Elastic properties of living cells studied by multimodal atomic force microscopy

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Abstract

Many cellular biophysical mechanisms are directly related to the cell viscoelastic properties. We have used a combined light fluorescence and atomic force microscope in quasi-static mode to quantitatively map local elastic properties and measure volume of living cells in physiological buffered solution. A few different contact mechanics models were used to numerically extract the cellular elastic parameters from the AFM force-volume data. The accuracy in the numeric simulation and evaluation was investigated. The force-volume imaging was also successfully used to image ultrastructure on delicate biological samples where standard AFM imaging modes failed. We present a few examples where the technique has been used, complementary to other microscopic methods, to solve cellular biophysical problems. First, neuronal growth and degeneration mechanisms have been studied. The extension and reorganization of growth cones and dendritic arborization are related to the local elasticity and to the neuronal plasma membrane tension. Secondly, the physiological role of hemichannels in extracellular calcium dependent cell volume regulation, cell stiffness and cytoskeletal reorganization have been studied. Finally, the nanomechanics of fibroblast cells and its correlation with the underlying ultrastructural substrate have been investigated.