Utilizing 3D Additive Biomanufacturing To Develop a Biocompatible, Customizable and Durable Mechanical Aortic Valve — Year 2

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Background Over 182,000 patients receive aortic valve replacements annually in the United States. However, valve replacement recipients must choose between two undesirable options, mechanical and tissue prostheses, each with specific advantages and disadvantages. A superior valve prosthesis is critical, and DLP bioprinting is the ideal vehicle. Year 1 of research was encouraging; however, improvements in fabrication and testing protocols are necessary. Methods A mock circulatory loop (MCL) that could test for 12 consecutive hours was developed, allowing for durability assessment. Endoscopic, insufficiency and stenosis (ISE), and particle image velocimetry (PIV) data were collected from the MCL. These data were inputted into models to simulate patient vitals and hemolysis rate. Results Prototype Four was based off the human aortic valve, with some modifications. It performed well in all metrics except durability; at hour 9 of testing, a fissure formed in the left coronary leaflet of the prosthesis, compromising structural integrity and causing a significant decline in the simulated patient's condition. Prototype Five was designed to further mimic the human aortic valve. Prototype Five had many of the same beneficial characteristics as Prototype Four, such as low ISE, hemolysis, etc.; however, it had significantly higher durability. Rather than deteriorating, Prototype Five improved over time, as did the simulated patient's condition. Conclusions This prosthesis is chemically and mechanically biocompatible, as well as durable and customizable to the specific patient – it combines the best of both mechanical and tissue prostheses. While promising and exciting strides have been made over the past two years of research, more investigation is required.

Awards Won:
Second Award of $2,000
NC State College of Engineering: Scholarship to attend NC State Engineering Summer Camp