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**A fluid structure interaction model of native aortic valve with physiologic tissues properties and flow boundary conditions**

Moshe Rosenfeld1, Rami Haj-Ali1 and Ehud Raanani2  
1School of Mechanical Engineering, Tel Aviv University and 2Cardiothoracic Surgery, Sheba Medical Center

Although the native aortic valve and root were extensively studied, including with numerical models, well-known effects of the coaptation and hemodynamics on valve durability have not completely been assessed. Moreover, numerical limitations prevented producing sufficient data for planning valve-sparing procedures or for evaluating the influence of asymmetric morphologies on the hemodynamics. The objectives of the present study were to develop a new fluid-structure interaction (FSI) model of native aortic valves and to employ it for determining the influence of the valve configuration on the hemodynamics and tissue mechanics.

The numerical model includes valve coaptation under physiologically realistic boundary conditions and tissue properties. The FSI simulations are based on fully coupled structural and fluid dynamic solvers that facilitate accurate modeling of the pressure load on both the root and the cusps. The cusps' tissues in the structural model have hyperelastic behavior and different layers of elements for the collagen fibers network and the elastin matrix. The coaptation is modeled with a master-slave contact algorithm. The opening, systole, closing and diastole phases are simulated by imposing physiological blood pressure at the ventricle and aortic boundaries.

This FSI model was employed in several parametric studies of aortic root geometries for optimizing the kinematic and mechanical performance of the valves post valve-sparing procedure. These parametric studies suggest that improving effective height during valve repair or replacement, by either aortic annulus or cusp intervention, could lead to increased diastolic coaptation and better performance. The model was also employed to investigate the asymmetric bicuspid aortic valve (BAV) and asymmetric collagen fibers network in the cusps. The asymmetric configuration of BAVs caused asymmetric vortices and much larger wall shear stress on the cusps, which could be a potential cause for their early valvular calcification. Highly asymmetric valve kinematics and hemodynamics was also found in a model of a valve with porcine specific fiber alignment.



**Figure 1:** Maximum principal stress contours plotted on the deformed structure and blood velocity vectors with blood pressure contours plotted on two dimensional sections of the mapped (first column) and symmetric (second column) models during peak systole (first row) and diastole (second row).