Understanding the biomechanical behavior of vascular tissue across spatial and time scales

CONTEXT

The internship candidate will play an active role in the collaboration between the BIOTIC team at LMGC, University of Montpellier and the Continuum Mechanics Lab at Yale University (USA) in unravelling multiscale relationships leading to life-threatening diseases in blood vessels. The identification of microstructural features most relevant for macroscopic mechanical properties of the arteries can guide dedicated experiments and provide advice what features should be paid particular attention during vascular tissue engineering.

DESCRIPTION

The microstructural and macroscopic mechanical properties of soft tissues, in particular arterial tissues, are strongly related. While significant efforts have been made to quantify such a relationship, the prediction of the macroscopic mechanical properties of vascular tissues from microstructural data is still limited to a low accuracy.
The project is structured around the comprehension and data analysis of multiple multiscale modelling techniques to better understand two major cardiovascular diseases, namely aneurysms and aortic dissections, and the underlying mechanisms of arterial remodelling. Comprehensive multiscale experimental data acquired from animal models will be analysed to investigate the correlations between tissue microstructure (fibrous extracellular matrix and cells) and tissue biomechanical functions.

The candidate will be introduced to the understanding of numerous experimental techniques for microstructural assessment (histology, immunohistochemistry, fluorescence and multiphoton microscopy) and mechanical *ex vivo* and *in vivo* characterisation with advanced imaging techniques (Figure 1).
Following an dedicated bibliographic study, the project will develop in 3 fundamental steps:

- Analysis and processing of 2D and 3D microscopy images of the tissue under analysis with the aim of microstructural parameterization;
- Analysis of macroscopic biomechanical data of the vascular tissue and use of constitutive models with the aim of biomechanical parameterization;
- Statistical analysis to find multiscale relationships in space and time for the particular models related to aneurysms and aortic dissections.

The study will be conducted using 3D image vision tools and image processing algorithms. It will then make use of curve and distribution fitting techniques and

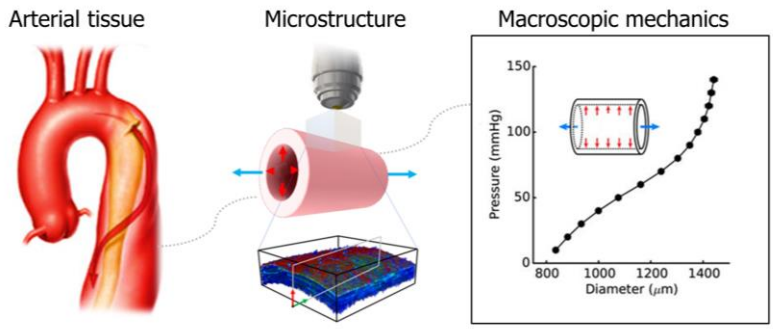

Figure 1. Conceptual outline of the project illustrating the process of data analysis from microstructure to macroscopic biomechanics of the arterial tissue.

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move on to more complex concepts in the field of biomechanics such as modelling with material and structural parameters.

REQUIREMENTS

The internship offer is addressed to engineering and master's students in mechanical engineering, bioengineering or materials science. Prior programming experience and knowledge of MATLAB for image and signal processing is required. Basic knowledge of image processing and continuum mechanics is recommended. A strong spirit of initiative in bringing ideas and improvements will be highly appreciated.

ENVIRONMENT

The student will work for 4 months at the LMGC and collaborate remotely with Yale University. The BIOTIC (Biomechanics of Interactions and Organisation of TIssues and Cells) group at LMGC has delevoped over the years a strong expertise in characterizing the multiscale biomechanical behaviour of soft tissues and bioengineered substitutes in the cardiovascular and cartilage fields. The Continuum Biomechanics Group at Yale University is one of the most renowned international groups focusing on vascular mechanics and mechanobiology. Both labs are at the forefront of developing novel theoretical frameworks, corroborated by both experimental and computational mechanics to understand and treat soft tissue diseases. The candidate will find in this high-level collaboration a fertile ground to develop his skills in healthcare-oriented scientific research.

CONTACTS

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