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# The Three-Dimensional Geometry of the Native Aortic Valve: A New Mathematical Description for Biomechanics and Clinical Diagnostics

**Rotem Halevi**[1], Rami Haj-Ali[1], Gil Marom[1], Ashraf Hamdan[2], Sagit Ben Zekry[3], Ehud Raanani[4]

[1]*Faculty of Engineering, School of Mechanical Engineering, Israel*
[2]*Heart Institute, Chaim Sheba Medical Center, Israel*
[3]*Echocardiography Laboratory, Chaim Sheba Medical Center, Israel*
[4]*Department of Cardiothoracic Surgery, Chaim Sheba Medical Center, Israel*

**Background:**

The complex three-dimensional (3D) geometry of the native aortic valve (AV) is represented by a mathematical model composed of select parametric curves allowing for the general construction and representation of the 3D-AV structure including the cusps (leaflets), commissures and sinuses.

**Methods:**

The proposed general mathematical description is performed by using three independent parametric curves, two for the cusp and one for the sinus. These curves are used to generate different surfaces that form the structure of the AV. Additional dependent curves are also generated and utilized in this process, such as the joint curve between the cusps and the sinuses. The generated geometry is validated against 3D-transesophageal echocardiogram (3D-TEE) measurements from four healthy tricuspid AVs. Computational AV mechanics modeling using the finite-element (FE) can be applied using the proposed geometry.

**Results:**

Examples are given for constructing several 3D-AV geometries by estimating the needed parameters from echocardiographic measurements, and by targeted variations of some of these parameters. The average distance (error) between the calculated geometry and the 3D-TEE measurements was only 0.86±0.64mm. Implementation of the geometric model for bicuspid AVs and asymmetric tricuspid AVs are also presented.

**Conclusions:**

The proposed general 3D parametric mathematical AV geometry is very effective in quantitatively representing a wide range of native AV structures, with and without pathology. One potential use is in computational fluid-structure interaction (FSI) biomechanics modeling. It can also facilitate a methodical quantitative investigation over the effect of pathology and mechanical loading on these major AV parameters.