Microstructural-mechanical image correlation for quantifying cell tractions in a three-dimensional fibrous matrix

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During processes such as development and cancer metastasis, cells migrate into three-dimensional fibrous matrices. Previous studies have speculated on the mechanical forces required for migration by observing matrix fiber alignment, densification, and degradation, but these forces remain difficult to quantify. Here, we present a new experimental technique to simultaneously measure full-field 3D displacements and structural remodeling of a fibrous matrix, both of which result from cellular forces. We apply this "2-in-1" experimental technique to dynamically follow single cells invading into a physiologically relevant fibrin matrix. We find regions with unique signatures of matrix structural remodeling showing large elastic and plastic deformation of the matrix, and we reveal that cells invade by using both pushing and pulling forces.