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ESTIMATION OF ELEMENT-BASED ZERO-STRESS STATE FOR ARTERIAL FSI COMPUTATIONS

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In patient-specific arterial fluid–structure interaction (FSI) computations [1-3] the image-based arterial geometry comes from a configuration that is not stress-free. We present a method [4] for estimation of element-based zero-stress (ZS) state. The method has three main components. 1. An iterative method, which starts with an initial guess for the ZS state, is used for computing the element-based ZS state such that when a given pressure load is applied, the image-based target shape is matched. 2. A method for straight-tube geometries with single and multiple layers is used for computing the element-based ZS state so that we match the given diameter and longitudinal stretch in the target configuration and the "opening angle." 3. An element-based mapping between the arterial and straight-tube configurations is used for mapping from the arterial configuration to the straight-tube configuration, and for mapping the estimated ZS state of the straight tube back to the arterial configuration, to be used as the initial guess for the iterative method that matches the image-based target shape. We present from [4] a set of test computations to show how the method works (see Figures 1 and 2).

REFERENCES

[1] K. Takizawa, C. Moorman, S. Wright, J. Christopher and T.E. Tezduyar, "Wall Shear Stress Calculations in Space-Time Finite Element Computation of Arterial Fluid-Structure Interactions", *Computational Mechanics*, **46** (2010) 31-41.

[2] T.E. Tezduyar, K. Takizawa, T. Brummer and P.R. Chen, "Space-Time Fluid-Structure Interaction Modeling of Patient-Specific Cerebral Aneurysms", *International Journal for Numerical Methods in Biomedical Engineering*, **27** (2011) 1665-1710.

[3] K. Takizawa, Y. Bazilevs and T.E. Tezduyar, "Space-Time and ALE-VMS Techniques for Patient-Specific Cardiovascular Fluid-Structure Interaction Modeling", *Archives of Computational Methods in Engineering*, **19** (2012) 171-225.

[4] K. Takizawa, H. Takagi, T.E. Tezduyar and R. Torii, "Estimation of Element-Based Zero-Stress State for Arterial FSI Computations", *Computational Mechanics*, published online, DOI: 10.1007/s00466-013-0919-7 (September 2013).

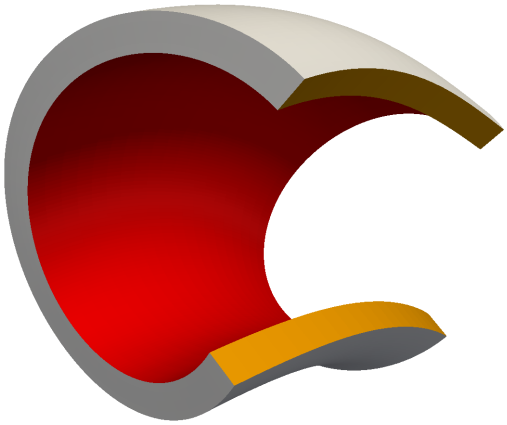

Figure 1. A curved tube. Longitudinal-cut state for opening angle, $\phi = \pi/2$ and longitudinal stretch, $\lambda_z = 1.0$. The lumen is colored red, and the cut edge, $\theta_c = 0$, orange (see [4]).

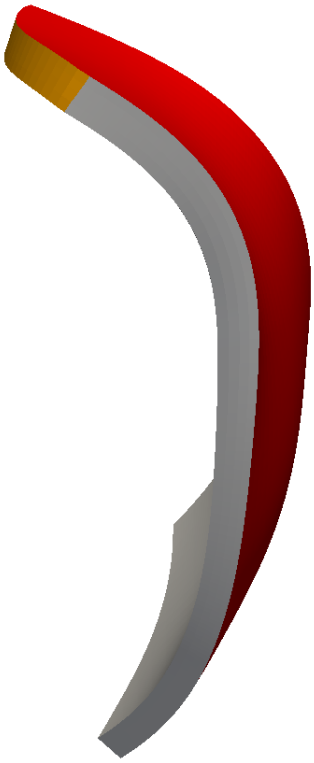

Figure 2. A curved tube. Longitudinal-cut state for opening angle, $\phi = 5\pi/2$ and longitudinal stretch, $\lambda_z = 1.0$. The lumen is colored red, and the cut edge, $\theta_c = 0$, orange (see [4]).