Determination of Ligament Tension Using Raman Technique

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ABSTRACT

The incidence of acute rupture of the anterior cruciate ligament is about 1 in 3000 and more than 100,000 such injuries are surgically repaired each year in the United States [1]. Setting a proper tension on the graft is necessary for regaining normal anteroposterior translation. Using the 658 nm and the 785 nm lasers for excitation, Raman spectra of the ligament samples from mink and rabbit were measured as a function of the applied tension. A suture was attached to each end of the horizontally-mounted sample. The incident laser beam impinged at the sample at a 90º angle. Two points on the sample, located outside the measurement area, were marked with ink. The distance between the two points was measured before and after applying tension. The strain, defined as the fractional change of the sample length, was used as a variable. The Raman spectra were obtained at several points on the sample. Raman lines associated with the collagen backbone and with the amino acid residues attached to the backbone were observed. Both positive and negative changes in Raman frequencies were observed as the strain increases, consistent with those reported in the literature [2], [3]. Raman lines having their origin in the residues shift to higher frequencies whereas those with their origin in the collagen backbone shift to lower frequencies. The decrease in Raman frequency is associated with the elongation of collagen backbone. The change in Raman frequency is linear with increasing strain, consistent with the Hook's Law.

Keywords: Raman, anterior cruciate ligament, tendon, frequency shift, tension, strain, stress

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