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Continuum model of epithelial morphogenesis during caenorhabditis elegans embryonic elongation. (English) Zbl 1185.74056

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Summary: The purpose of this work is to provide a biomechanical model to investigate the interplay between cellular structures and the mechanical force distribution during the elongation process of Caenorhabditis elegans embryos. Epithelial morphogenesis drives the elongation process of an ovoid embryo to become a worm-shaped embryo about four times longer and three times thinner. The overall anatomy of the embryo is modelled in the continuum mechanics framework from the structural organization of the subcellular filaments within epithelial cells. The constitutive relationships consider embryonic cells as homogeneous materials with an active behaviour, determined by the non-muscle myosin II molecular motor, and a passive viscoelastic response, related to the directional properties of the filament network inside cells. The axisymmetric elastic solution at equilibrium is derived by means of the incompressibility conditions, the continuity conditions for the overall embryo deformation and the balance principles for the embryonic cells. A particular analytical solution is proposed from a simplified geometry, demonstrating the mechanical role of the microtubule network within epithelial cells in redistributing the stress from a differential contraction of circumferentially oriented actin filaments. The theoretical predictions of the biomechanical model are discussed within the biological scenario proposed through genetic analysis and pharmacological experiments.

MSC:

74L15 Biomechanical solid mechanics
92B05 General biology and biomathematics

Keywords:

morphogenesis; caenorhabditis elegans; embryo elongation; mechanobiology; biomechanics

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