Project Statement

A System to Quantify 3D Spatial Deformation of Heart Valve Leaflets

Team #8
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Project for Client: Dr. Wei Sun
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Statement of Need:

The purpose of this project is to design and fabricate a strain measurement system that can be used to quantify 3D heart valve deformation in both static and dynamic loading conditions in order to ensure proper valve design and function. In order to better design and analyze bio-prosthetic heart valves, it is important to test their functionality and performance prior to implanting them into the body. Bio-prosthetic heart valves are designed based on several patient factors including size, gender, etc., and therefore, it is important to be able to test individual valves and their functionalities to ensure proper behavior. Valve geometries and sizes differ greatly, and therefore, measurement systems need to be able to incorporate several different types and sized valves. Such a measurement system would allow for the development and testing of bio-prosthetic valves in vitro before implantation, leading to a safer, more efficient implantation.

Introduction and Overview:

For this project, the design team will develop and construct a strain measurement system that can easily test bio-prosthetic heart valves of different geometries and sizes in order to quantify 3D heart valve deformation in both static and dynamic loading conditions.

Both static and dynamic loading conditions will be applied to the system via a pressure transducer, while multiple cameras acquire images, one leaflet at a time. The system will consist of a.) a fluid chamber that houses a bio-prosthetic heart valve, b.) an optical strain measurement system that is composed of at least two cameras (with research into whether the addition of a third camera would be productive) to capture 3D leaflet cusp deformations under a variety of hydrostatic loading conditions, and c.) a pressure transducer that simultaneously measures the transvalvular pressure. The system will be computer-controlled using LabVIEW with automatic data visualization and analysis. The 3D motion of the leaflets will be numerically reconstructed and plotted within the LabVIEW program, as well as the stresses calculated. The accuracy of the strain measurement system will be determined and validated to ensure that the system and LabVIEW program are efficient and yield accurate results.

Such systems have previously been developed; therefore, further development and improvement will be performed to yield more detailed and accurate results.

Realistic Constraints

Ideally the design team would have access to a high-speed camera to capture the most frames per second as possible for more accurate data acquisition, but due to their extremely high cost and lack of funding, such a camera is not possible to obtain. Also, there is a limited access to heart valves, both bio-prosthetic and real tissue. In response, porcine valves will be the dominant valves to be tested. Due to a need for specific mounting plates for each type of heart valve due to different sizes and geometries, a limited number of valve types will be tested.
Other Data

Dr. Wei Sun is an assistant professor of Mechanical Engineering at the University of Connecticut. His research areas include soft tissue mechanics, computational biomechanics and medical device design. Several of the machine parts, including the cameras and pressure transducers, will be supplied by Dr. Sun. The device will be assembled in the Senior Design laboratory area in the Castleman building on the Storrs campus at the University of Connecticut.

Questions

Some unresolved possibilities remain in the design, including whether to use two or three cameras. Research will go into whether it is possible to use mirrors to provide different angles on one camera and still get high enough resolution to distinguish the graphite markers. Also, it will be determined whether the markers on the valve will go out of focus during the deformation of the valve, and whether it be quantified to determine displacement perpendicular to the view of the camera/mirror angle. Finally, it will be determined whether two pressure transducers should be used to measure flow pressure before and after the valve, or is one sufficient.