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Quantitative Magnetic Resonance Imaging and Phantom Development

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Magnetic Resonance Imaging (MRI) uses strong magnetic fields and radiofrequency pulses to produce images of proton locations and properties. Image contrast reflects relative density of excited water protons, differences in relaxation times of water protons due to surrounding structure, and the sequence of RF pulses used to excite the water protons. MRI can be used to quantitatively measure longitudinal (T1) and transverse (T2) spin relaxation times, measure tissue volumes, track motion of water molecules (flow/diffusion), measure temperature, assess susceptibility differences, create maps of tissue electrical properties, etc. This talk will focus on quantitative measurement of relaxation times, diffusion and electrical properties. Diffusion MRI varies the homogeneous magnetic field using an initial gradient, followed by a refocusing gradient with the same magnitude with opposite direction: protons begin to precess at different rates, depending on the applied gradient, and will disperse. The refocusing gradient cannot refocus spins that have moved between gradient pulses, and the apparent proton diffusion can be calculated from the signal attenuation. Typically, gradient pulses are applied in three orthogonal directions to calculate a bulk diffusion coefficient. Tissue electrical properties can be mapped by measuring the complex RF transmit and receive fields (B1+, B1-). New methods estimate local electrical conductivity from *in vivo* B1+ phase measurements based on the homogeneous Helmholtz equation. Quantitative relaxation measurements, diffusion and electrical properties can distinguish healthy tissue from malignant tumor from benign tumor or identify the time of a particular event, e.g. a stroke. In this talk, I will describe how the NIST system, diffusion, and breast phantoms help validate these important measurements.