Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Computational Modeling and Simulation of Leukocyte Rolling Adhesion VIJAY PAPPU, PROSENJIT BAGCHI, Rutgers University — A 3D computational model is presented to simulate transient rolling adhesion and deformation of leukocytes over a selectin coated surface in shear flow. The model is based on immersed boundary method for cell deformation, and Monte Carlo simulation for receptor/ligand interaction. The model is shown to predict the characteristic 'stop-and-go' motion of rolling leukocytes. We examine the effect of cell deformation, shear rate, and microvilli distribution on the rolling characteristics. We observe that compliant cells roll more stably, and have longer pauses due to reduced bond force and increased bond lifetime. Microvilli presentation is shown to affect rolling characteristics by altering the step size, but not pause times. Adhesion is seen to occur via multiple tethers, each of which forms multiple selectin bonds, but often one tether is sufficient to support rolling. The adhesion force is concentrated in only 1–3 tethered microvilli in the rear-most part of a cell. We also observe that the number of selectin bonds that hold the cell effectively against hydrodynamic shear is significantly less than the total adhesion bonds formed between a cell and the substrate. The force loading on individual microvillus and selectin bond is not continuous, rather occurs in steps. Further, we find that the peak force on a tethered microvillus is much higher than that measured to cause tether extrusion.

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Date submitted: 03 Aug 2007 Electronic form version 1.4