Mechanical traits of isolated nuclear membranes elucidated via force spectroscopy

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In normal cells, the larger stiffness of the nuclei when compared to the rest of the cell imposes a key restriction to cell deformability and, therefore, to cell migration and their capability to traverse interstices. In contrast to nuclei featured by the aforementioned cells, cancerous cells have been reported to exhibit larger and poorly-defined nuclear shapes. Upon probing the mechanical properties of these abnormal nuclei, the measured membrane rigidities were found to be below that of normal nuclei, thus making them easier to deform. A plausible explanation for this phenomenon is an altered distribution of the nuclear chromatin, which render the nuclei incapable of dampening external forces acting upon them. This argument is in line with the increased migration capabilities of invasive nuclei and their enhanced adaptability to the abnormal forces these cells experiment. Moreover, it is worth mentioning that, as a mechanical response to mechanical stresses, the normal function of the nuclei is altered and can induce changes such as gene expression alteration in the cell. Despite the obvious relevance of the nuclear mechanical traits, few works report data directly acquired on nuclear membranes without any participation from the plasma membrane, which is bound to induce alterations that may disrupt results yielded by high sensitivity tests such as those performed using optical tweezers.

In the present work, optical tweezers are used alongside force spectroscopy to test the mechanical traits of isolated nuclear membranes. Membranes' Young moduli and, therefore, stiffnesses are calculated by performing indentation/retraction cycles inducing gentle deformation on the membranes using an optically trapped microbead. Nuclear membrane responses are studied as a function of the frequency with which cycles were performed to highlight possible dependency on the time lapse over which the perturbation is applied. Additionally, drastic pushing of the trapped bead against the membranes and pulling motions were performed to trigger more dramatic mechanical responses from the nuclei. During those perturbations, maximum indentation depth and maximum tension could be measured from simultaneously acquired confocal microscopy images.