13.8

Non-parametric statistical shape modelling for in silico trials of TAVI

Sabine Verstraeten[1], *Damián Suasso de Lima de Prado*[2], *Martijn Hoeijmakers*[3], *Frans van de Vosse*[4], *Wouter Huberts*[4 5]

1 *Eindhoven University of Technology, Biomedical Engineering, Eindhoven, Netherlands*
1 *Eindhoven University of Technology, Biomedical Engineering, Eindhoven, Netherlands*
3 *ANSYS Utrecht, Netherlands*
1 *Eindhoven University of Technology, Biomedical Engineering, Eindhoven, Netherlands*
5 *Maastricht University, Biomedical Engineering, Netherlands*

1. Introduction

In silico clinical trials are a promising method to increase efficacy and safety of trans-catheter aortic valve implantation (TAVI) devices. Synthetic aortic stenosis (AS) valve geometries for in silico trials can be created by using a Statistical Shape Model (SSM). SSM methods used in previous studies [1], have two disadvantages: (1) They require consistent inter-patient topology; (2) These methods do not consider the relation between shape features and outputs of interest. By considering output related features, the geometries may be described with fewer parameters. Therefore, the aim of this study was to set up a non-parametric SSM for AS valve geometries and take into account the output of interest: the pressure drop across the aortic valve (Δp).

2. Materials and Methods

A data set of 74 aortic valve meshes (EurValve project) and the corresponding Δp resulting from a Computational Fluid Dynamics model [1], were used to train the SSM model [2]. The first step was to obtain deformation vectors, located at fixed grid points for each patient, that deform a template geometry to a patient specific geometry, using the open-source software called "Deformetrica" [3]. The second step was to obtain the main directions of shape variance (shape modes) within these sets of vectors, that are most correlated to Δp, by using Partial Least Square regression [2]. Synthetic and original meshes could be (re)constructed using the template geometry and the resulting shape modes.

3. Results

In Figure 1 the mean distance between the original shape and the shapes reconstructed by using respectively zero, one, and seven shape modes, are visualized on the template geometry.

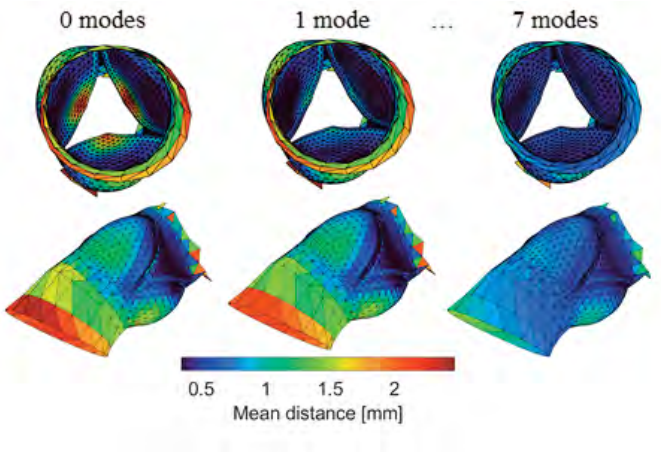

Figure 1: mean distance between original shape and shape reconstructed with 0, 1, and 7 shape modes.

The mean ± std distance between the original and the template shape (zero shape modes) is 0.83 ± 0.36 mm. The distance decreases with increasing number of shape modes included. After including seven modes, the distance was reduced to 0.62 ± 0.22 mm, and 95% of the total shape variation was captured.

4. Discussion and Conclusions

The results demonstrate that this non-parametric SSM can accurately reconstruct the real geometries by only using seven pressure drop related shape modes. The SSM is now ready to be used to construct realistic, synthetic, stenosed aortic valve geometries for in silico trials of TAVI.

5. References

Hoeijmakers MJMM et al., Int. J. Numer. Methods Biomed. Eng. vol. 36, p. e3387 (2020).

Bruse JL et al., BMC Med. Imaging, vol. 16, no. 1 (2016)

Bône A et al., LNCS, vol. 11167, pp. 3–13 (2018)

Acknowledgements:

We acknowledge the European Union's Horizon 2020 research and innovation programme (grant agreement No 101017578) for their financial support.