OPTICAL MICRO-ELASTOGRAPHY – IMAGING WITH FINE MECHANICAL CONTRAST ON THE SCALE BETWEEN CELLS AND WHOLE ORGANS

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The mechanical interactions of cells play an important role, in concert with biochemical interactions, in how they grow, differentiate and migrate. Impairment in a cell’s capacity to respond to mechanical forces contributes to the pathogenesis of diseases such as cancer¹, and leads to differences in biomechanical properties manifested on length scales from the cellular level, to the tissue microenvironment, to whole organs.

At the extremes of tissue length scales, the mechanical behaviour of individual cells may be probed by atomic-force and traction-force microscopy², and whole organs may be probed by medical elastography methods²,³. However, such methods are not well developed on the intermediate scale, between cells and whole organs, i.e., on a length scale ranging from 10 micrometres to 1 millimetre. We have been developing methods to characterize the mechanical properties of tissue microstructure on this length scale. They are based on compressive loading of whole tissues and measurement of the resulting displacement using three-dimensional optical coherence tomography⁴–⁷. By utilizing a similar signal processing approach to that used to measure fluid flow, it is possible to sense displacements with order 100-picometre sensitivity, enabling detection of exquisitely small variations in mechanical properties.

Such methods promise new information on the mechanical heterogeneity of tissues on intermediate length scales. We will present measurements on malignant and normal breast, lung, lymph node and muscle tissues that highlight the promise of these methods (Fig. 1).