In Vivo MRI-Based 3D FSI Multi-Component Models for Carotid Plaque Assessment
(NIBIB R01-EB004759 FY 04)
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The objective of this project is to integrate computational modeling, Magnetic Resonance Imaging (MRI) technology, ultrasound (US)/Doppler technology, mechanical testing, and pathological analysis to perform quantitative mechanical analysis to atherosclerotic carotid plaques, to quantify critical blood flow and plaque stress/strain conditions under which plaque rupture is likely to occur, and to seek the potential that quantitative mechanical analysis can be integrated into state-of-the-art imaging technologies for better screening and diagnostic applications. 3D multi-component models with fluid-structure interactions (FSI) based on in vivo MRI data were introduced to perform mechanical image analysis [8-11]. Sensitivity analyses were performed to quantify effects of plaque structure, material properties, and pressure conditions on flow and stress/strain behaviors. A “local maximal stress hypothesis” was proposed to replace the current popular “maximal stress hypothesis” for plaque assessment which will have considerable impact in the field. Results from 34 2D cases using the new hypothesis showed 89% agreement rate with histopathological classifications. Model comparisons (Newtonian/non-Newtonian fluids, wall-only, fluid-only and FSI models) were conducted and results were reported in several papers. A positive correlation between low wall stress and wall thickness was identified using our in vivo MRI-based FSI models. A possible new hypothesis has been proposed that low wall stress (LWS) in the plaque has positive correlation with plaque wall thickness, and may create favorable mechanical conditions for further plaque progression. Our new LWS hypothesis provides a possible explanation/mechanism for continued plaque growth for intermediate and advanced plaques and may have considerable impact in the atherosclerosis research directions.
Fig 1. Correlation analysis based on results from our *in vivo* multi-component FSI model for human carotid atherosclerotic plaques indicates that there is a positive correlation between fluid maximal shear stress (MSS) and wall thickness and a negative correlation between wall maximum principal stress (Stress-$P_1$) and wall thickness.

**Project (or PI) Website**

http://users.wpi.edu/~dtang/

**Publications**


16. Xueying Huang, Chun Yang, Jie Zheng, Pamela K. Woodard, and Dalin Tang,* Quantifying vessel material properties using MRI under pressurized condition and MRI-based FSI models for blood flow in diseased human arteries, Accepted to: The 5th World Congress of Biomechanics, 2006.

17. Chun Yang, Xueying Huang, Jie Zheng, Pamela K. Woodard, and Dalin Tang,* Quantifying vessel material properties using MRI under pressurized condition and MRI-based FSI mechanical analysis for human atherosclerotic plaques, ASME IMECE 2006-13938, abstract accepted, final paper pending.

Other Items

Patent(s)

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<th>Image-Based Computational Mechanical Analysis and Indexing for Cardiovascular Diseases</th>
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