PATIENT SPECIFIC BIOMECHANICAL MODELING OF ABDOMINAL AORTIC ANEURYSM TO IMPROVE AORTIC ENDOVASCULAR REPAIR

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This project is aiming at the integration of a biomechanical computer program with a guidance code to simulate the endovascular repair (EVAR) procedure of abdominal aortic aneurysm (AAA). The computational time associated with finite element simulation generally renders its usage impractical for real-time application. Based on data collected during clinical interventions and a priori knowledge of AAA and endovascular device mechanical modeling, we are proposing a deformable registration between preoperative CT-scans and per-operative fluoroscopy that will take into account prior simulations of patient specific EVAR procedures. To avoid the computational cost of a full finite element simulation, we propose a simplified and real-time compliant repetitive mechanical behaviour based on patient specific parameters.

PhD1 : Biomechanical engineering

Optimization of a simulation model

The simulation will be computed massively over the entire database and (semi-) automatic measurements will be compiled. There are several parameters in FEM that can be adjusted in order to produce more accurate results. The performance criterion is the deformation accuracy registered on image taken from interventions. The meshing method, mesh quality and density, as well as the solver parameters, and the biomechanical model used for specific tissues have a direct influence on the solution. The literature on biomechanical models is quite extensive, so the decision of a model needs to be validated using the database.

PhD2 : Biomedical engineering

Statistical influences on biomechanical deformable model

Compile specific biomechanical properties on the patient database that has an influence on the deformation of the vessel during the procedure. Several potential contributing variables will be investigated, including the vessel tortuosity, the calcifications morphologies and distribution, the standard thrombus metrics, the surrounding tissue influence (bones, fat, muscles) and their proximity and contact mechanism. These variables may have a direct role into the global deformation behaviour. Their influence will be statistically studied to explain and improve FEM models.

PhD3 : Biomechanical engineering

Biomechanical simulation of endovascular neuro surgery

The abdominal modeling methodology will be translated to the neurovascular anatomy (vessel tree, brain matter, skull) in order to simulate neuro intervention procedures involving the release of stents for the treatment intracranial aneurysm. The release of these flow-diverters needs to be very accurate since the coverage of side branches can induce ischemic strokes. These endovascular interventions are also subject to tissue deformation caused by the endovascular tools, influencing the accuracy of overlay images.

MSc1: Biomedical engineering

Geometrical analysis of deformable abdominal models

Develop geometrical and mechanical equation models to recreate artificially the projection of synthetic models over real interventional images. Design a prototype application as a demonstration of the technology and propose a workflow for its usage.

MSc2 : Biomedical engineering

Numerical fit to recreate in real time accurate biomechanical simulations

The goal here is to find mathematical equations based on the influencing biomechanical properties that can reproduce the deformation results acquired on a large database.

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