

A COMPARISON OF STRAIN RATE DEPENDENCY BETWEEN HUMAN PROSTATE AND OTHER SOLID ORGANS IN UNCONFINED COMPRESSION

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ABSTRACT

Background: Knowledge of material properties and behavior is essential to understanding organ response to external stimuli. However, in human solid organ models, due to a lack of knowledge researchers sometimes falsely assume that all organs behave similarly and use the same properties for different organs. The focus of this study was on identifying the response of the human prostate to unconfined compression loads and comparing the resulting material properties to other solid organs such as kidney, spleen, and liver.

Methods: Unconfined compression tests were performed on two fresh human prostates in vitro. A servo hydraulic material testing system (MTS, MN) was used to perform nondestructive testing (at strain rates of 1%/s to 25%/s) and destructive testing (at strain rates of 100%/s and 500%/s). Elastic modulus was calculated for all trials and failure stress and strain were calculated for the destructive tests. Failure was defined as a 10% drop in stress or if stress did not increase after a 3% increase in strain.

Results/Discussion: Prostate elastic modulus at rates of 1%/s to 25%/s ranged from 0.02 to 0.43 MPa. A strain rate dependency was observed between each tested rate, even at the lower rates. Failure stress was found to be 1.13 MPa at 100%/s and 2.08 MPa at 500%/s. Similarly, failure stress at 100%/s and 500%/s were measured as 53% and 66% respectively. Based on the results from our previous studies and other literature, the kidney, spleen and liver were found to be less stiff, had lower failure stress, and did not exhibit strain rate dependence at lower strain rates [1-5]. These results from our initial testing show that the prostate behaves very differently from other solid organs and provides direction for future research to further parameterize the behavior.

Keywords: Human abdominal organs, prostate, material properties

INTRODUCTION

Knowledge of human organ material properties is essential for several fields of study. However more recently researchers have been characterizing the material behavior of organs in order to develop comprehensive finite element models to study blunt force trauma [1]. The goal of these models is to aid in the prediction of injuries to abdominal organs and provide insight on the mechanism of injury. However, when researchers construct a comprehensive human body model, material properties of other organs are used to fill in gaps of the material properties for understudied organs [2]. Researchers are forced to assume that other organs have similar material properties and thus use the same properties for two different tissues. However, utilizing incorrect material properties could affect the efficacy of the model.

From the available research, it has already been established that material properties differ between organ types. For example, Umale et al. found that the elastic modulus of the kidney was 15 kPa while the liver modulus was 1.98 kPa using a compressive loading protocol [3]. Davis et al. observed that intestinal tissue was over 3 times stiffer than bladder tissue [4]. Failure properties were observed to be different between the liver and spleen as well. Kemper et al determined the failure stress and strain of the spleen

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