

Characterization of Porcine Cardiac Tissue Compressive Viscoelastic Properties for Human Models

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ABSTRACT

Accurate and reliable human tissue models require large amounts of data and are often difficult to develop due to the complex structure of biological tissue. The nonlinear, time and direction-dependent characteristics of soft tissues, combined with variances across species and collection sites poses unique challenges to the generation of accurate and consistent data. Additionally, quality and biofidelity of tissue properties degrade with time post mortem and cold/frozen storage. Therefore, the objective of the current study was twofold; to improve upon current literature for viscoelastic biological tissue material properties using fresh *ex vivo* porcine cardiac tissue in compression and provide a concise method of collection for future development of soft tissue properties. Fresh porcine cardiac tissue was received from a local abattoir and maintained at average human body temperature (+37° C) until tested within 8 h postmortem. Using an MTS hydraulic system, 12 fresh cardiac porcine specimens were compressed to a relative displacement of 35% at an average strain rate of 23.9/s perpendicular to the mean fiber direction (MFD). Peak stress and elastic moduli averages were determined to be 135.96 ± 51.68 kPa and 418.47 ± 178.64 kPa, respectively. Myocardium tissue demonstrates nonlinear and viscoelastic properties. These compressive viscoelastic data from fresh specimens can be used to supplement existing material property data in literature for the development of complex finite element models.

Keywords: Viscoelastic properties; stress relaxation; compressive behavior; cardiac muscle; left ventricle

INTRODUCTION

To better understand the factors that affect the biomechanical response of the heart, it is necessary to understand the tissue-level properties that contribute to the organ-level response mechanical stimuli. Reliable means to accurately measure stresses of the ventricular wall *in vivo* do not yet exist; at present, the most effective method is testing properties of sacrificed or donor cardiac tissue *ex vivo* [1]. Comprehensive mathematical tissue models are necessary to make experimental data meaningful over a range of conditions and are used to predict *in vivo* stresses and injury [1]. For example, the mechanical response of biological tissue is known to be nonlinear, viscoelastic and inhomogeneous, and these factors must be accounted for in accurate computational models. Finite element analysis is one effective numerical method, cited throughout literature, which helps model the mechanical response of biological tissues, organs and systems from input material properties [2, 3, 4]. Estimation of parameters for these numerical models requires accurate experimental data from laboratory testing to characterize the complex mechanical response of biological tissue [2, 3, 4, 5, 6]. To gain a better understanding, further research investigating the mechanical properties of myocardial tissue must be conducted [3].

Experimental compression data reported in literature covers a range of testing from high strain rate compression through the use of a split Hopkinson pressure bar on small specimens, to low rate tests at the

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