# Researchers 3-D print lifelike heart valve models

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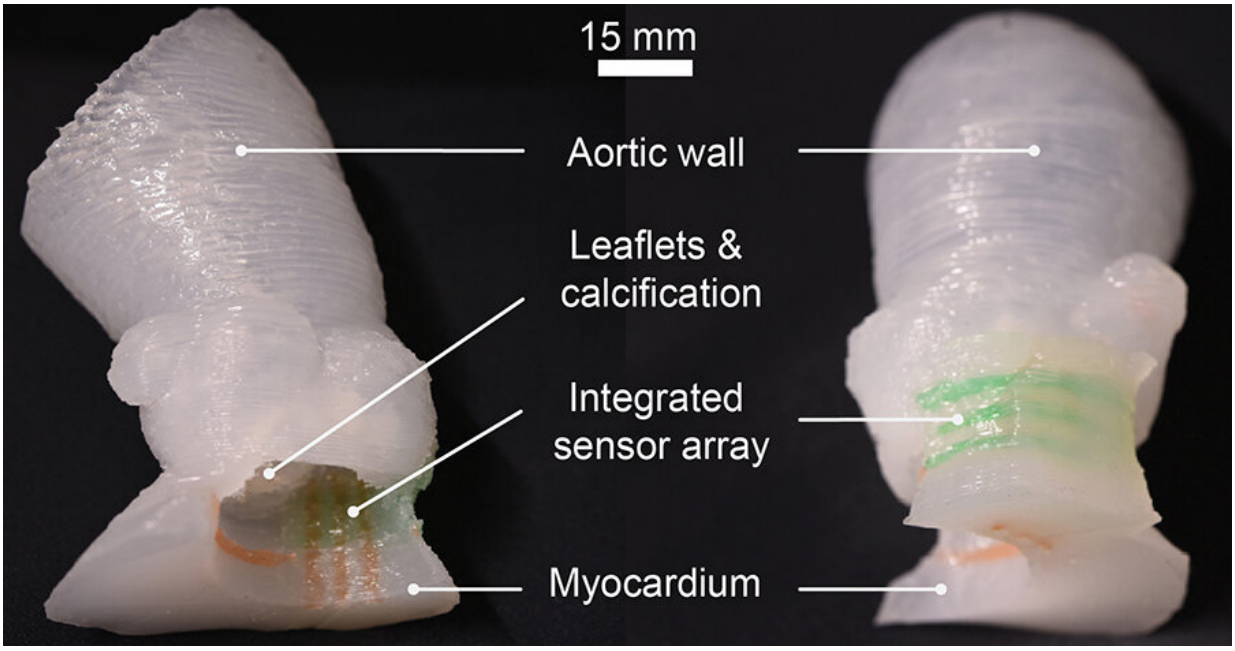


Patient-specific organ models, which include integrated 3D-printed soft sensor arrays, are fabricated using specialized inks and a customized 3D printing process. Such models can be used in preparation for minimally invasive procedures to improve outcomes in thousands of patients worldwide. Credit: McAlpine Group, University of Minnesota

Researchers from the University of Minnesota, with support from Medtronic, have developed a groundbreaking process for multi-material 3-D printing of lifelike models of the heart's aortic valve and the

surrounding structures that mimic the exact look and feel of a real patient.

These patient-specific organ models, which include 3-D-printed soft sensor arrays integrated into the structure, are fabricated using specialized inks and a customized 3-D printing process. Such models can be used in preparation for minimally invasive procedures to improve outcomes in thousands of patients worldwide.

The research is published in *Science Advances*.

The researchers 3-D printed what is called the aortic root, the section of the aorta closest to and attached to the heart. The aortic root consists of the aortic valve and the openings for the coronary arteries. The aortic valve has three flaps, called leaflets, surrounded by a fibrous ring. The model also included part of the left ventricle muscle and the ascending aorta.

"Our goal with these 3-D-printed models is to reduce medical risks and complications by providing patient-specific tools to help doctors understand the exact anatomical structure and mechanical properties of the specific patient's heart," said Michael McAlpine, a University of Minnesota mechanical engineering professor and senior researcher on the study. "Physicians can test and try the valve implants before the actual procedure. The models can also help patients better understand their own anatomy and the procedure itself."

This organ model was specifically designed to help doctors prepare for a procedure called a Transcatheter Aortic Valve Replacement (TAVR) in which a new valve is placed inside the patient's native aortic valve. The procedure is used to treat a condition called aortic stenosis that occurs when the heart's aortic valve narrows and prevents the valve from opening fully, which reduces or blocks blood flow from the heart into

the main artery. Aortic stenosis is one of the most common cardiovascular conditions in the elderly and affects about 2.7 million adults over the age of 75 in North America. The TAVR procedure is less invasive than open heart surgery to repair the damaged valve.

The aortic root models are made by using CT scans of the patient to match the exact shape. They are then 3-D printed using specialized silicone-based inks that mechanically match the feel of real heart tissue the researchers obtained from the University of Minnesota's Visible Heart Laboratories. Commercial printers currently on the market can 3-D print the shape, but use inks that are often too rigid to match the softness of real heart tissue.

On the flip side, the specialized 3-D printers at the University of Minnesota were able to mimic both the soft tissue components of the model, as well as the hard calcification on the valve flaps by printing an ink similar to spackling paste used in construction to repair drywall and plaster.

Physicians can use the models to determine the size and placement of the valve device during the procedure. Integrated sensors that are 3-D printed within the model give physicians the electronic pressure feedback that can be used to guide and optimize the selection and positioning of the valve within the patient's anatomy.

But McAlpine doesn't see this as the end of the road for these 3-D-printed models.

"As our 3-D-printing techniques continue to improve and we discover new ways to integrate electronics to mimic organ function, the models themselves may be used as artificial replacement organs," said McAlpine, who holds the Kuhrmeyer Family Chair Professorship in the University of Minnesota Department of Mechanical Engineering.

"Someday maybe these 'bionic' organs can be as good as or better than their biological counterparts."

**More information:** "3D printed patient-specific aortic root models with internal sensors for minimally invasive applications" *Science Advances* (2020). advances.sciencemag.org/lookup … .1126/sciadv.abb4641

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