ON THE IMPACT OF ARTERIAL MODELLING IN CORONARY STENTING SIMULATIONS: A VALIDATED STUDY ON 5 PATIENT-SPECIFIC CASES

Gianluca Poletti (1), Luca Antonini (1), Georgia S. Karanasiou (2), Dimitrios I. Fotiadis (2), Lorenza Petrini (3), Giancarlo Pennati (1)

1. LaBS – Dept. of Chemistry, Materials and Chemical Engineering, Politecnico di Milano, Milan, Italy;
2. Dept. of Biomedical Research, FORTH-IMBB, GR 45110 Ioannina, Greece;
3. Dept. of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy.

Introduction

Recent studies highlighted the potential of patient-specific coronary stenting simulations to support clinical decisions for individual treatments [1,2]. A crucial point for a reliable stenting simulation is the modelling of the patient-specific artery. By exploiting invasive clinical imaging techniques, it is possible to have individual anatomical details in the reconstruction of the arterial geometry. Different aspects of the arterial mechanical modelling were considered in the literature, such as heterogeneous plaque description, modelling of different external layers (media and adventitia), and the effect on the mechanical properties of *in vivo* axial pre-stretching and pressurization [2]. However, it is still unclear which of these modelling aspects are essential for reliable outcomes in terms of clinical endpoints such as lumen gain and stent malappositions, and which can be considered excessive details given the uncertainties associated with clinical imaging data. To investigate this, five clinical cases were replicated through numerical methods involving the highlighted modelling aspects. The comparison with post-treatment clinical data allowed the impact of these aspects to be identified.

Methods

A phenomenological damage model capable of describing the deterioration of mechanical properties at high strain levels of media and adventitia layers was combined with the arterial model developed and validated in a previous work [2]. Damage model parameters were defined to best fit the arterial mechanical behavior in response to the replication of the stenting procedure of two clinical cases (cases A and B). The whole model was evaluated in its ability to predict the lumen area and stent malappositions by replicating three additional patient-specific cases (cases C, D and E). Once the model was validated, the five clinical cases were exploited to analyze the importance of each modelling aspect in representing the clinical outcomes.

Results

The developed damage model proved to be effective in comparison with post-stenting clinical data (Figure 1). Among the evaluated modelling aspects, interesting results were found in the role of damage modelling to predict the lumen gain and on a low impact of heterogeneous plaque modelling compared to the homogeneous one.

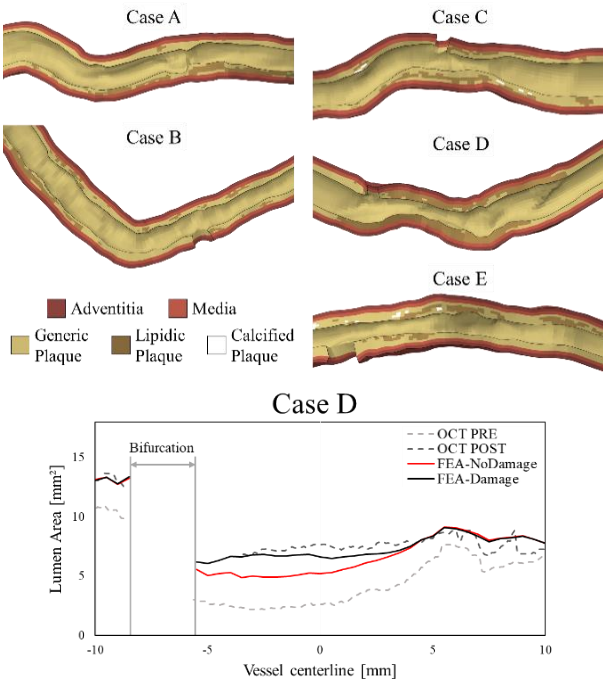

Figure 1: The reconstructed arteries of the clinical cases replicated in this study (top) and a comparison between FEA results (with and without the damage model) and OCT data (pre- and post-stenting) (bottom).

Discussion

The damage model proved to be essential for the development of a robust and validated arterial model. Patient-specific details of low impact on simulation outcomes can raise questions on the possibility of exploiting other imaging techniques for arterial reconstruction: techniques not able to capture the patient details such as plaque components but less invasive than catheter-based techniques might be a valid alternative for a future clinical application of stenting simulations.

References

1. Chatzizisis et al., JACC Case Rep., 4(6):325-335, 2022.
2. Poletti et al, Electronics, 11(3):502, 2022.

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