Role of tissue surface tension in the morphogenesis of brain organoids

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Abstract

Understanding the mechanics of brain embryogenesis can provide insights on pathologies related to brain development, such as *lissencephaly*, a genetic disease which cause a reduction of the number of cerebral sulci. Recent experiments on brain organoids have confirmed that gyrification, i.e. the formation of the folded structures of the brain, is triggered by the inhomogeneous growth of the peripheral region [1]. However, the rheology of these cellular aggregates and the mechanics of lissencephaly are still matter of debate [2, 3].

In this talk, we develop a mathematical model of brain organoids based on the theory of morpho-elasticity. We describe them as non-linear elastic bodies, composed of a disk surrounded by a growing layer called cortex. The external boundary is subjected to a tissue surface tension due the intercellular adhesion forces. We show that the resulting surface energy is relevant at the small length scales of brain organoids and significantly affects the mechanics of cellular aggregates. We perform a linear stability analysis of the radially symmetric configuration and we study the post-buckling behaviour through finite element simulations.

We find that the process of gyrification is triggered by the cortex growth and modulated by the competition between two length scales: the radius of the organoid and the capillary length due to surface tension. We show that a solid model can reproduce the results of the *in-vitro* experiments. Furthermore, we prove that the lack of brain sulci in lissencephaly is caused by a reduction of the cell stiffness: the softening of the organoid strengthens the role of surface tension, delaying or even inhibiting the onset of a mechanical instability at the free boundary [4].

References

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