Talk 4.2

In Vivo MRI-Based 3D FSI Multi-Component Models for Carotid Plaque Assessment

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Dalin Tang
Worcester Polytechnic Institute

Allen Hoffman
Worcester Polytechnic Institute

Christopher Sotak
Worcester Polytechnic Institute

Pamela K Woodard
Washington University

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.

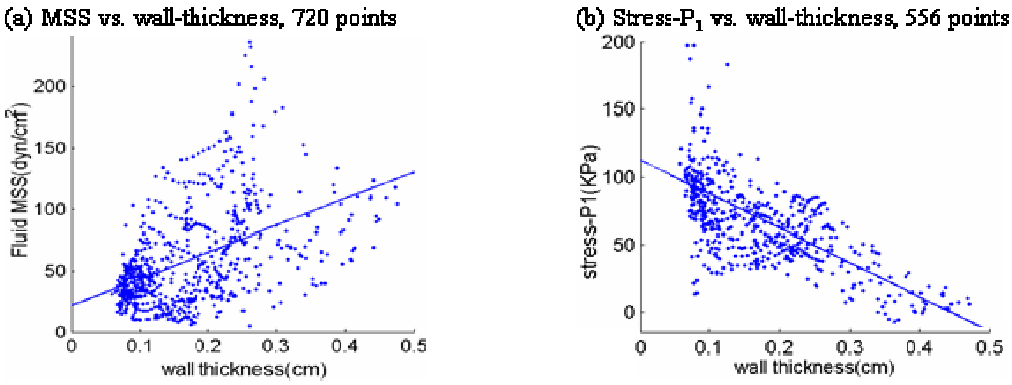

Fig 1. Correlation analysis based on results from our *in vivo* multi-component FSI model for human carotid atherosclerotic plaques indicates that there is a positive correlation between fluid maximal shear stress (MSS) and wall thickness and a negative correlation between wall maximum principal stress (Stress-P_1) and wall thickness.

Project (or PI) Website

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

Publications

1. Dalin Tang, Chun Yang, Jie Zheng, Pamela K. Woodard, Gregorio A. Sicard, Jeffrey E. Saffitz, Shunichi Kobayashi, Thomas K Pilgram, and Chun Yuan, 3D Computational Mechanical Analysis for Human Atherosclerotic Plaques Using MRI-Based Models with Fluid-Structure Interactions, Medical Image Computing and Computer Assisted Intervention, Springer, Vol. II, p. 328-336, 2004.

2. Dalin Tang, Chun Yang, Jie Zheng, Pamela K. Woodard, Jeffrey E. Saffitz, Gregorio A. Sicard, Thomas K. Pilgram, and Chun Yuan, Sensitivity Analysis of 3D MRI-Based Models for Atherosclerotic Plaques, Proceedings of The IASTED International Conference on Biomechanics, Editor: M. H. Hamza, ACTA Press, Anaheim, pp. 97-100, 2004.

3. Dalin Tang, Chun Yang, Jie Zheng, Pamela K. Woodard, Jeffrey E. Saffitz, Gregorio A. Sicard, Thomas K Pilgram, and Chun Yuan, Unsteady 3D MRI-Based FSI Models for Human Carotid and Coronary Atherosclerotic Plaques, Proceedings of 2004 BMES Annual Fall Meeting, 1009, Oct. 13-16, 2004.

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Other Items

Patent(s)

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