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PII: S1751-6161(14)00089-7
DOI: http://dx.doi.org/10.1016/j.jmbbm.2014.03.017
Reference: JMBBM1123

To appear in: *Journal of the Mechanical Behavior of Biomedical Materials*

Received date: 22 November 2013
Revised date: 22 March 2014
Accepted date:
25 March 2014

Cite this article as: M. Kavitha, M. Ramasubba Reddy, S. Suresh, Characterization of biomechanical properties of agar based tissue mimicking phantoms for ultrasound stiffness imaging techniques, *Journal of the Mechanical Behavior of Biomedical Materials*, http://dx.doi.org/10.1016/j.jmbbm.2014.03.017

Characterization of biomechanical properties of agar based tissue mimicking phantoms for ultrasound stiffness imaging techniques

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Abstract

Pathological changes of the body tissues have been observed to change the mechanical properties of biological tissue types. Ultrasound Elastography is a technique to image the mechanical properties of tissues. Though initial clinical results using Ultrasound Elastography imaging in detection of cancer lesions is promising, quantification of signal to noise ratio, resolution and strain image patterns are still researched and best achieved under a controlled study using tissue mimicking phantoms. Tissue mimicking phantoms should resemble human soft tissues in terms of its biomechanical properties for normal and abnormal categories. It is quite challenging to reproduce these properties in phantoms. The purpose of this work is to characterize the biomechanical properties of agar based tissue mimicking phantoms and identify the optimum property to be used in classification of cancerous tissues. We developed agar based tissue mimicking phantoms in which mechanical properties were varied by changing agar concentration from 1.7 % to 6.6 % by weight. We performed quasi static uniaxial compression test under a strain rate of 0.5 mm / min upto 15 % strain and found out the linear elastic modulus of phantom samples. The observed values are from 50 kPa to 450 kPa which is the similar range as usually encountered in soft biological materials. Phantoms show nonlinear stress strain characteristics at finite strain which were characterized using hyperelastic parameters by fitting Neo-Hookean, Mooney Rivlin, Ogden and Veronda Westmann models to the stress strain data. We also examined the nonlinearity of stress strain curve by computing stress differences at various strain levels to differentiate various stiffness inclusions. We also investigated viscoelastic parameters of the samples by