

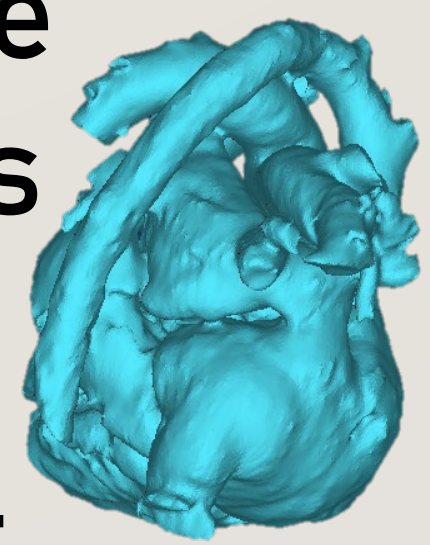
Background

Patient-specific 3D anatomical models can be a valuable tool for specialists. It has a substantial impact on surgical planning and medical fellow's training. 3D models can play an important role in the field of cardiology where complex congenital heart diseases occur. Many 3D models are produced using a 3D printer or viewed in virtual reality. While many 3D printers can provide anatomically correct and detailed models, existing 3D printing materials fail to replicate myocardial tissue properties and can be extremely costly. The objective of this protocol is to develop a process for the creation of patient-specific models of complex congenital heart defects using a low-cost silicone that more closely matches cardiac muscle properties.

Current Patient Specific Cardiac Models

Digital

- + Very Accurate
- + Fast Process
- + Inexpensive
- Not Physical
- Inoperable



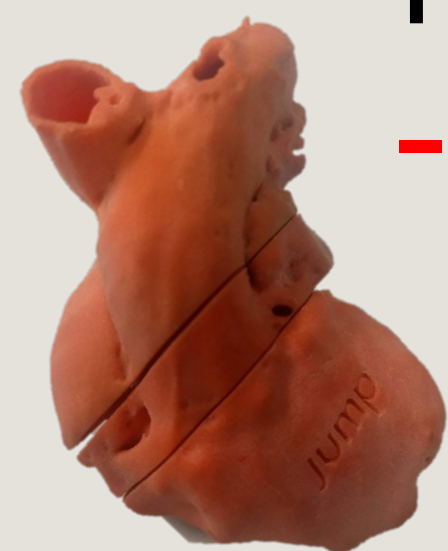
PLA Plastic

- + Accurate
- Long Process
- + Inexpensive
- Hard Material
- Inoperable



Gypsum

- + Very Accurate
- Long Process
- Expensive \$\$
- Hard Material
- Inoperable



TangoPlus FullCure930

- + Accurate
- Long Process
- Expensive \$\$\$
- + Softer Material
- + Operable
- Shore Hardness of 27 A

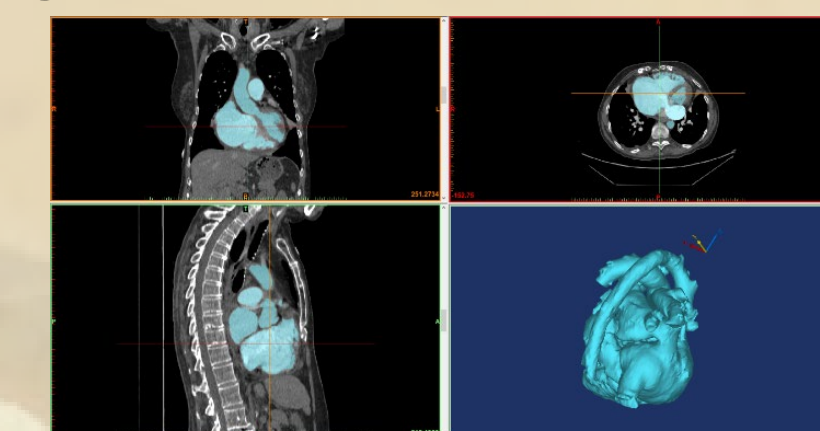
Methodology

Segment Anatomy

1. Obtain patient CT or MRI
2. Segment myocardium
3. Invert myocardium segmentation and select the appropriate regions to generate:



1. Blood pool
2. Epicardium case



Create Mold

1. 3D Print blood pool and epicardium case in ABS using a FDM 3D printer
2. Vapor-smooth case with acetone
3. Assemble case around blood pool
4. Ensure all pieces fit together tightly, adjust as necessary



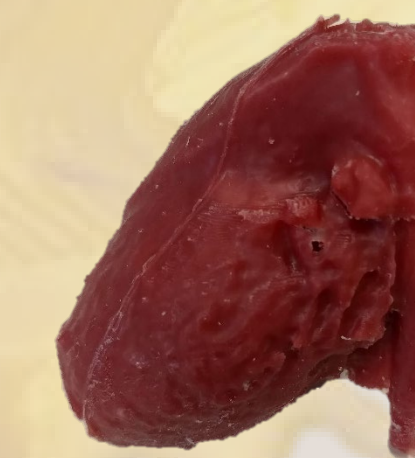
Pour Silicone

1. Submerge and coat blood pool in DragonSkin Fx-Pro silicone
2. Assemble one half of case around blood pool
3. Pour silicone into space between blood pool and case wall
4. Assemble remaining pieces of case
5. Place assembled case in vacuum chamber
6. Allow silicone to set
7. Repeat steps with remaining half of case and blood pool



Dissolve Blood Pool

1. Remove silicone heart from case
2. Submerge silicone in acetone until blood pool dissolves

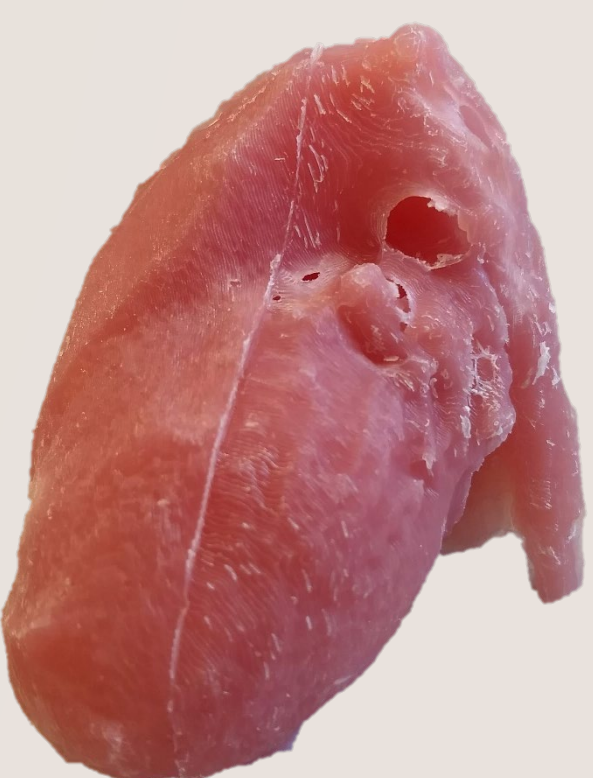


Results

This procedure resulted in a patient-specific silicone heart model produced with less than \$10 in materials. The successful surgical correction of a model with a ventricular septal defect (VSD) using a GORE-TEX patch demonstrates the utility of the method.

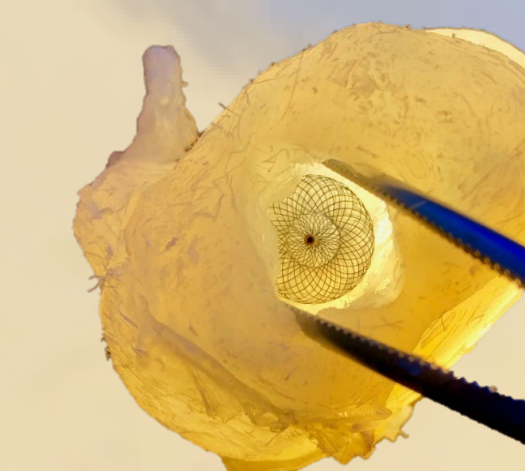
DragonSkin Fx-Pro Silicone Model

- + Accurate
- Long Process
- + Inexpensive
- + Soft Material
- + Operable
- + Shore Harness of 2 A



Current Successes

- Tetralogy of Fallot Modeled
- VSD Modeled
- Cut and Suture
- Stent Placement Procedure in VSD



Next Steps

- Material Property Quantification
- Surgical Simulation Validity



Conclusion

This procedure allows for cost effective patient-specific surgical procedural simulation; silicone tissue characteristics were acceptable but leave potential for improvement.