Three-dimensional characterisation of cellular elasticity using quantitative micro-elastography

Matt S. Hepburn[a,b], Alireza Mowla[a,b], Jiayue Li[a,b], Samuel Maher[c], Danielle Vahala[c], Sebastian Amos[c], Farzan Navaeipour[a,b], Yu Suk Choi[c], and Brendan F. Kennedy[a,b]

[a]*BRITElab, Harry Perkins Institute of Medical Research, QEII Medical Centre, Nedlands and Centre for Medical Research, The University of Western Australia, Crawley, WA, Australia 6009.*

[b]*Department of Electrical, Electronic & Computer Engineering, School of Engineering, The University of Western Australia, Crawley, WA, Australia 6009.*

[c]*School of Human Sciences, The University of Western Australia, Crawley, WA, Australia 6009.*

The mechanical properties of cells and the extracellular matrix (ECM) are increasingly recognised as critical regulators of cell functions including growth and differentiation [1]. The field of mechanobiology seeks to understand, quantitatively, how mechanical properties, such as elasticity, influence cell function. However, whilst it is established that accurate measurement of cell mechanical properties should be performed in a three-dimensional (3-D) environment, *e.g.*, 3-D biomaterials, techniques available to quantify mechanical properties on the microscopic scale are typically limited to two-dimensional (2-D) surface characterisation or analysing cells in isolation. Optical coherence elastography (OCE) holds potential to characterize the mechanical properties of cells in 3-D within their microenvironment [2]. OCE refers to a range of techniques that use optical coherence tomography (OCT) to map the mechanical properties of tissue into an image. OCE features three key steps: (1) deforming the sample by applying a mechanical load, (2) measuring deformation using OCT, and (3) relating deformation to a mechanical property using a mechanical model. Quantitative micro-elastography (QME) is a variant of compression-based OCE that maps elasticity throughout a sample volume with micro-scale resolution over millimetre fields of view [3]. In this work, we present the development of QME to characterise the elasticity of cells and the ECM in 3-D biomaterials. Our results demonstrate that QME can reveal elevated elasticity in local regions surrounding cells and can distinguish between different cell types. Furthermore, we demonstrate the ability of QME to characterise intra-cellular elasticity in both cells and cell spheroids. We believe QME has potential to bridge the gap between the large body of existing research in 2-D substrates and how mechanical properties influence cell behaviour *in vivo*.

[1] B. Ladoux and R. M. Mège, "Mechanobiology of collective cell behaviours," *Nature Reviews Molecular Cell Biolology*, vol. 18, pp. 743–757, 2017.

[2] K. V. Larin and D. D. Sampson, "Optical coherence elastography – OCT at work in tissue biomechanics [Invited]," *Biomedical Optics Express*, vol. 82, pp. 1172–1202, 2017.

[3] K. M. Kennedy, L. Chin, R. A. McLaughlin, B. Latham, C. M. Saunders, D. D. Sampson, and B. F. Kennedy, "Quantitative micro-elastography: imaging of tissue elasticity using compression optical coherence elastography," *Scientific Reports*, vol. 5, 15538, 2015.