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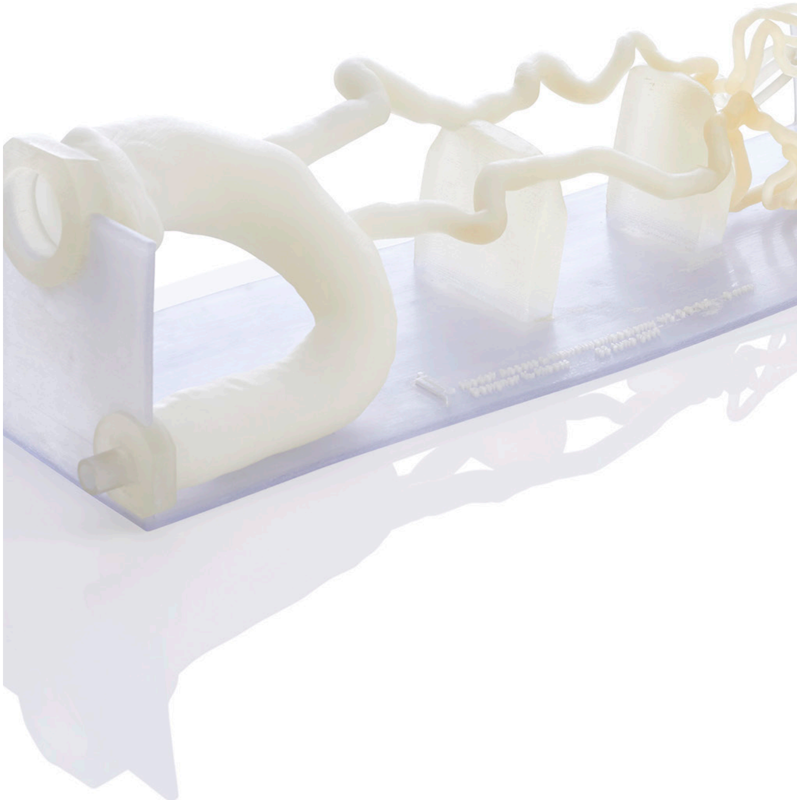
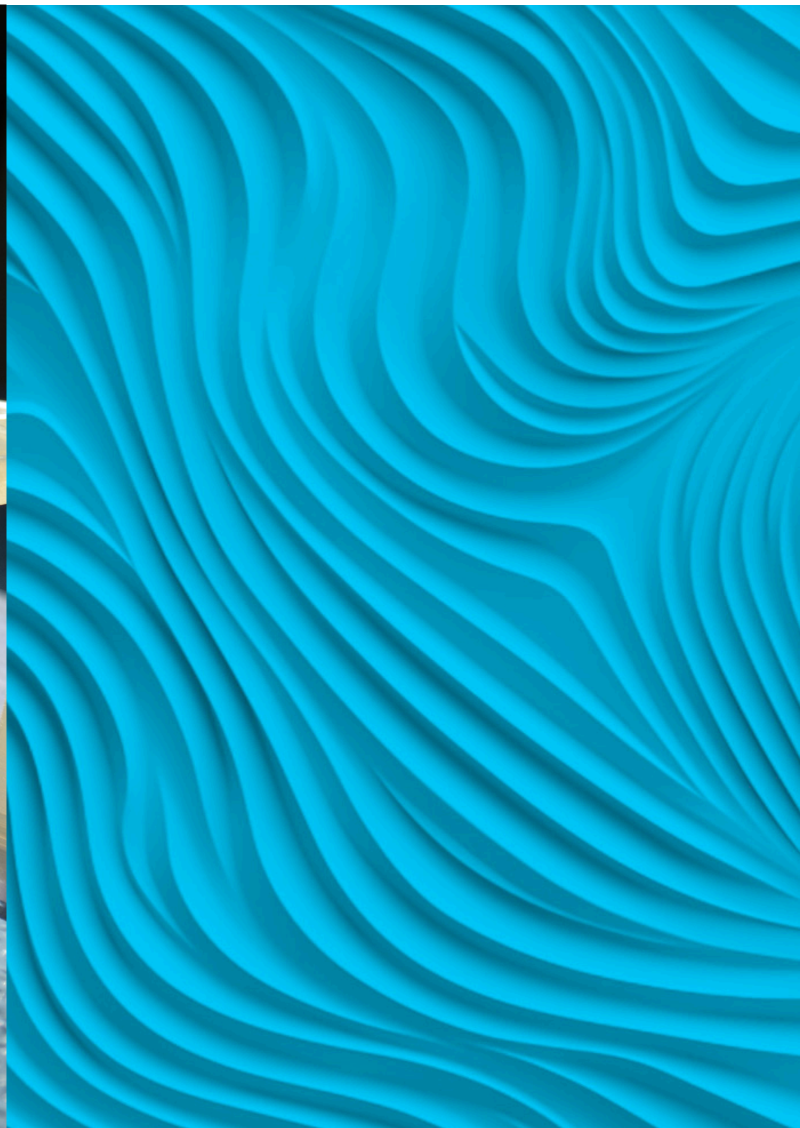


# Achieving Realistic Blood Vessel Distensibility with J5 Digital Anatomy™ Printer



# Advanced 3D-Printed Vascular Models Deliver Realistic Insights for Medical Research

## Introduction

Understanding the distensibility of blood vessels is vital for analyzing cardiovascular function and developing medical treatments. Distensibility refers to the ability of vessels to expand and contract with pressure changes. This lab report focuses on the creation and testing of 3D-printed vascular models using J5 Stratasys Digital Anatomy Printers. The aim is to compare the distensibility of these models (Aorta, Carotid, and Coronary) with values reported in the literature, thereby evaluating their realism and potential application in medical research and training.

## Printing

Three types of models were printed on J5 Stratasys Digital Anatomy Printers (J5 DAP) to simulate different blood vessels:

| | Wall Thickness | Inner Diameter | Length |
|---|---|---|---|
| **Aorta** | 2mm | 30mm | 150mm |
| **Carotid** | 1.5mm | 7mm | 150mm |
| **Coronary** | 1mm | 3mm | 115mm |

The walls were printed using ElasticoClear material, with Gel Support used as the internal support material. Pure Gel Support was utilized for the coronary models due to their smaller diameter. All models were printed with a matte finish and a standard grid style. The models were then tested by the Jacobs Institute for distensibility.

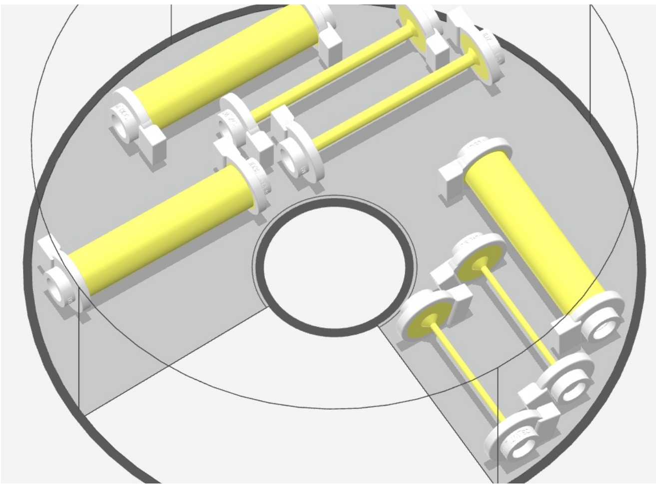


Figure 1 – Visualization of a printed tray containing 3 Aorta models, 2 Carotid models and 2 Coronary models.

## Testing

The models were connected to a flow loop system while the cross-sectional area was measured with intravascular ultrasound (IVUS). The change in cross-sectional area was compared to the literature values of the corresponding blood vessel type.

The number of samples tested included two for both the Coronary and Carotid models, and three for the Aorta models.

## Flow System Setup:

Each vascular model was mounted on a fixture allowing axial movement to prevent artificial increases in lumen area change.

A pulsatile pump provided cyclical flow with adjustable cardiac output, mimicking physiological conditions with a target temperature of 37.5°C and pressures of 120/80 mmHg and pulse pressure of 40 mmHg.

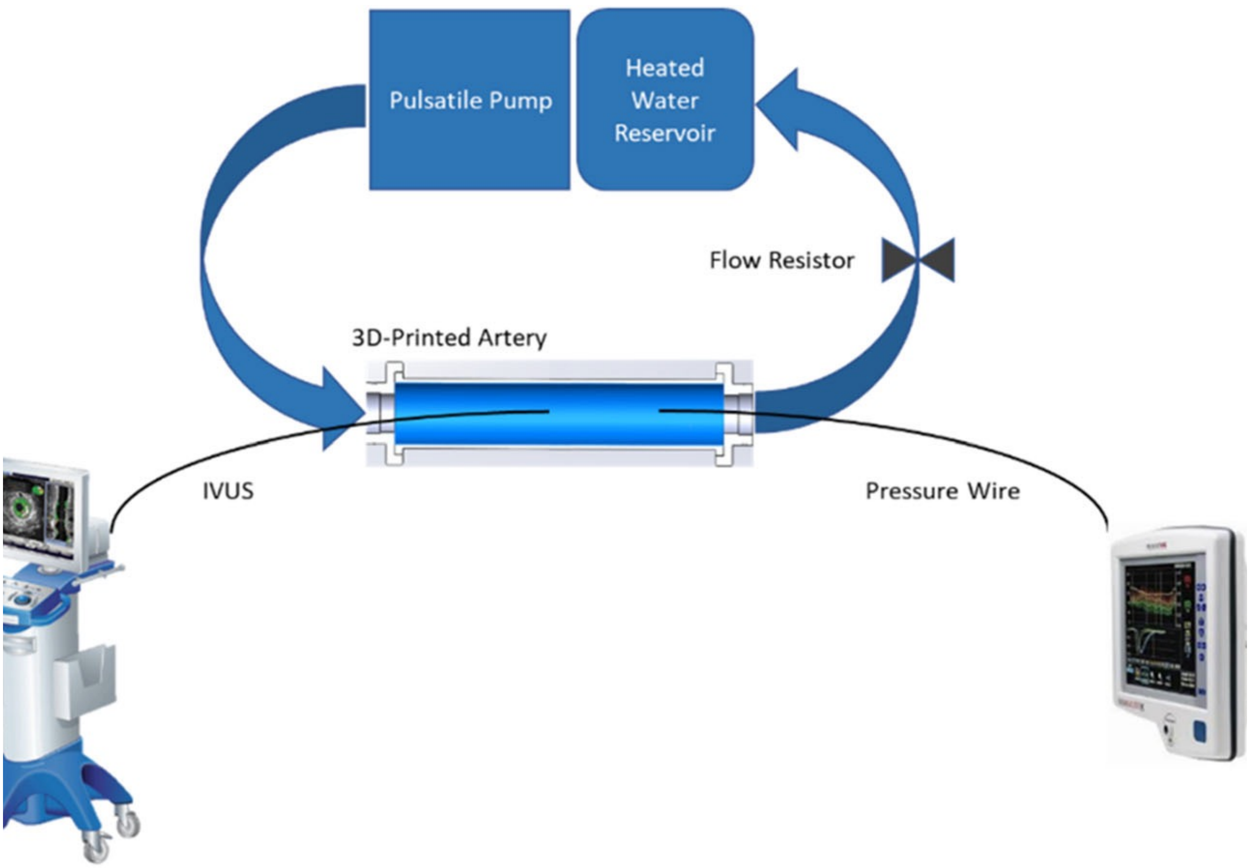



Figure 2 – Flow System Setup.

## Distensibility Testing:

An intravascular ultrasound (IVUS) catheter was positioned at the center of each model, supported by a guide wire.

Hemodynamic conditions were stabilized for two minutes before measurements were taken. IVUS readings were recorded for 15 seconds, capturing mean arterial pressure, systolic, diastolic and pulse pressures.

The models' distensibility was assessed by analyzing changes in lumen area in response to the pulsatile flow according to the equation:

$$D = \frac{\Delta A / A_{\mathrm{min}}}{\Delta P}$$

Where:

D is the distensibility.

$\Delta A$ is the change in lumen area.

$A_{min}$ is the minimal lumen area.

$\Delta P$ is the change in pressure between systole (maximum) and diastole (minimum).

## Results and Conclusion

The measured distensibility values for each model sample were compared to the corresponding values reported in the literature.

- **Aorta:** The samples tested displayed values at the lower end of the literature range. This indicates that printing with the compliant preset should yield a realistic aorta vessel.
- **Carotid:** The samples displayed values within the range documented in the literature. Consequently, using the Compliant preset for the blood vessel wall should produce a realistic carotid vessel.
- **Coronary:** The samples measured had values that were at or slightly above the literature range. Therefore, to achieve a more realistic coronary vessel, users should utilize the less compliant presets (such as Moderately or Slightly compliant).

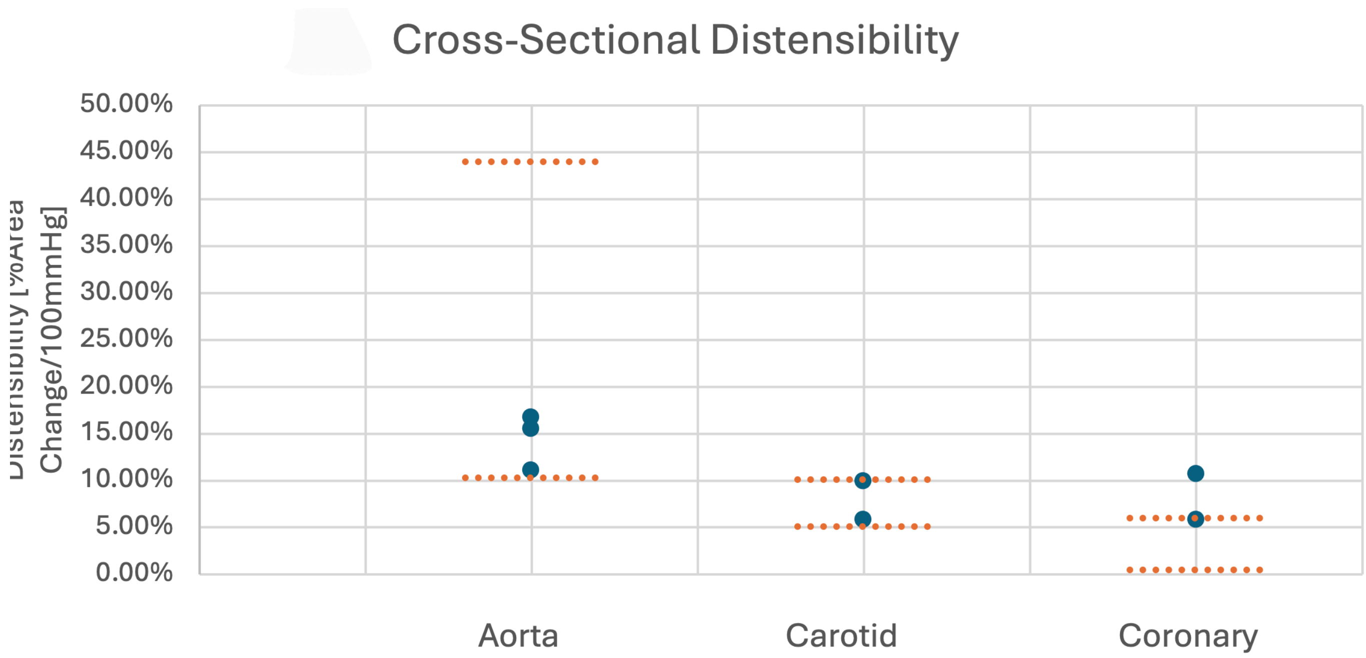



Figure 3 – Cross-Sections Distensibility values for Aorta, Coronary and Carotid models. Orange dotted lines represent the range of distensibility values found in literature for each blood vessel type[1].

## References:

Sparks, A.J., Smith, C.M., Allman, A.B. et al. Compliant vascular models 3D printed with the Stratasys J750: a direct characterization of model distensibility using intravascular ultrasound. 3D Print Med 7, 28 (2021). https://doi.org/10.1186/s41205-021-00114-8

stratasys

stratasys.com
ISO 9001:2015
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Stratasys Headquarters
7665 Commerce Way,
Eden Prairie, MN 55344
+1 800 801 6491 (US Toll Free)
+1 952 937-3000 (Intl)
+1 952 937-0070 (Fax)

1 Holtzman St., Science Park,
PO Box 2496
Rehovot 76124, Israel
+972 74 745 4000
+972 74 745 5000 (Fax)

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