A plastic relationship to tension keeps cell-matrix adhesions focal and transient

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Keywords: Cell adhesion, tension, vinculin, adhesion dynamics, size control

Abstract

Cell adhesion is a key process involved in cell migration, proliferation, survival and differentiation, as well as in several patho-physiological conditions such as cancer. These cellular functions are tuned depending on the cellular microenvironment and the external forces applied, but the role that cellular tension plays in modulating cell adhesion remains poorly characterised. Quantitative live cell imaging of H1299 cells expressing a FRET-based vinculin tension sensor (TS) allowed us to clarify the relationship between vinculin- mediated tension and cell-matrix adhesion complex (CMAC) dynamics. Here, we show that the relationship between vinculin-mediated tension and CMAC area is complex, non-monotonic, and non-linear. The multimodal nature of this relationship defines a probabilistic landscape that explains empirically observed limits to CMAC area and CMAC lifetime. Moreover, time-resolved cross-correlation analysis also reveals that vinculin-mediated tension indeed drives large changes in CMAC area. Surprisingly, modelling on this background not only reproduces empirical area and lifetime distributions, but also predicts the existence of CMAC attractor states, where both vinculin-mediated tension and CMAC area remain stable. We find empirical evidence of these attractors as overrepresented CMAC area categories, whose proportion was further increased upon nocodazole treatment. This suggests that the known mechanism of catastrophic CMAC disassembly through microtubule-targeting may provide a mechanism for attractor state exit and associated CMAC disassembly.