Leaflet Stress Quantification of Surgical vs. Transcatheter Aortic Valve Bioprostheses: An In Vitro Study

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1. Introduction

Calcified aortic stenosis is among the most prevalent forms of cardiovascular diseases. This progressive disease ultimately requires aortic valve replacement-either surgical (SAV) or transcatheter heart valve (THV) implantation. Like SAV, the THV leaflet tissue calcify and degrade over time. Increased leaflet mechanical stress is one of the main determinants of the structural valve deterioration[1–3]. In order to assess the durability of these valves, we applied an in-vitro/in-silico method to compare the magnitude, and regional distribution of leaflet mechanical stress in SAV and THV.

2. Methods

In-vitro testing was conducted using a double activation simulator, with two different SAVs (St.Jude Trifecta 25mm and Medtronic Mosaic 25mm) and two different THVs (Edwards Sapien 23mm and Medtronic CoreValve 26mm) mounted in aortic position.

A non-contact system based on stereophotogammetry and digital image correlation (DIC) with high spatial and temporal resolution (2000img/sec) was used to visualize the leaflet motion and perform the three-dimensional analysis. A finite element model of the valve was developed, and the leaflet deformation obtained from the DIC analysis was applied to the finite element model to calculate local leaflet mechanical stress during the diastole.

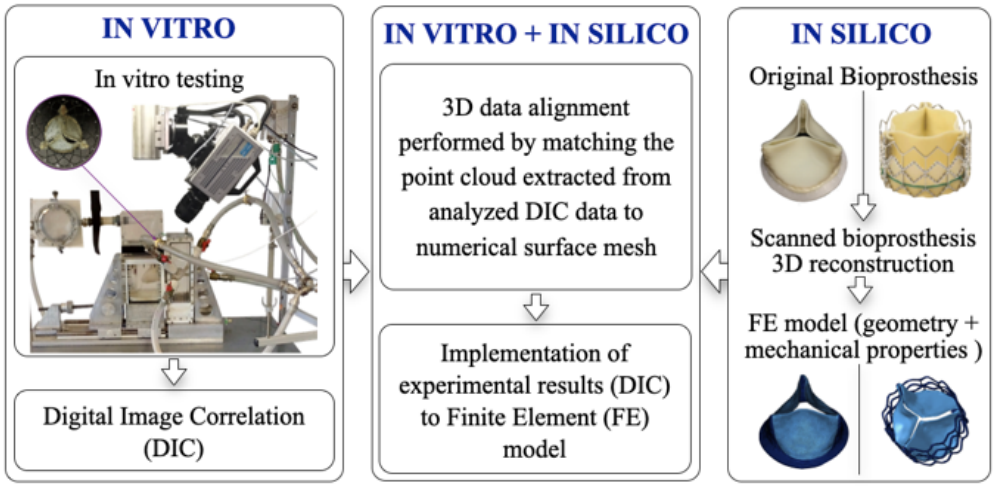

Figure 1 *Schematic representation of the stress computation method.*

3. Results

The maximum leaflet stress for SAV reached 2.03 (Trifecta) and 1.31MPa (Mosaic) and for THV 2.48 (Sapien) and 1.40MPa (CoreValve)(Figure 2). For both SAV and THV, the highest values of leaflet stress were primarily observed in the upper leaflet edge near the commissures and to a lesser extent in the mid-portion of the leaflet body.

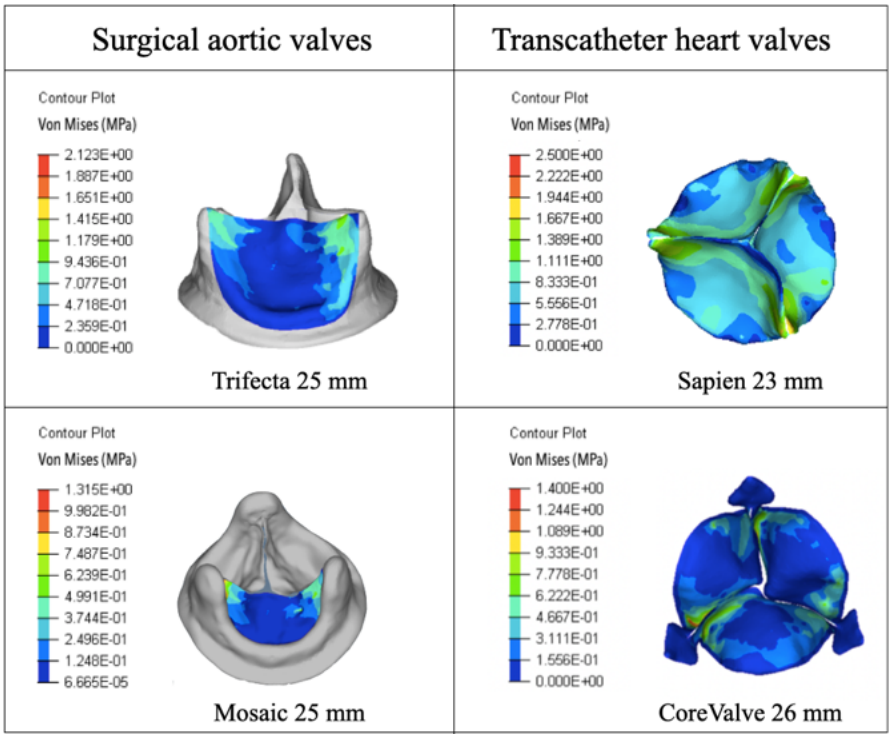

Figure 2 *Mechanical stress applied on leaflets of different bioprosthetic valves.*

4. Conclusions

The method proposed in the present study provides a useful tool to determine the magnitude and distribution of the leaflet stress. The highest levels of leaflet stress occurred near the commissures and mid-portion of the leaflet body. This information may help to predict the durability of a given model and size of bioprosthetic valve in different conditions relevant to the clinical context.

References

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