“Characterizing the Deformation Signatures of Human Neutrophils in Two and Three-dimensional Environments”

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Abstract: Neutrophils are the first responders to defend the body against life threatening bacterial diseases, infections and inflammation. In navigating to the site of infection, neutrophils are exposed to changing microenvironments that differ not only in their structure, composition and mechanical properties but also in their dimensionality (2D vs. 3D). This talk will highlight the pivotal role mechanics plays in understanding neutrophil motility as a function of the dimensionality and compliance of its microenvironment, and how material deformations might be used as a clinical metric to characterize a potentially life-threatening disease state. First, I will provide a quantitative mechanical description of how neutrophils perceive both the stiffness and dimensionality of their surrounding environment by analyzing their motility and 3D cell traction signatures in two and three dimensions. By utilizing an interchangeable 2D-3D sandwich gel structure system with tunable mechanical properties, I will show that neutrophils have the ability to switch from an integrin-dependent 2D to an integrin-independent 3D migration phenotype provided sufficient 3D spatial confinement and the presence of cell tractions. Finally, I will quantify the material strains induced by migrating neutrophils through 3D collagen matrices during chemotaxis. Utilizing our recently developed fast, iterative digital volume correlation (FIDVC) technique, I will show that these cells generate highly localized, and finite strain fields indicative of their phenotype and motility status. Putting these results in the context of a biologically important question, my talk will contrast the deformation fields of healthy human neutrophils to septic neutrophils to characterize differences in how these cells interact with their surrounding collagen matrix. Given that sepsis is a serious medical condition with not current treatment, a quantitative understanding of the deformation signature of these cells during migration could provide much needed new insight into the importance of physical cues during the progression of the disease.

Bio: Christian Franck is a mechanical engineer specializing in biomechanics and new experimental mechanics techniques at the micro and nanoscale. He received his B.S. in aerospace engineering from the University of Virginia in 2003, and his M.S. and Ph.D. from the California Institute of Technology in 2004 and 2008. His doctoral research was on the development of a quantitative three-dimensional experimental technique for applications in soft biomaterials and cellular traction investigations. Dr. Franck held a post-doctoral position at Harvard investigating brain and neural trauma before beginning his appointment at Brown in 2009.