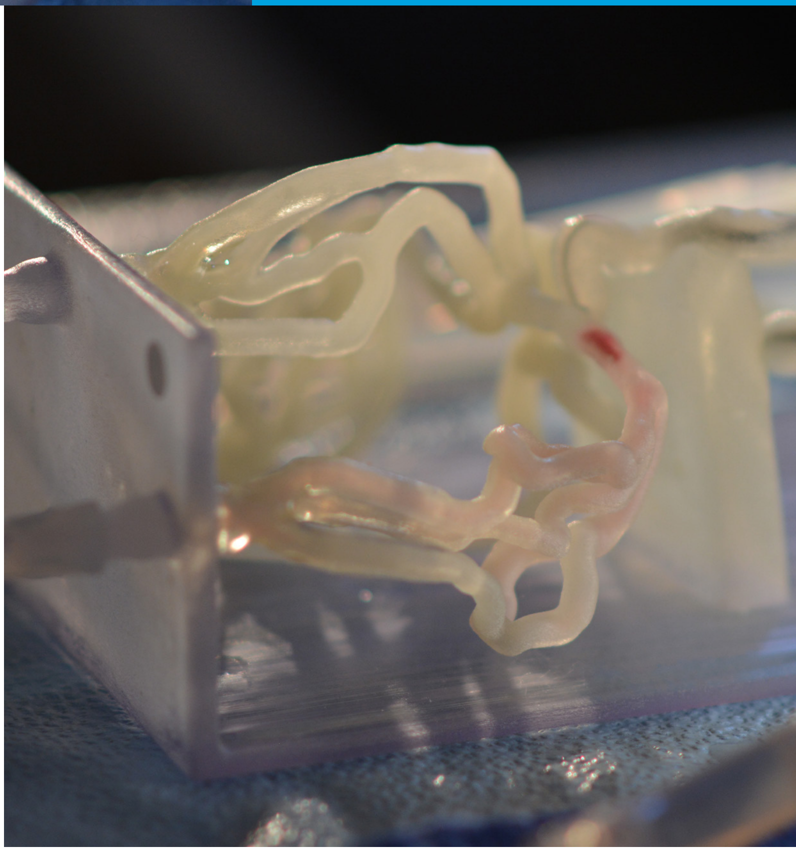


Creating Biomechanically Accurate Vascular Models

White Paper

Creating Biomechanically Accurate Vascular Models

To create realistic synthetic vascular models for medical device development, physician training, surgical demonstration, and procedural planning, arteries must replicate how native tissue expands and contracts as pulsatile pressures are applied. Mimicking arterial distensibility, or an artery's ability to expand in response to an increase in blood pressure, is a key biomechanical attribute.

The J750 Digital Anatomy™ 3D printer technology gives clinicians and engineers the power to create the most lifelike anatomical models available. More than 100 clinically validated preset anatomy options—that vary in softness, flexibility, and density—mimic human tissue like never before.

In 2020, scientists and researchers at the Jacobs Institute performed the first study of its kind to evaluate the characteristics of J750 Digital Anatomy 3D printed vascular models and how accurately they replicate vessel behavior under hemodynamic pressure.

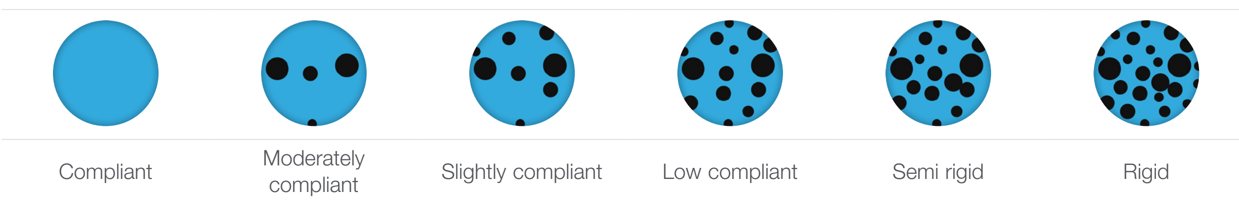
Creating Biomechanically Accurate Vascular Models

Method

3D printed models of the aorta, carotid artery, and coronary artery were created using the six preset Digital Anatomy software blood vessel material configurations that range from compliant to rigid. The wall thickness of the arteries was set to the minimum that could withstand physiological pressures.

Artery Type	Inner Diameter, ID [mm]	Wall Thickness, WT [mm]	Artery Materials
Coronary	3.0	1.0	Compliant
Carotid	7.0	1.5	Semi-Compliant
Aorta	30	3.0	Rigid

Vessel walls were formed using varying preset ratios of flexible Agilus™ material and rigid VeroClear™ material.



A pulsatile pump was used to circulate water at body temperature through the printed model. Mean arterial pressure and pulse pressure were monitored and adjusted to match physiological values.

Systolic and diastolic distensibility measurements were acquired with Intravascular Ultrasound (IVUS). Distensibility was then calculated based on these measurements and compared to clinical values.

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The Results

The 3D printed arteries demonstrated accurate physiological distensibility values similar to human vessels.

Accurately simulates the biomechanical behavior of vessel tissue	Enables clinically relevant benchtop testing	Produces highly repeatable, consistent results

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The Conclusion

Arteries are dynamic structures that expand and contract as a result of internal blood pressures. Replicating the movement of arteries is an important part of realistic treatment planning, education, and product testing. The J750 Digital Anatomy printer, thereby, provides value by enabling accurate simulation.

This study suggests that the Digital Anatomy printer and its unique material combinations can create arterial models that are biomechanically similar to human vessels.

In addition, this study demonstrates that it is both feasible and appropriate to characterize distensibility in vascular models using IVUS.

Suggested Parameters for Distensible Arteries

Vessel Type	Inner Diameter [mm]	Wall Thickness [mm]	Material
Aorta	30	3	Compliant
Carotid	9	1.5	Compliant, Moderately Compliant
Coronary	3	1	Rigid, Semi-Rigid

To learn more about the J750 Digital Anatomy printer, materials and software, visit stratasys.com, or you can email medical@stratasys.com with questions.

References
Sparks, Adam et al., "J750 Digital Anatomical Printing: A direct characterization of 3D-Printed Materials for use as Compliant Arteries using Intravascular Ultrasound (IVUS)," *Publication pending.*

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