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Mechanical Monte-Carlo modelling of the cell-wall interface without damping

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Summary

Cell adhesion is an important phenomenon in several biological phenomena such as the immune defence and the cell division (Bongrand et Benoliel 1999). The adhesion of a single cell to another cell or to a wall combines two different mechanisms occurring at specific scales: the molecular kinetics of adhesion and rupture at the microscopic scale and the active deformation of the cell at a mesoscopic scale (Bongrand et Benoliel 1999, Sagvolden et al. 1999). The purpose of this contribution is the mechanical description of the rupture and adhesion of bonds occurring at the interface between a single cell and the wall during the rolling, extending a preliminary model reported in (Mefti et al. 2006): improvements are made herewith regarding the shape of the distribution of the fluid action and the limit of failure of the connections by the use of pseudo random sequences without spatial correlation. The rolling represents the motion of the cell along the wall of an extracellular matrix (ECM), as the net result of the combination of creation and failure of ligand-receptors connections. We assume that the ECM-cell interface is composed of two elastic beams linked by springs, subjected to the pressure of the surrounding fluid flow, to Van der Waals attractive forces and to electrostatic repulsive interactions. These connections are characterized by probabilistic fluctuations of their limit of rupture, as a way to account for the random fluctuation of cell adhesion as reported in experimental studies. Numerical simulations emphasize the behaviour of the interfacial zone during the rolling phenomenon through the time evolution and position of the failed and newly established connections. The global simulated force corresponding to the total rupture of the adhesion zone (0.01 nN) is in accordance with the value of the adhesion forces presented in (Bongrand and Benoliel 1999).

References

Mechanical modeling of the rolling phenomenon at the cell scale. N. Mefti, B. Haussy, J.-F. Ganghoffer. Int. J. Solids and Struc