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In vivo Mechanical Characterization of Ascending Aortas from Magnetic Resonance Imaging

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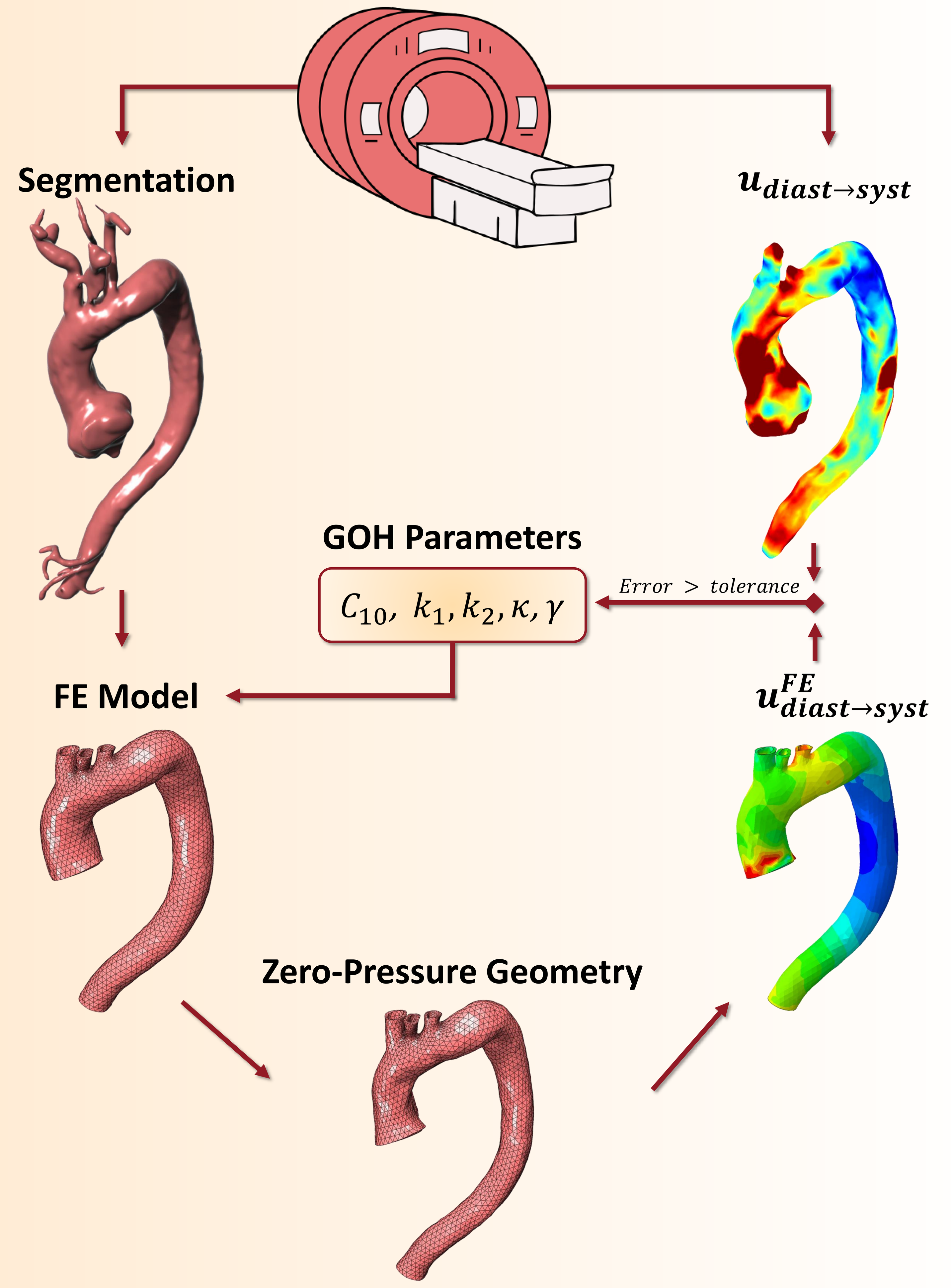
INTRODUCTION

The rupture of ascending aortic aneurysm (AAA) results in the death of the patient in the vast majority of the cases [1]. Therefore, a proper follow-up could prevent risks. Studies suggest that mechanical properties could become useful criteria for clinical intervention [2]. In this work, we present a methodology to obtain the non-linear anisotropic properties of the AAA from magnetic resonance imaging (MRI).



MATERIAL & METHODS

1st Data Processing

MRI data were derived from patients who underwent surgical repair of AAA at the *Vall d'Hebron Hospital*. We segment the diastolic aorta and estimate the relative displacements between diastole and systole ($u_{diast \to syst}$).

2nd Finite Element (FE) Model

We assumed a thickness of 2 mm to obtain the aortic wall. Robin conditions were applied to mimic the external tissue support [3], and the measured displacements were enforced as boundary conditions to consider the heart movements.

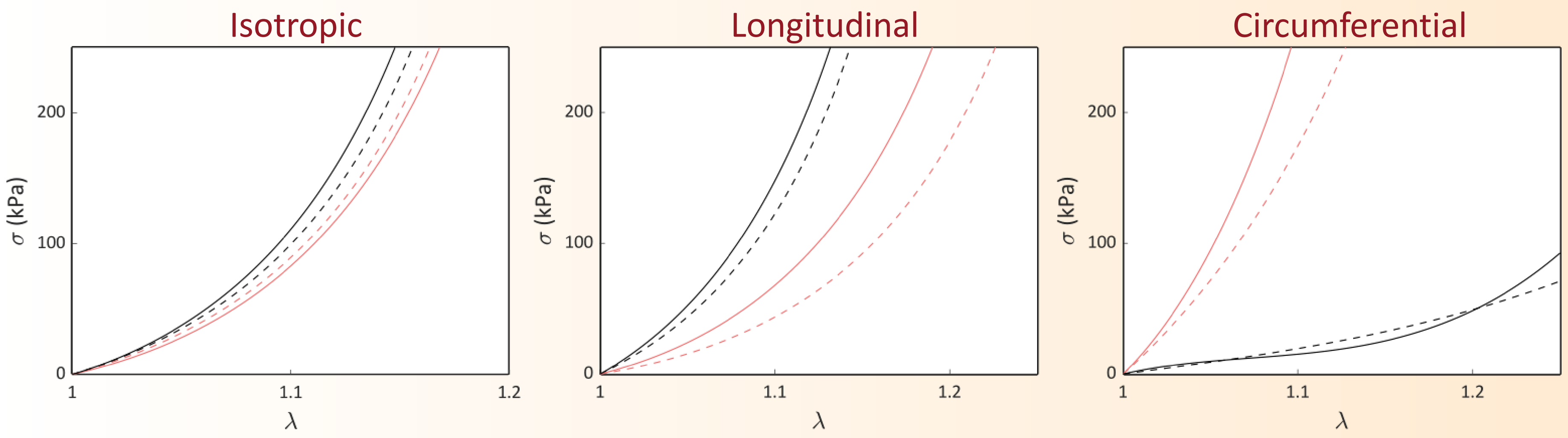
3rd Mechanical Characterization

We implemented a pattern-search algorithm to minimize the error between the measured displacements and those derived from the FE simulation ($u^{FE}_{diast \to syst}$). On each iteration, a different set of material parameters from GOH strain density function was evaluated [4], and we estimated the unpressurized configuration to consider the non-linear properties.

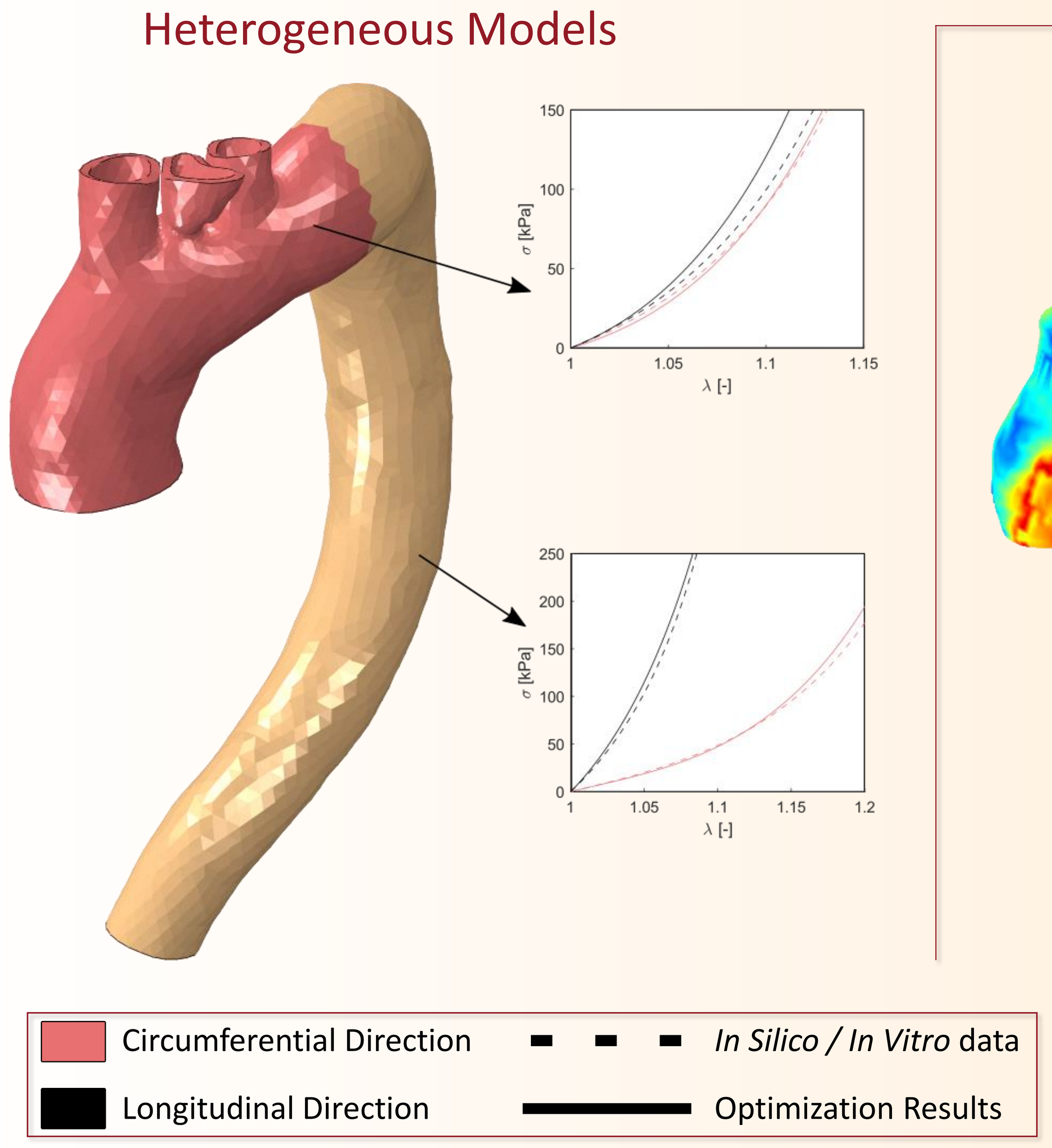
RESULTS

In Silico Models

Homogeneous Models

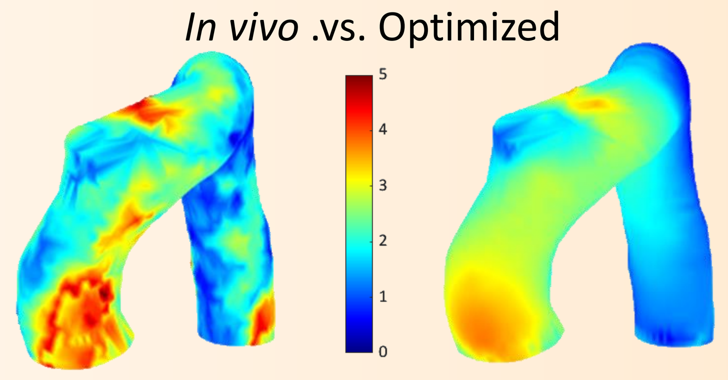


Heterogeneous Models

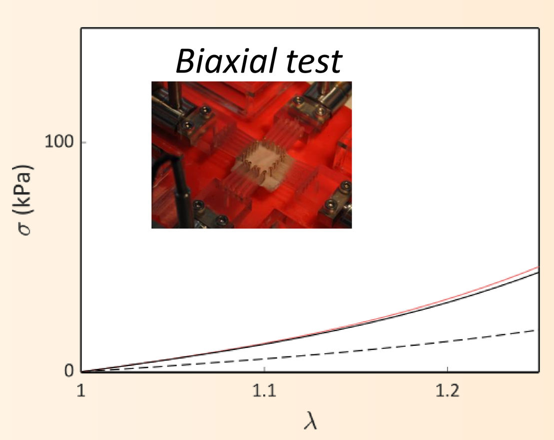


In Vivo

Displacement
In vivo .vs. Optimized



Mechanical Response
In vivo .vs. *in vitro*



CONCLUSIONS

We have developed a methodology for extracting the nonlinear anisotropic properties and the unpressurized geometry of the ascending aortas from MRI data. Utilizing *in silico* models, we tested this methodology with many different mechanical behaviors of healthy and diseased aortas. Directly applying this characterization process to *in vivo* data yielded strong correlations with *in vitro* tests. This approach allows estimation of the stress distribution in the aortic wall and, therefore, the risk of rupture.

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