possible treatment for shoulder instability.[1-8] The advantage of this method is that it is less traumatic for the patient because of its arthroscopic application. Some studies have also reported a quicker healing response compared with conventional treatment methods.[9] The principle of RF treatment is to heat the redundant areas of tissue, causing them to shorten and thereby improving joint stability without the need for open surgery.

The heating of various collagenous tissues to induce shrinkage has been proposed for the treatment of a variety of orthopaedic conditions.[3,4,8,10-15] However, the mechanical properties of the tissues after heat treatment have not been well documented. There is conflicting evidence regarding the effect of RF on collagenous tissues,[16-23] further complicating the evaluation of the effectiveness of RF for use in orthopaedic surgery. The aim of this study was to objectively evaluate the effects of RF on 2 different types of collagenous tissue and to investigate if changes in the RF power level or treatment time alters the tissue response significantly.

Type I collagenous tissues that have been studied with RF treatment are capsule, ligament, and tendon. Although all these tissues are dense, regular connective tissues, there are important structural differences between these tissues, leading to their different mechanical properties and possibly different responses to RF treatment.

When collagenous tissue is heated with RF, the helical structure of collagen is thought to become unraveled and the amino acid chains to become randomly orientated.[24] The hypothesis of our study was

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0749-8063/05/2112-4443$30.00/0
doi:10.1016/j.arthro.2005.09.010

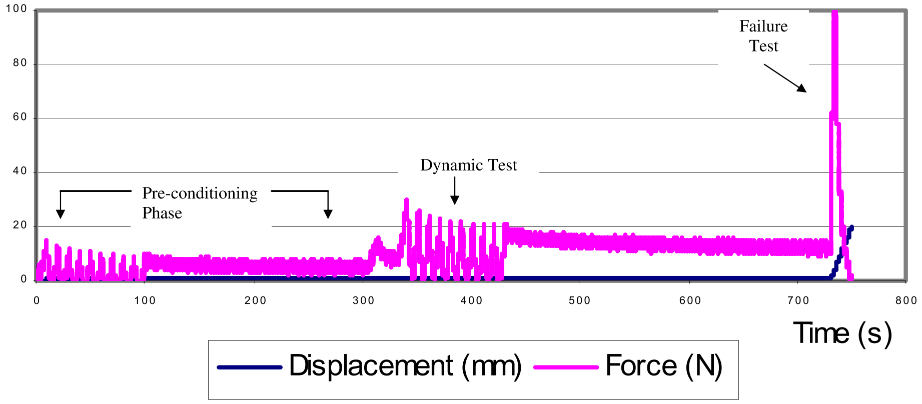

FIGURE 1. Mechanical testing regimen for the dynamic and failure properties of RF-treated tendon and capsule

that the more highly linearly structured tendinous tissue will, therefore, have a greater alteration in its mechanical properties than other collagenous tissues. This study examined the percentage of shrinkage and the mechanical properties on cyclic loading and tensile testing to failure of ovine tendons and human cadaveric shoulder capsule. The effects of RF treatment power and time on these 2 tissues were also examined.

METHODS

Seventy-eight specimens of extensor tendon were harvested from the hind limbs of skeletally mature sheep and fresh frozen before testing. The width and thickness were measured using digital calipers at 3 sites in the treatment area to determine the average cross-sectional area.

Capsule tissue was harvested from 12 human cadavers. The rotator cuff and inferior glenohumeral ligament were separated from the capsule to produce a purely capsular specimen rather than one of mixed tissue types. The capsular tissue was sectioned into longitudinal strips (from the humeral to scapula attachments) so that 60 specimens were obtained for testing. The cross-sectional area was obtained for each specimen as for the tendon specimens.

Treatment consisted of the application of RF using the Mitek VAPR generator and thermal electrodes with a bipolar coil tipped probe (Depuy Mitek Inc., Norwood, MA). RF energy was applied at 5, 10 or 20 W for either 10 or 30 seconds to the middle 10-mm portion of the specimen. One swipe over the 10-mm portion was performed for the 10-second groups and the 30-second groups received 2 even swipes down and back over the 30-second period.

Length changes were investigated in 6 tendon and 5 capsule specimens at each treatment setting. A constant tension of 0.1 N by a weight was applied to the specimens while suspended in a 0.9% solution of sodium chloride. This allowed the tissue to contract while maintaining some tension and for treatment to be applied evenly to the treatment area. The length was measured before and after treatment using digital calipers to calculate the percentage of shrinkage that occurred with treatment.

Mechanical testing consisted of 2 phases: (1) dynamic testing and (2) tensile testing to failure (Fig 1). Testing was performed on an 858 MTS Materials Testing Machine (MTS Systems, Minneapolis, MN) with 2 press grips holding each end of the specimen in the sodium chloride solution. The gauge length was measured using digital calipers before testing and each specimen was preloaded to approximately 5 N. Dynamic testing consisted of 5 tendon and capsule specimens for each treatment setting and a tendon control group not receiving any treatment. There were 2 subsequences: the pretreatment sequence consisting of 10 cycles of loading from 0.1 to 0.6 mm at a rate of 0.1 Hz as preconditioning and then holding at 0.6 mm for 3 to 4 minutes. After treatment, the specimens were cycled between 0.7 and 1.2 mm at 0.1 Hz. Analysis consisted of the last 3 cycles of the pretreatment phase to indicate the normal dynamic properties of the specimen while still cycling the tissue sufficiently to account for any hysteresis changes. The last 7 cycles after treatment were used for the dynamic properties postshrinkage.

Processing of the dynamic data was performed using Matlab (Mathworks, Natwick, MA) to convert the curves into Fourier series. The phase lag and dynamic modulus were determined. To analyze any changes in the tissues, the ratio of the treated tissue phase lag over the pretreatment phase lag was used. This ratio

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