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Optical methods are promising for non-invasive tissue characterization. Biological tissues can be classified into isotropic tissues and anisotropic tissues. The optical properties of isotropic tissues such as adipose tissue are independent of measurement direction. However, optical properties of anisotropic tissues such as tendon are different along different measurement directions. Although optical measurement in isotropic tissue is established and widely applied, light propagation in anisotropic tissue is not well understood.

We used Monte Carlo simulation to study light propagation in fibrous tissues such as tendon and cartilage. Fibrous tissues were modeled as a mixture of aligned cylinders and randomly distributed background spherical particles. Both spatial- and time-resolved reflectance measurements were simulated and compared with predictions from anisotropic diffuse theory. Optical scattering and absorption properties of fibrous tissue can be measured by numerically fitting the analytical diffuse solution to time-resolved reflectance. The results indicated that both isotropic and anisotropic diffuse theory can be applied to derive the background optical properties of fibrous tissue. The scattering properties of the fibrous component can also be also determined if the fiber size is known.

Experimental studies were also conducted to study time-resolved reflectance in fibrous tissue by using a fiber optics based low-coherence Mach-Zehnder interferometer. The experimental system was validated in tissue phantoms. In tendon samples, the measured time-resolved reflectance was different at different measurement angles, which was satisfactorily explained by using the anisotropic diffuse theory. Both optical absorption and scattering properties can be derived by fitting the time-resolved isotropic diffusion solution to experimental measurements.