Elastically Anisotropic Phantoms Constructed from 3D-printed PLA Fibers

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Abstract

Many tissues including muscle, kidney, and breast are elastically anisotropic. Improperly considered, elastic anisotropy may confound elasticity imaging. However, if appropriately exploited, elastic anisotropy can be a relevant biomarker. To experimentally evaluate an elasticity imaging method's performance in mechanically anisotropic materials, calibrated tissue-mimicking phantoms are needed. The objective of this work is to demonstrate the feasibility of constructing mechanically anisotropic phantoms using 3D-printed PLA fibers embedded in gelatin or polyvinyl alcohol (PVA) cryogel. In this experiment, PLA fibers were 3D-printed and embedded in either gelatin or PVA. ARFI imaging was performed on the constructed phantoms. A computerized rotation stage enabled data acquisitions at 0°, 30°, 60°, and 90° concentric orientations, where 0° and 90° corresponded to the long-axis of a spatially asymmetric ARF excitation being aligned across and along the fibers, respectively. Degree of anisotropy (DoA) was calculated as the ratio of peak displacements at 90° versus 0° orientations. It was found that, while both gelatin and PVA embedded fibers demonstrated elastic anisotropy, DoA values were 32% higher in gelatin versus PVA phantoms. These pilot experimental results demonstrate that phantoms constructed of 3D-printed PLA fibers embedded in gelatin or PVA exhibit elastic anisotropy as assessed by ARFI ultrasound. Future work will investigate how fiber size and spacing impact mechanical anisotropy.