Fully funded PhD position of 3 years in "Cardiovascular Mechanics"
University Joseph Fourier, Grenoble, France

Development of a New Finite Element Approach for the Resolution of Inverse Problems in Mechanics: Application to Atherosclerotic Plaque Elasticity Reconstruction Based on Intravascular Strain Measurements

Key words:
Continuum mechanics - Elasticity - Finite element method - Structural analysis - Inverse problems - Mechanical models - Physics of ultrasound - Experimental analysis

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Team: Cellular/Tissular Dynamics and Functional Microscopy (DyCTiM)

Scientific Project

Vulnerable atherosclerotic plaque (VP) rupture remains the leading cause of acute coronary syndrome (ACS), myocardial infarction and stroke. Atherosclerotic lesions with a relatively large extracellular necrotic core and a thin fibrous cap infiltrated by macrophages are prone to be vulnerable to rupture. The rupture of the thin-cap fibroatheroma may lead to the formation of a thrombus causing the acute syndrome and possibly death. Because early detection of vulnerable atherosclerotic lesions is a crucial step in preventing risk of rupture and managing ACS and strokes, several intravascular imaging techniques have been developed. These include intravascular ultrasound (IVUS), optical coherence tomography (OCT) and magnetic resonance imaging (IV-MRI).

Diagnosis of high-risk atherosclerotic plaques remains problematic as the thickness of the fibrous cap alone is not a sufficient predictor of plaque stability. Previous works have identified peak cap stress (PCS) amplitude as the biomechanical key predictor of vulnerability to rupture. Quantifying PCS in vivo remains a challenge since such mechanical stress within the cap depends not only on the VP morphology, but also on the mechanical properties of the plaque components. Although several methods have been developed to extract the spatial strain distributions, the complex geometries of atherosclerotic plaques inhibit direct translation into plaque mechanical properties.

The present theoretical and experimental PhD research program was therefore designed to develop (with Matlab, Comsol, Ansys, ...) a new finite element approach for atherosclerotic plaque elasticity reconstruction based on intravascular strain measurements. This research program will be perform in collaboration with the University of Montpellier (Dr. S. Le Floc’h), the Cardiologic hospital of Lyon (Dr G. Finet), the Hospital of Grenoble (Dr L. Riou), the University of Montréal (Pr. G. Cloutier), the National Institutes of Health USA (Dr R.I. Pettigrew), the University of Rochester USA (Pr. M.M. Doyley) and the University of South Alabama USA (Pr S.K. Yazdani). The international France/USA/Canada ultrasound research platform for intravascular explorations (located in the laboratory TIMC-Grenoble and composed of one Galaxie II IVUS-40Mhz system from Boston Scientific with image precision close to 150 µm, one optical coherence tomography system from Lightlab Imaging with image precision close to 20 µm, and the last IVUS-60Mhz system of Silicon Valley Medical Instrument with image precision close to 60µm) will be used to test the performance of the proposed elasticity reconstruction algorithms.

The successful PhD candidate will require:
• A degree in Engineering and/or Master in Biomechanics/Mechanics, Mathematics or Physics
• Experimental skills in Mechanics and/or Physics of Ultrasound/Optics
• An interest and/or experience in working with biologists and physicians

Applications (PDF files of CV + motivation letter) should be sent by email to both: Jacques.Ohayon@imag.fr and Simon.Le-floc-h@um2.fr

Successful applicants will be invited for an interview in June/July 2013. The starting date will be September 2013. For further details about the PhD studentship, please contact by email Prof. Jacques Ohayon.