Application for QIBA Project Funding

Title of Proposal: Development and Validation of Simulations and Phantoms Mimicking the Viscoelastic Properties of Human Liver		
QIBA Committee/Subgroup: US SWS Tech Cmte		
NIBIB SOW Objective which this project addresses:		
Project Coordinator or Lead Investigator Information:		
Last Name: Palmeri	First Name: Mark	Degree(s): PhD, MD
e-mail:	Tel #:	
Institution/Company: Duke University, Department of Biomedical Engineering		
Amount Requested:		

Motivation

Experimentally, development of a dispersive phantom that models hepatic tissue and serves as a calibration standard for commercial systems has been a significant focus of the QIBA group. CIRS, Inc. and the University of Wisconsin-Madison (UWM) have been iterating on the design of liver-mimicking dispersive phantom materials for the ultrasound QIBA effort for the past year. Personnel at Duke University and the Mayo Clinic have been collaborating to test the phantom samples and compare their viscoelastic behavior to previously acquired *in vivo* liver data from Duke University. These efforts have been challenged by the lack of a pre-existing method for fabricating and calibrating dispersive phantoms, a variety of viscoelastic material models and data processing methods, and different metrics that can be used to compare them with the existing human data.

Proposal

We propose to combine the simulation and phantom data analysis efforts in this Round IV funding proposal. We will employ the viscoelastic simulations in both the commercial (LS-DYNA [Duke] and Abaqus [Mayo]) and developing open-source numerical tools (FEBio [Jiang] and finite-difference code [McAleavey]) to provide a reference standard for development and analysis of different processing algorithms to quantify the dispersive nature of the phantom and reference human datasets.

As Phase II phantom materials are established by CIRS and UWM, Mayo and Duke will continue to measure the test samples for consistency in viscoelastic behavior and reproducibility, and a consensus methodology and metrics will be recommended to the QIBA technical subcommittee how viscoelastic properties can be compared between researchers and manufacturers. This methodology and metrics will be validated with the known material parameters in the simulations, and ultimately the recommended methodology and metrics could be included in the QIBA profile.

We will refine the existing simulation tools to match the dispersive characteristics of the Phase II phantoms, and representative datasets will be made publicly-available on the RSNA QIBA QIDW US-SWS-Digital-Phantoms community. Mayo and Duke will reach a consensus on what viscoelastic material definitions and material constants can be used to represent the Phase II phantom samples and human liver shear wave data. This collaboration between institutions has been very valuable in the past year, and we expect to build upon this collaborative momentum in the coming year.

Given the challenges in having manufacturers provide the metadata for the focal configurations in acquiring shear wave data, both the Mayo and Duke research teams will simulate a parametric variable space of realistic focal configurations used in commercial systems to evaluate these effects on downstream estimated group and phase velocity profiles. This parametric variable space will include excitation duration, excitation F/#, focal depths and different shear wave arrival time estimators. The device manufacturers may then use this data with their proprietary algorithms and compare their results against the input parameters of the simulated media.

Select configurations from the Mayo and Duke FEM Phase II viscoelastic models will be used to test and validate the open-source numerical tools being developed by Drs. Jiang and McAleavey. If made available, the Mayo and Duke teams will process raw data from up to 10 *in vivo* datasets. Ideally the raw data will be provided in RF format (to avoid the complications of re-modulating IQ data acquired with a commercial system), and the necessary metadata associated with the raw data acquisition will need to be provided (see separate list of necessary metadata parameters). This processing of raw *in vivo* data will be optional, dependent on data availability, and none of the previously-delineated funding objectives are dependent on this specific task.