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Optical Elastography and Measurement of Tissue Biomechanics

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Since the days of Hippocrates, it has been recognized that tissue mechanical properties can play a key role in the diagnosis and understanding of many diseases. For example, in cancer, the stromal response associated with tumor progression often results in stiffening of tissue surrounding tumor cells. In cardiovascular disease, atherosclerotic plaque mechanics are linked to plaque rupture.

Elastography—the use of medical imaging to map the mechanical properties of tissue—has been developed extensively over the past 25 years, based mainly on ultrasound and magnetic resonance imaging. These methods continue to develop, are available commercially, and are finding ever-growing application in the clinical and biological sciences. Although promising, these methods offer limited spatial resolution to detect small structures and lesions.

Over the last several years, the exciting prospect of adapting optical imaging methods, such as optical coherence tomography, to elastography has been investigated with increasing vigor. Due to its superior spatial resolution, optical elastography can be used to image the mechanical properties of biological tissues on a scale that cannot be achieved with other competing elastography modalities, e.g., ultrasound and magnetic resonance imaging. In addition, the exquisite subnanometer displacement sensitivity afforded by optical methods can enable the detection of more subtle changes in mechanical properties, potentially enabling disease to be imaged at an earlier stage than is currently feasible. Furthermore, realizing such methods using fiber optics allows for the development of compact endoscopic elastography probes for application in areas such as cardiology and pulmonology.

In this special section, fourteen papers highlighting the latest technical developments in optical elastography and measurement of tissue biomechanics are presented. Optical elastography methods are presented based on a number of imaging methods; optical coherence tomography, digital photography, ultrasound modulated optical tomography and laser speckle imaging. These methods are being developed for a range of medical applications, including in cardiovascular disease, breast cancer, ophthalmology, and skin disease.

A key element of elastography is the mechanism used to impart a mechanical load to the tissue being assessed. A number of methods are employed that generate either internal or external loads, and these loading mechanisms are applied either quasi-statically or dynamically. In this special section, papers are presented utilizing an external actuator [K. Kennedy et al., *J. Biomed. Opt.* **18**(12), 121508; S. Song et al., *J. Biomed. Opt.*, 121509], acoustic radiation force [Y. Cheng et al., *J. Biomed. Opt.* **18**(12), 121511], motion of magnetic nanoparticles [V. Crecea et al., *J. Biomed. Opt.* **18**(12), 121504], needle insertion [K. Kennedy et al., *J. Biomed. Opt.* **18**(12), 121510] and air-pulses [J. Li et al., *J. Biomed. Opt.* **18**(12), 121503].

Novel methods to measure tissue displacement in response to mechanical loading are investigated in several papers. Methods presented include advances in phase-sensitive detection [S. Song et al., *J. Biomed. Opt.* **18**(12), 121505], digital image correlation [C. Sun et al., *J. Biomed. Opt.* **18**(12), 121515; J. Fu et al., *J. Biomed. Opt.* **18**(12), 121512] and surface tracking [L. Coutts et al., *J. Biomed. Opt.* **18**(12), 121513].

The response of tissue to loads imparted by physiological processes is an exciting aspect of tissue biomechanics measurements. In this special section, two optical coherence tomography–based methods are presented to measure natural motion within the human eye [N. Dragostinoff et al., *J. Biomed. Opt.* **18**(12), 121502; K. O'Hara et al., *J. Biomed. Opt.* **18**(12), 121506].

The special section incorporates two invited papers. In the first, A. Nahas et al. [*J. Biomed. Opt.* **18**(12), 121514] present a combination of transient elastography with full-field optical coherence tomography, which provides higher spatial resolution than existing optical coherence elastography methods. In the second, S. Nadkarni [*J. Biomed. Opt.* **18**(12), 121507] presents a review of optical methods for measuring the mechanical properties of arterial tissue.

The advances being made in optical elastography and measurement of tissue biomechanics, as highlighted in this special section, suggest that these methods may well follow the precedent set by ultrasound and magnetic resonance imaging in translation of laboratory techniques to clinical and biological practice. The papers herein represent important steps along this path.

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Special Section Guest Editors