Elasticity Imaging: Dynamic Approaches

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The mechanical characterization of tissues and lesions within tissues has been used by clinicians to determine states of disease. Clinicians characterize the mechanical properties of tissue through manual palpation, but not all tissues are accessible through this approach. Therefore, imaging modalities that can interrogate tissue to illicit this mechanical information are desired clinically. This short course will explore the use of ultrasound in imaging the mechanical properties of tissue and lesions through the use of dynamic excitation modalities. The fundamentals of ultrasound imaging, as related to dynamic tissue elasticity imaging, will be reviewed. A foundation for elastic material characterization will be established, including the relationships of force-displacement and stress-strain, the definition of elastic material properties (elastic moduli, Poisson's ratio, density), and the concept of stiffness, both structural and material. Linear isotropic materials will serve as the primary medium discussed in this course, but extensions will be made to anisotropic, viscoelastic, and nonlinear materials. Methods of static and dynamic excitation of soft tissue will be explored, using both external tissue compression/relaxation, and steady-state and impulsive acoustic radiation force excitation techniques. Imaging methods (MR and ultrasound) used to track static and dynamic displacement fields will be reviewed. The reconstruction of material properties from these dynamic displacement fields will be analyzed, including the use of inverse problems, the estimation of shear wave speeds, and the optimization and fitting of simplified viscoelastic and nonlinear tissue models.

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