Abstract: Biological cells are complex living systems that can be viewed as micromachines, which derive their many mechanical functions from the biomolecular motors within the cell. The forces cells apply to their surroundings control processes such as growth, adhesion, development, and migration. Experimental techniques have primarily focused on measuring tractions applied by cells to synthetic two-dimensional substrates, which do not mimic in vivo conditions for most cell types. This talk will describe an experimental approach to quantify cell tractions in a natural three-dimensional matrix. Cells and their surrounding matrix are imaged in three dimensions with confocal microscopy; cell-induced matrix displacements are computed using digital volume correlation; and tractions are computed directly from the full-field displacement data. The technique is used to investigate how cells employ physical forces during cell division, spreading and sensing. In a three-dimensional matrix, dividing cells apply tensile force to the matrix through thin, persistent extensions that in turn direct the orientation and location of the daughter cells. During spreading, cells extend thin protrusions into the matrix and apply force using these protrusions. The cell forces induce deformations along directed linear paths in the fibrous matrix. A constitutive model is developed that accurately predicts the propagation of cell-induced displacements through the matrix. The model describes how cells use nonlinearities in the fibrous matrix to enable long-range cell-cell mechanical communication.

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