Towards mechanically realistic 3D printed arterial replicas

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ABSTRACT

Recently, 3D print technology with polymer materials got direct application in biomedicine, e.g. for educational purposes and medical device testing. A printed replica should not only have realistic geometry, but also exhibit similar mechanical behaviour. Soft tissues, including arteries, have complicated non-linear and anisotropic behaviour and in addition undergo large deformation. Single polymer isotropic material can not mimic described behaviour so two-part material (metamaterials) needs to be designed. Modern 3D printing machines, such as Connex 350 (Stratasys, USA), use multiple materials in the printing process, enabling creation of parts with more complex mechanical response.

The focus of this work is on healthy common carotid arteries (CCA) which are of biomedical interest, since they are prone to atherosclerosis and frequently undergo treatments, such as angioplasty and stenting, to prevent stroke [1]. Additionally, their mechanical response has been extensively studied in literature [2]. The goal is to design a metamaterial that can realistically represent carotid tissue.

A cylindrical sample has been numerically simulated. The sample is modeled as incompressible using two material models, Neo-Hookean and Demiray. The corresponding parameters for the used polymeric materials are previously experimentally obtained. The modeled cylinder is made from two materials, softer one representing matrix response, while harder one represents collagen fiber contribution. Circumferential and axial stretch-pressure curves obtained from extension-inflation tests reported in [2] are compared to the same curves obtained from finite element simulations. In order to achieve realistic desired behavior, the volume ratio and the geometry of the embedded harder material is iteratively changed.

The final geometry will be 3D printed and experimentally tested on an extension-inflation setup to confirm simulated mechanical response.

Acknowledgment

This work was supported by a grant from the Croatian Science Foundation (project IP-2014-09-7382 I. Karšaj).

REFERENCES

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