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薄壁细胞受微吸管与探针共同作用接触模型及数值模拟

The contact model and numerical simulation of parenchyma cell aspirated by micropipette and squashed by mechanical probe

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中文关键词： 细胞力学模型 微吸管 微探针 计算生物力学

英文关键词:cell mechanical model micropipette microprobe computational biomechanics

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中文摘要:

建立了以典型的薄壁球型植物细胞为原型的细胞、微吸管及探针接触模型。模型的细胞壁采用封闭球形薄膜,其本构关系为体积不可压超弹性,膜球内充满有压流体以模拟细胞质。应用轴对称几何非线性方法得出了基本微分方程组,并应用龙格-库塔法进行了求解;同时,应用流固耦合有限元法进行了数值模拟以资比较。两种方法得出了较为一致的变形和应力分布。分析、总结了吸管口径和探针直径对压入深度、细胞内压和接触区变化等数值解的影响。

英文摘要:

A numerical model was formed from a typical parenchyma spherical plant cell to show the contact behavior of a cell suckled by a micropipette and squashed by a probe. The cell was built as a spherical membrane filled with static liquid. The incompressible hyper-elastic constitutive was used for cell wall, the incompressible hydrostatic fluid was used to simulate inner cytoplasm. The contact model was used to simulate the interaction of membrane touching with micropipette and microprobe. Considering nonlinear geometric and physic relations, the differential control equations were deduced. The numerical solutions were obtained through Runge-Kutta method. As a comparative solution, the cell was also modeled and simulated by fluid-solid coupled finite element method. The solutions of the two methods were fairly agreed with each other. Finally, looking into the solutions of deformation, inside pressure, stresses on the wall and contact forces, the effect of inner diameter of pipette and diameter of probe to these results were discussed.

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