Computer simulation of cellular shape based on elastic deformation

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Abstract

A computer simulation of elastic deformation of a cell was conducted to investigate effects of focal adhesions on the cellular shape. A fibrosarcoma suspended in a stationary fluid was modeled as a spherical elastic capsule, where an elastic surface membrane was assumed to represent all mechanical elements of the cell. In a simulation of cell deformation, at first, focal adhesions were positioned on a flat plane based on an experimental observation. A spherical model cell was placed on the flat plane. Second, a nodal point of the spherical cell was selected so that the distance between the nodal point and a certain single focal adhesion was the minimum. Third, all selected nodal points were moved to the positions of corresponding focal adhesions on the flat plane (Fig. 1a), and they were fixed as a boundary condition of elastic deformation. Finally, an equilibrium cell shape was obtained as a result of elastic deformation simulation [1,2]. In the simulation, a cellular shape was changed from a spherical shape to a flatten and stretched one because the cell was pinned at focal adhesions in the deformation. Arcuate contours were obtained in the equilibrium shape, where focal adhesions were positioned at the ends of each arcuate contour (Fig. 1b). The simulated cellular shape was consistent with a cellular shape observed in in vitro experiment, indicating that elastic deformation constrained by focal adhesions plays an important role in determining various cell shapes which appear in locomotion of a cell. In an undergoing work, mechanical structures inside a cell and their changes due to biochemical events are taken into account to quantitatively predict a reaction force at a focal adhesion, as well as interrelation between the reaction forces and assembly/disassembly of the focal adhesions as an important factor in locomotion [3].

Keywords: Computational biomechanics, Adhesive cell, Locomotion, Elastic deformation, Focal adhesion.

References

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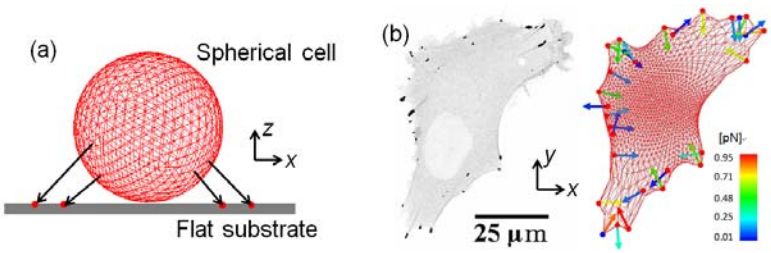

Fig. 1 Elastic deformation simulation of adhesive cell. (a) Simulation model. (b) Cellular shapes after spreading observed in experiment (left) and predicted by computer simulation (right)