Are rigidity-dependent cellular contractile forces indeed mechanosensitive?

Abstract:

It is experimentally well-established that contractile forces generated by adherent cells, F(t), depend on the rigidity, k, (and possibly other properties) of the extracellular matrix. These robust experimental observations are regarded as one of the major manifestations of cellular mechanosensitivity, i.e. a feedback between mechanical stimulation and cellular activity (here, between the rigidity of the extracellular matrix and the contractile forces generated by the cells). We develop an actomyosin-based model of cellular contractility that suggests that cells in fact actively generate a time-dependent contractile displacement d(t) INDEPENDENTLY of the rigidity of the extracellular matrix. Consequently, the contractile force depends trivially on the rigidity of the extracellular matrix, F(t) = d(t) k, without any feedback on cellular active contractility. We perform micropillar array experiments and demonstrate a collapse onto a master curve when F(t)/k is plotted, strongly supporting our basic result. We show that data available in the literature follow the same master curve. The model is also consistent with direct experiments on stress fibers, such as laser cutting and sarcomere dynamics, and with the possible dependence of the focal adhesion area on the extracellular matrix rigidity. Additional implications of the model are briefly discussed, along with their ongoing investigation.