Experimental Evaluation of Nonlinear Viscoelastic Behavior in Rabbit Ligament

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INTRODUCTION: The goal of this study was to characterize the viscoelastic behavior of the rabbit medial collateral ligament (MCL) at multiple levels of strain and their corresponding stresses for stress relaxation and creep, respectively. Herein, we hypothesized that in the rabbit MCL the rate of stress relaxation would be strain dependent and the rate of creep would be stress dependent. METHODS: White New Zealand rabbits were used in this study. The MCL with intact tibial and femoral sections was harvested and the bone blocks fixed with polyester resin in plastic molds. The specimen was then placed into the testing machine. Stress relaxation and creep tests were carried out with testing time of 100 seconds followed by a recovery time of 1000 seconds. The same general procedure was used for the creep tests except an idealized step load was applied. Load values corresponding to the peak force of the contralateral stress relaxation test were used in the creep tests. RESULTS: Results show the rate of stress relaxation is strain dependent in the rabbit MCL with the rate of relaxation decreasing with increasing tissue strain. The rate of creep is stress dependent in the rabbit MCL with the rate of creep decreasing with increasing stress. Statistical analyses reveal that the rate of stress relaxation is dependent upon strain p=0.0001, while creep is dependent on stress p=0.0001. Additionally, the rate of relaxation was approximately two fold greater than the rate of creep. DISCUSSION: Results reported herein support our hypothesis and show that the greatest nonlinearities observed is in the physiologically relevant, low-load region. The viscoelastic behavior seen herein has previously been observed in rat ligaments (1), and data from this study confirm similar nonlinear viscoelastic behavior in rabbit ligament. It also gives insight into the fact that nonlinearities in rates of creep and relaxation cannot be robustly modeled by the QLV formulation (2). The rabbit ligament however displays a greater nonlinearity in the rate of creep with changing stress than does the rat. Lastly, repeated tests carried out on the MCLs show only mild dispersion at the same strain or corresponding stress levels which provide confidence that specimens had effectively recovered in repeated testing. ACKNOWLEDGEMENT: This work was funded in by NSF grant # CMS-9907977. The authors thank Dennis Heisey for assistance with statistical analysis. REFERENCES: 1) Provenzano, PP et al., Ann Biomed Eng .29:908-914, 2001; 2) Lakes, RS and Vanderby Jr. R, J Biomech Eng .121:612-615,1999;

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