Tools for cardiovascular in silico medicine

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Fluid-structure interaction simulations of healthy carotid bifurcations

Introduction

The significance of the hemodynamic environment in the **carotid artery bifurcation** in the origin and progression of atherosclerosis[1] relied on computational fluid dynamics (CFD) models under the **rigid wall assumption**[1,2].

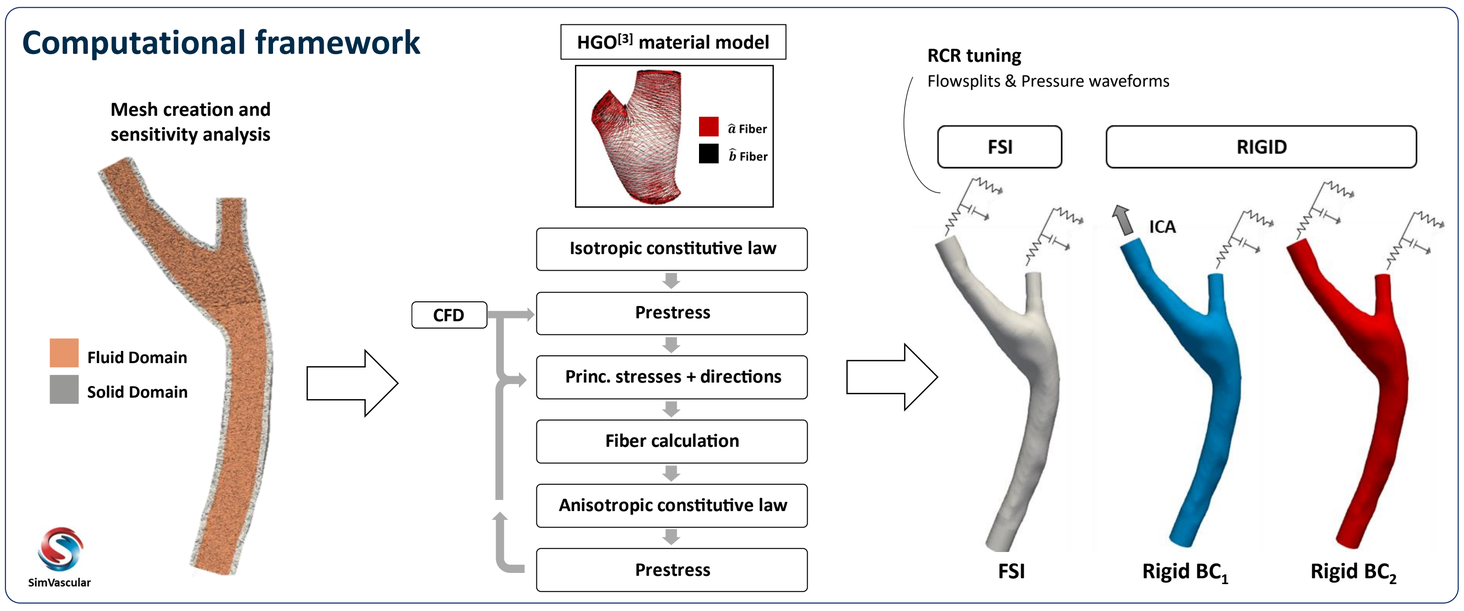
Aim

Investigate the impact of wall distensibility through **FSI simulations** on intravascular and near-wall hemodynamic features of a large dataset of healthy carotid bifurcation computational models.

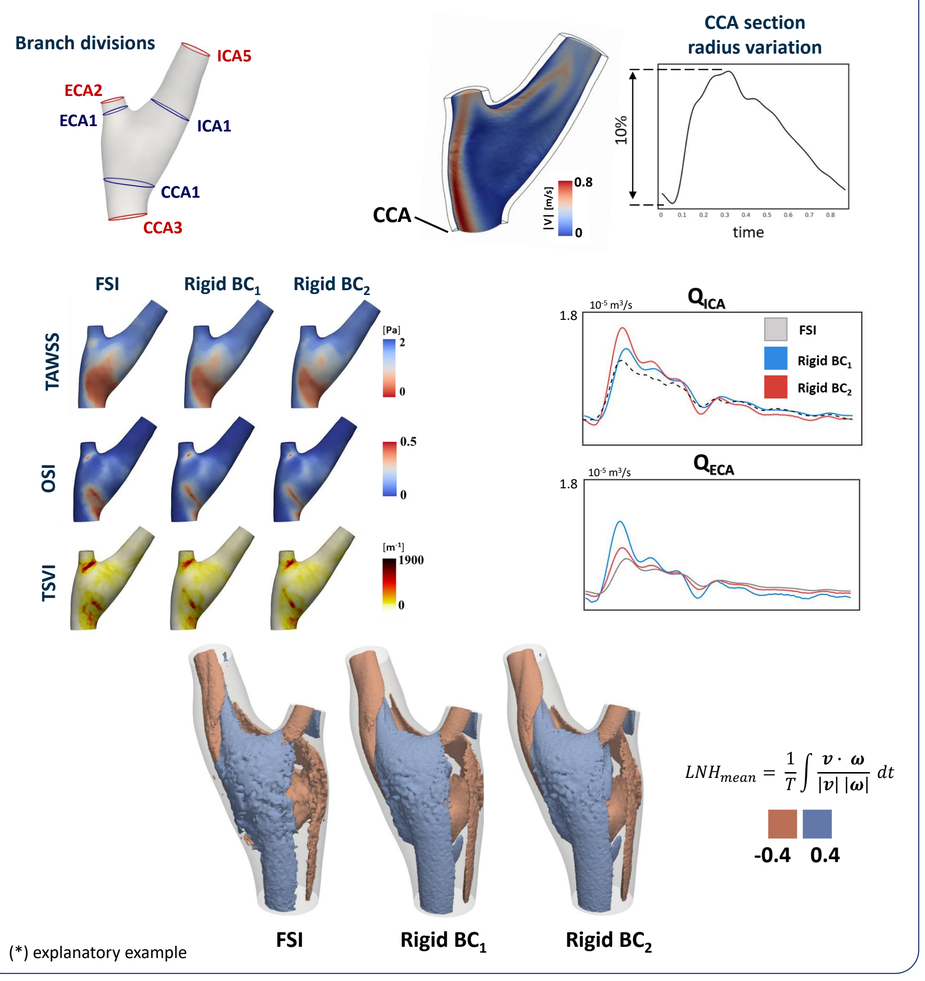
Conclusions

Hemodynamic features are comparable in terms of localization and topology when modeling wall distensibility or under the rigid wall assumption; in rigid-wall simulations the two considered boundary conditions have a limited impact hemodynamic features. However, quantitative differences emerge, deserving further consideration. Their influence on the association hemodynamics-atherosclerosis will be subject to future investigations.

Computational framework



Results



(*) explanatory example

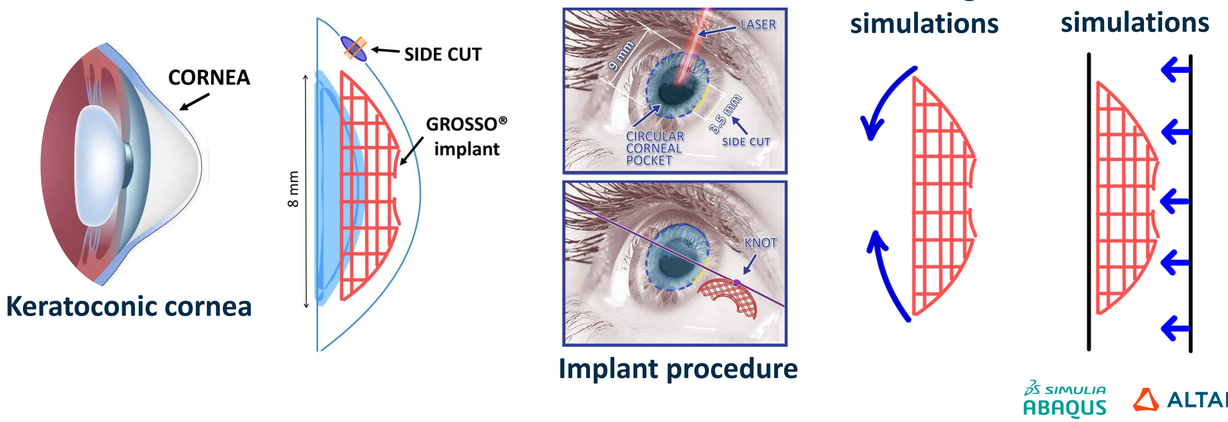
Mechanical characterization of a Nitinol device for keratoconus

The GROSSO® implant is a patented Nickel-Titanium (Nitinol) corneal implant aiming to **reshape keratoconic corneas**, characterized by localized thinning and conical protrusion.

RECORNEA securing your vision

Aim

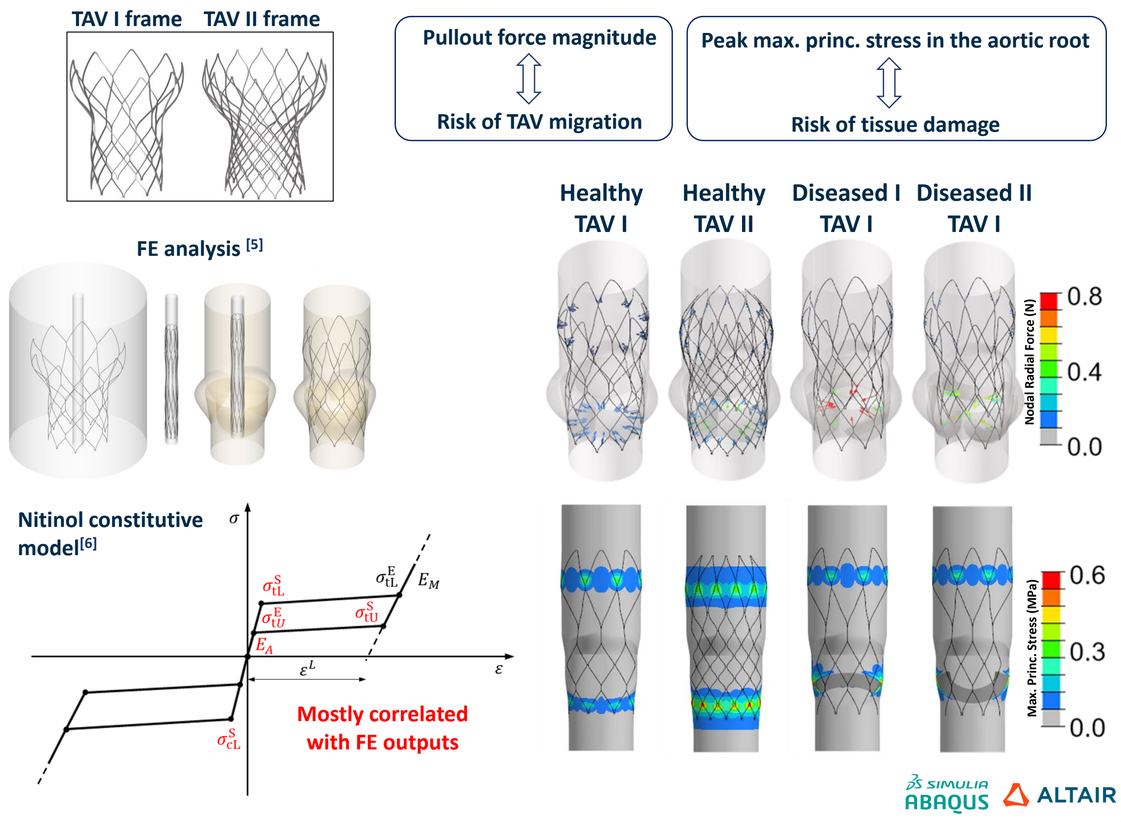
- Compare **two different device designs**
- Simulations of two specific **conditions**
- Verify the absence of material **permanent deformations**



SIMULIA ABAQUS ALTAIR

Impact of Nitinol material properties on TAVs performances

Transcatheter aortic valves (TAVs) resume their initial shape when implanted. Experimental findings suggest that Nitinol properties have a strong dependence on its chemical composition and processing operations. In this context, the study[4] presents a computational framework to investigate the impact of the Nitinol super-elastic material properties on the TAVs mechanical performances.



SIMULIA ABAQUS ALTAIR

Hard skills

78 h

- **An introduction to turbulent flows** - Turbulence theory and its application to tackle engineering problems
- **Principles, materials and applications of robotics in biomedicine** – Basics of automation and overview of robotics applications in surgery and urology
- **Statistical data processing** – Methods for statistical analysis and statistical inference
- **Numerical methods for fluid-structure interaction** - Basic competences on the numerical modeling and approximation of the fluid-structure interaction problem
- **Personalized medicine: an enabling tool to break down boundaries in chronic skin wound management** – Webinar on new frontiers for treating chronic skin wounds

Soft skills

56 h

- **Writing Scientific Papers in English**
- **Entrepreneurial Finance**
- **Navigating the hiring process: CV, tests, interview**
- **Project management**
- **Public speaking**
- **Research integrity**
- **Time management**
- **Communication**
- **Responsible research and innovation, the impact on social challenges**
- **The new Internet Society: entering the black-box of digital innovations**
- **Thinking out of the box**

Papers

[4] D. Carbonaro, S. Zambon, A. Corti, D. Gallo, U. Morbiducci, A. Audenino, C. Chiastra - *Impact Of Nickel-titanium Super-elastic Material Properties On The Mechanical Performance Of Self-expandable Transcatheter Aortic Valves*. Journal of the Mechanical Behavior of Biomedical Materials (To be published)

Conferences

S. Zambon, M. Arminio, U. Morbiducci, C. Chiastra, D. Gallo - *Impact Of Wall Distensibility On Prominent Features Of Carotid Bifurcation Hemodynamics*. ESB ITA XI Annual meeting (6-7 October 2022)

References

[1] Gallo *et al.*, J R Soc Interface, 2018
[2] Morbiducci *et al.*, Ann Biomed Eng, 2020
[3] Gasser *et al.*, J R Soc Interface, 2006
[5] Carbonaro *et al.*, Struct Multidiscip Optim, 2021
[6] Auricchio *et al.*, Comput Methods Biomech Biomed Engin, 1997

Tutors: D. Gallo, U. Morbiducci

PhD Day 2022
25th October 2022, Dental School, Torino