Supporting Information detailing estimation of strain

Strain profiles of the thin membrane on which cells were cultured were estimated using theoretical methods. In addition to strain, we confirmed that shear was not a major factor using monitoring of dye injection.

Estimation of Strain

The average radial strain of a free deforming circular membrane was determined using equation 1 which uses the central deflection point (ω_0) and the undeformed radius (R_m) of the membrane.

$$\varepsilon_R \approx \frac{2\omega_0{}^2}{3R_M{}^2} \qquad (1)$$

To experimentally validate our strain estimations, PDMS posts of known height were placed underneath the membrane as pressure was applied across the surface. To minimize shear stress the inlet and outlet direct their flow above and parallel to the cell layer. To visualize the flow lines dye was injected into the media reservoir and its flow within the chamber monitored. The dye reached the bottom of the chamber primarily through diffusion and not via active convective transport indicating minimal shear stress at the cell layer (data not shown).