Influence of Initial Residual Stress on Growth and Pattern Creation

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Abstract

Residual stress is ubiquitous and indispensable in most biological and artificial materials, where it sustains and optimizes many biological and functional mechanisms. The theory of volume growth, starting from a stress-free initial state, is widely used to explain the creation and evolution of growth-induced residual stress and the resulting changes in shape, and to model how growing bio-tissues such as arteries and solid tumors develop a strategy of pattern creation according to geometrical and material parameters. This modelling provides promising avenues for designing and directing some appropriate morphology of a given tissue or organ and achieve some targeted biomedical function. Here we rely on a modified, augmented theory to reveal how we can obtain growth-induced residual stress and pattern evolution of bilayer tubular soft tissues (artery, intestine) and soft matter (silicone, hydrogel), starting from an existing, non-zero initial residual stress state. We conduct experiments on bilayer hydrogel/silicone tubes and confront the results to the predictions. Our results show that initial residual stress has a more significant impact on residual stress accumulation and the subsequent evolution of patterns than geometry and material parameters.

References

[1] Y. Du, C. Lu, W. Chen and M. Destrade, Modified Multiplicative Decomposition Model for Tissue Growth: Beyond the Initial Stress-Free State. *Journal of the Mechanics and Physics of Solids*, 118:133–151, 2018.

[2] Y. Du, C. Lu, W. Chen and M. Destrade, Influence of Initial Residual Stress on Growth and Pattern Creation for a Layered Aorta. *Scientific Reports*, to appear, 2019.