SOFT TISSUE CHARACTERIZATION: MECHANICAL PROPERTY DETERMINATION FROM BIOPSIES TO WHOLE ORGANS

Amy Elizabeth Kerdok
Division of Engineering and Applied Sciences, Harvard University, Cambridge, MA
Division of Health Science and Technology, MIT/Harvard, Cambridge, MA
kerdok@fas.harvard.edu

Less invasive imaging modalities and surgical simulations are technologies that greatly enhance clinical diagnosis, assessment, and predictive capabilities. Further advances in these technologies are limited by the lack of accurate and complete soft tissue data, understanding of whole organ behavior and validation tools.

The goal of this study is to use finite element analysis and to design new instrumentation to accurately characterize the complex nonlinear mechanical behavior of normal and pathologic soft tissues. This will be accomplished by adjusting the constitutive relations in a finite element model simulation until the predicted results match the experimental results obtained from force displacement measurement instrumentation. Measuring the properties of materials with known constitutive relations and demonstrating accurate finite element model predictions of these properties will validate this approach.

Initially we will use this modeling and testing approach to characterize a core needle biopsy of breast tissue in indentation. A finite element model has been developed that predicts published experimental data for indentation tests of cartilage within 6%. The model is currently being refined to determine the most appropriate constitutive relations and assumptions for breast tissue, kidney, spleen, and liver. The initial prototype for the mechanical testing device is being designed simultaneously.

The system will eventually be used to catalogue clinical data of the mechanical properties of both normal and pathologic soft tissue states. The system and the constitutive relations that emerge can be extended to predict whole organ behavior and to characterize other soft tissue samples both ex-vivo and in-vivo. The data will serve to validate less and noninvasive tissue property identification modalities such as elastography and surface tactile imaging of breast masses. They will also be useful as inputs for models requiring knowledge of tissue behavior such as those used in surgical simulations and robotic surgery.

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