

Brillouin microscopy to image cell and tissue mechanical properties

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Brillouin spectroscopy has been widely used for decades to characterize material mechanical properties. However, due to the weakness of its signal, it was never considered viable in biomedicine. Developing a spectrometer with million-fold improved throughput and combining it with a confocal microscope, we developed Brillouin microscopy, a 3D imaging modality that uses the longitudinal modulus as contrast mechanism for imaging. Our first area of application has been in ophthalmology: e.g. 1) Lens biomechanics is involved in the loss of accommodation power (presbyopia) and the genesis of cataract but it is difficult to measure lens mechanical properties in vivo. 2) Loss of corneal strength leads to ectasia (thinning and bulging) and is a major risk factor for LASIK surgery; however, current diagnostic tools only rely on morphology, not on biomechanics. To address this issue, we have developed an in vivo Brillouin ophthalmoscope and have measured ~200 subjects so far. Encouraging data show we can differentiate ectatic corneas based on elasticity and characterize the most promising of treatments, collagen crosslinking. Recently we have increased Brillouin microscopy resolution to characterize intracellular modulus and we have now developed a flow cytometry platform to rapidly characterize cells based on their mechanical properties. As cells sense and respond to the mechanical forces of their surrounding microenvironment, cell mechanical signatures are promising as biomarkers and diagnostic indicators for underlying disease or treatment response.

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