Mechanical property estimation of carotid arteries : frictionless 2D inflation?

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Frictionless 2D inflation?

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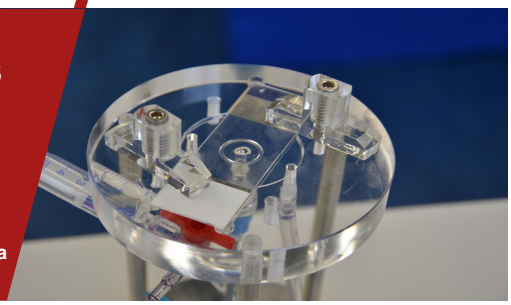

Introduction

Rupture of atherosclerotic plaques in the carotid artery is a major cause for stroke. Currently, the severity of the stenosis is used to estimate the risk of plaque rupture. However, plaque rupture occurs when the mechanical stresses in the cap of the plaque exceed the local tissue strength. Therefore, a biomechanical model of the plaque may help to better assess rupture risk.

Objectives

To determine the risk of rupture, mechanical properties of plaque components and cap strength are assessed with 2D inflation experiments and inverse numerical modelling. This study deals with the role of friction.

Materials & Methods

Thin slices of healthy porcine carotids are cut and slightly compressed between two glass plates, as shown in figure 1 and the top right corner of this poster. Paraffin oil is injected into the lumen, to inflate the plaque. A pressure sensor monitors the intraluminal pressure, while a high speed camera records the tissue displacement. The experiment is modelled in the finite element package MSC.Marc. With the experimental boundary conditions, 4 levels of friction have been assessed.

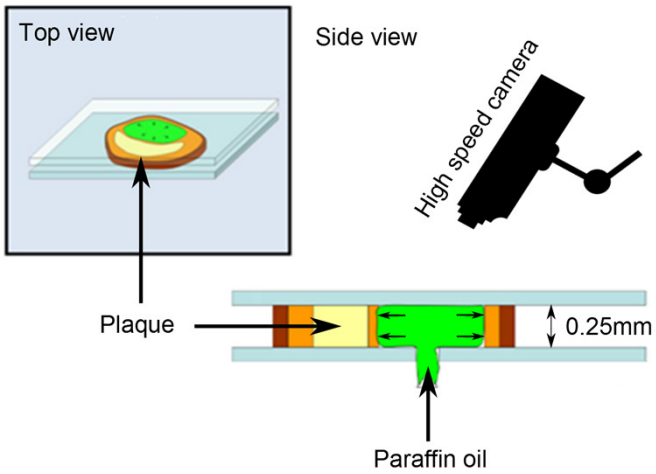

Figure 1: Schematic overview of the experiment.

Acknowledgment

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Results

In the experiment, at an increasing pressure, the diameter of the carotid sample increases: b > a (figure 2). The diameter decreases as pressure drops: c < b.

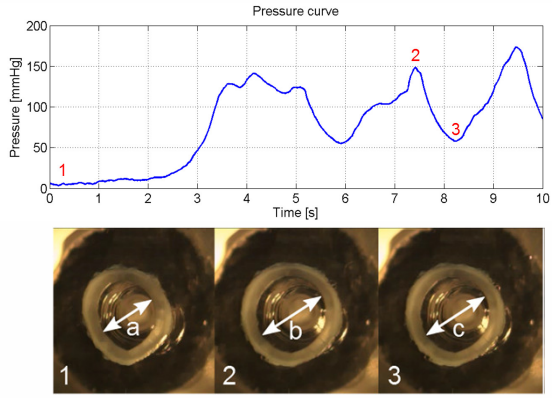

Figure 2: Experiment results, pressure signal with frames at specific time points. The arrows represent the diameters of the carotid sample.

In the model, a decrease in pressure does not result in a decrease in diameter at FC > 0.005 (figure 3).

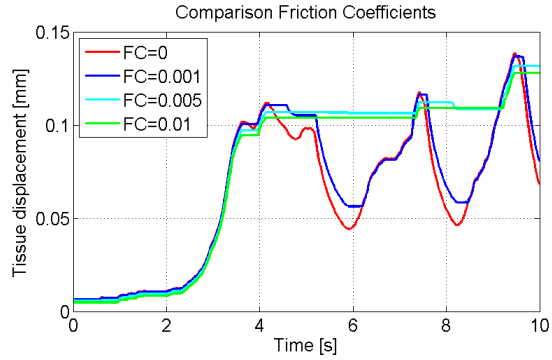

Figure 3: Model results, diameter change due to pressure, with different friction coefficients (FC) between glass and tissue.

Conclusions

The experiment does not show the behavior as found with friction coefficients larger than 0.005 in the model. The movement of the carotid wall follows the pressure changes, which suggests that friction plays a minor role in the 2D inflation experiment.

Future work

- To use vital staining and fluorescence microscopy to enable distinction between plaque components during inflation.
- To perform the experiment with human carotid plaques.
- To use high-speed recordings to visualize rupture.

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