Title: Numerical Evaluation Of Tissue Mechanics And Organ Level Function Of Engineered Mitral Valve With Chordal Apparatus

Author(s): Elisa Lanzalaco, Joan D. Laubrie, Federica Cosentino, Viktor Balashov, Pietro Terranova, Giuseppe Raffa, Michele Pilato, Petra Mela, Vincenzo La Carrubba, Antonio Pantano, Antonio D'Amore.

Objective: Mitral regurgitation (MR) represents a common mitral valve (MV) pathology. More specifically for secondary regurgitation, where incomplete valve closure is due to ventricular dilation that in turn is produced by cardiac infarction. MV replacement is the gold standard to address this pathology. However, valve repair remedies are still affected by significant failure rates and absence of chordal apparatus (CA), neglecting the natural mechanical continuum ventricle-cusps. Furthermore, clinically available devices are generally trileaflet, unlike the native bileaflet MV. This study assesses the tissue mechanics and the organ-level function of bileaflet MV with CA and identifies the most effective number and locations of chordae tendineae (CT). The evaluation also includes a comparative analysis of a flat annulus vs. a saddle shape, aiming to investigate the impact of biomimetic approaches on valve functions.

Methods: A 2D flat annulus (model-1) and a 3D saddle-shaped annulus (model-2) were analyzed.
Each model was evaluated with different CA designs including: CT=2,6,8, with a length=80,100,120% of the physiological one. The position of the CT anchoring points was varied (edge vs. center). The FEA was performed using Abaqus and a Yeoh model was used for the leaflet's behavior. Quantitative metrics for the assessment included: stress-strain distribution, Geometric Orifice Area and Bending Deformation.

Results: Statistically significant differences in stress-strain distribution were detected between the models with CT=2 and those with CT=6,8. The configuration with CT=2 showed a visible bulge effect. The configurations with edge leaflet anchoring showed better closure of the valve than the center one.

Conclusions: This study demonstrated that, consistently with the general biomimetic paradigm: A) 2 CT do not provide sufficient stability to the valve; B) in the commissural zone and in the areas surrounding the CT insertions were identified highest levels of stress; C) the native-like 3D configuration in Model-2 showed more homogeneous stress distribution.

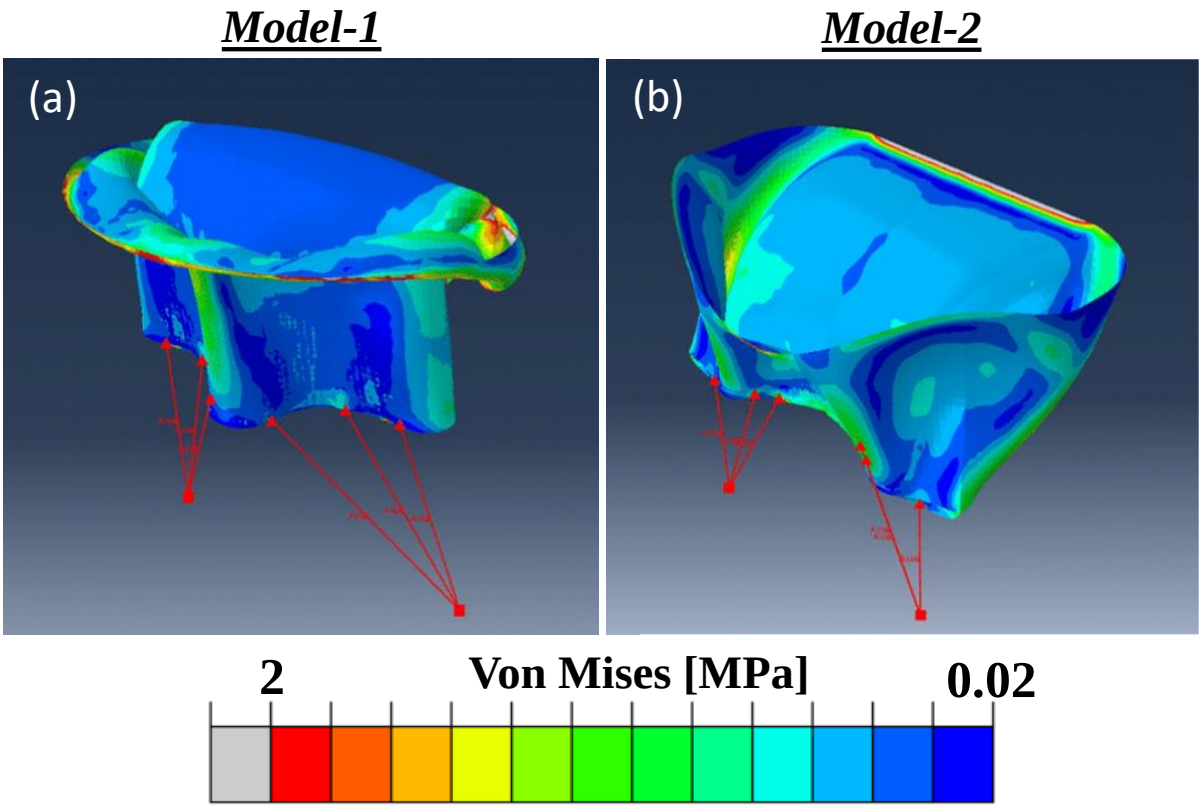

Figure 1 - Von Mises Stress distribution on Mitral Valves with Chordal Apparatus for two CAD models. a) model-1 with flat annulus, b) model-2 with a physiological-inspired lateral profile and saddle shape annulus