Medical Engineering and Physics 72 (2019) 76–77

Contents lists available at ScienceDirect

Medical Engineering and Physics

journal homepage: www.elsevier.com/locate/medengphy

Editorial

40th Anniversary Issue: Reflections on papers from the archive on "Mechanobiology"

Mechanobiology is an interdisciplinary field that concerns the relationships between a cell and its environment. It explores the complex molecular and biophysical interactions that take place at the cell and sub-cellular levels in relation to the extracellular matrix in the context of healthy and diseased tissues of the body. Measurements on such short length and time scales between a cell and its surroundings represent major challenges for research. A special section on the topic appeared in the Journal in 2005 (Volume 27, Issue 9). Edited by A.S.G. Curtis and M. Riehle, the section features the pioneering work of Curtis and his colleagues to ascertain the traction forces exerted by individual cells on a substrate, and how surface topography may be used to direct cellular behaviours in terms of cell growth, migration and differentiation. The use of bioreactors to exert physical forces on cells, and thereby induce deformation of the cytoskeleton by means of physical phenomena, such as electromagnetic interactions, piezoelectric effects and fluid flows in order to stimulate cells on biomaterial substrates and within 3D scaffolds, has been the subject of intense research in recent years. Mechanobiology plays an important role in tissue remodelling and pathophysiology. Its role in the context of wound healing, in particular, is the subject of an invited contribution elsewhere in this special issue.

This selection of papers from the archive is intended to highlight studies on this emerging topic that have appeared in the Journal in the past 20 years. These works examine the properties and structure of the cytoskeleton and the cellular responses to deformation and flow by a process known as *mechanotransduction*. The papers were identified using key words such as *cytoskeleton dynamics*, *membrane dynamics*, *mechanosignaling*, *genome regulation*, *cell development*, *pathogenesis*, *cell physiology*, *cell differentiation* and *disease*. They range from basic studies on the intrinsic mechanical properties of the cell and sub-cellular components, numerical modelling of deformation and fluid displacement within tissues subjected to load, and the apparatus used to apply those deformations and assess the responses of cells and tissues under controlled conditions within bioreactor systems in vitro. The potential for researchers to exploit such techniques for screening purposes is explored in several papers that investigate the mechanical properties of the cells of the immune system, model the intracellular properties of cells and examine the uptake of nanoparticles by cancer cells – studies that may lead eventually to new techniques and therapies to diagnose and treat cancer.

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Further reading

Abuhattum S, Weihs D. Asymmetry in traction forces produced by migrating preadipocytes is bounded to 33%. Med Eng Phys 2016;38(9):834–8.
Adekanmbi I, Franklin S, Thompson MS. A novel in vitro loading system for high frequency loading of cultured tendon fascicles. Med Eng Phys 2013;35(2):205–10.
Ahn AC, Grodzinsky AJ. Relevance of collagen piezoelectricity to "Wolff's law": a critical review. Med Eng Phys 2009;31(7):733–41.
Chen TJ, Wu CC, Su FC. Mechanical models of the cellular cytoskeletal network for the analysis of intracellular mechanical properties and force distributions: a review'. Med Eng Phys 2012;34(10):1375–86.
Couet F, Meghezi S, Mantovani D. Fetal development, mechanobiology and optimal control processes can improve vascular tissue regeneration in bioreactors: an integrative review. Med Eng Phys 2012;34(3):269–78.
Curtis A. Cell forces in tissues. Med Eng Phys 2005;27(9):773–9.
Dalby MJ. Topographically induced direct cell mechanotransduction. Med Eng Phys 2005;27(9):730–42.
Du MM, et al. Biomechanical properties of human t cells in the process of activation based on diametric compression by micromanipulation. Med Eng Phys 2017;40:20–7.
Gal N, et al. Effects of particle uptake, encapsulation, and localization in cancer cells on intracellular applications. Med Eng Phys 2015;37(5):478–83.
Gefen A, Weihs D. Cytoskeleton and plasma-membrane damage resulting from exposure to sustained deformations: a review of the mechanobiology of chronic wounds. Med Eng Phys 2016;38(9):828–33.
Gillies A, Willshaw D. Models of the subthalamic nucleus – the importance of intranuclear connectivity. Med Eng Phys 2004;26(9):723–32.
Gonzalez-Torres LA, et al. Influence of the frequency of the external mechanical stimulus on bone healing: a computational study. Med Eng Phys 2010;32(4):363–71.
Han SK, Colarusso P, Herzog W. Confocal microscopy indentation system for studying in situ chondrocyte mechanics. Med Eng Phys 2009;31(8):1038–42.
Hughes S, El Haj AJ, Dobson J. Magnetic micro- and nanoparticle mediated activation of mechanosensitive ion channels. Med Eng Phys 2005;27(9):754–62.
Jungreuthmayer C, et al. Deformation simulation of cells seeded on a collagen-GAG scaffold in a flow perfusion bioreactor using a sequential 3D CFD-elastostatics model. Med Eng Phys 2009;31(4):420–7.
Kamada H, et al. Computational analysis on the mechanical interaction between a thrombus and red blood cells: possible causes of membrane damage of red blood cells at microvessels. Med Eng Phys 2012;34(10):1411–20.

https://doi.org/10.1016/j.medengphy.2019.09.005

King JD, York SL, Saunders MM. 'Design, fabrication and characterization of a pure uniaxial microloading system for biologic testing'. Med Eng Phys 2016;38(4):411–16.
Knight MM, et al. Measurement of the deformation of isolated chondrocytes in agarose subjected to cyclic compression. Med Eng Phys 1998;20(9):684–8.
Kreutzer J, et al. Pneumatic cell stretching system for cardiac differentiation and culture. Med Eng Phys 2014;36(4):496–501.
LaMothe JM, Hamilton NH, Zernicke RF. Strain rate influences periosteal adaptation in mature bone. Med Eng Phys 2005;27(4):277–84.
Leucht P, et al. Primary cilia act as mechanosensors during bone healing around an implant. Med Eng Phys 2013;35(3):392–402.
Manzoli V, et al. Engineering human renal epithelial cells for transplantation in regenerative medicine. Med Eng Phys 2017;48:3–13.
Miramini S, et al. Influence of fracture geometry on bone healing under locking plate fixations: a comparison between oblique and transverse tibial fractures. Med Eng Phys 2016;38(10):1100–8.
Peperzak KA, Gilbert TW, Wang JHC. A multi-station dynamic-culture force monitor system to study cell mechanobiology. Med Eng Phys 2004;26(4):355–8.
Rosa N, et al. From mechanical stimulus to bone formation: a review. Med Eng Phys 2015;37(8):719–28.
Scannell PT, Prendergast PJ. Cortical and interfacial bone changes around a non-cemented hip implant: simulations using a combined strain/damage remodelling algorithm. Med Eng Phys 2009;31(4):477–88.
Schwarz US, Bischofs IB. Physical determinants of cell organization in soft media. Med Eng Phys 2005;27(9):763–72.
Srinivasan S, Gross TS. Canalicular fluid flow induced by bending of a long bone. Med Eng Phys 2000;22(2):127–33.
Steck R, Niederer P, Tate MLK. A finite difference model of load-induced fluid displacements within bone under mechanical loading. Med Eng Phys 2000;22(2):117–25.
Thompson MS, et al. Digital image correlation: a technique for determining local mechanical conditions within early bone callus. Med Eng Phys 2007;29(7):820–3.
Tomaiuolo G, et al. Microconfined flow behavior of red blood cells. Med Eng Phys 2016;38(1):11–16.
Yang J, et al. The myogenic response in isolated rat cerebrovascular arteries: smooth muscle cell model. Med Eng Phys 2003;25(8):691–709.
York SL, Sethu P, Saunders MM. In vitro osteocytic microdamage and viability quantification using a microloading platform. Med Eng Phys 2016;38(10):1115–22.