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Abstract

Compliant vascular models 3D printed with Stratasys J750: a direct characterization of model distensibility using intravascular ultrasound

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The purpose of this study is to evaluate biomechanical accuracy of 3D printed anatomical vessels using a material jetting printer (J750, Stratasys, Rehovot, Israel) by measuring distensibility via intravascular ultrasound. The test samples are 3D printed tubes to simulate arterial vessels (aorta, carotid artery, and coronary artery). Each vessel type is defined by design geometry of the vessel inner diameter and wall thickness. Vessel inner diameters are aorta = 30mm, carotid = 7mm, and coronary = 3mm. Vessel wall thickness are aorta = 3mm, carotid = 1.5mm, and coronary = 1mm. Each vessel type was printed in 3 different material options. Material options are user-selected from the J750 printer software graphical user interface as blood vessel wall anatomy elements in 'compliant', 'slightly compliant', and 'rigid' options. Three replicates of each vessel type were printed in each of the three selected material options, for a total of 27 models. The vessels were connected to a flow loop system where pressure was monitored via a pressure wire and cross-sectional area was measured with intravascular ultrasound (IVUS). Distensibility was calculated by comparing the % difference in cross-sectional area vs. pulse pressure to clinical literature values. Target clinical ranges for normal and diseased population distensibility are 10.3-44 % for the aorta, 5.1-10.1 % for carotid artery, and 0.5-6 % for coronary artery. Aorta test vessels had the most clinically representative distensibility when printed in user-selected 'compliant' and 'slightly compliant' material. All aorta test vessels of 'compliant' material (n = 3) and 2 of 3 'slightly compliant' vessels evaluated were within target range. Carotid vessels were most clinically represented in distensibility when printed in 'compliant' and 'slightly compliant' material. For carotid test vessels, 2 of 3 'compliant' material samples and 1 of 3 'slightly compliant' material samples were within target range. Coronary arteries were most clinically represented in distensibility when printed in 'slightly compliant' and 'rigid' material. For coronary test vessels, 1 of 3 'slightly compliant' materials and 3 of 3 'rigid' material samples fell within target range. This study suggests that advancements in materials and 3D printing technology introduced with the J750 Digital Anatomy 3D Printer can enable anatomical models with clinically relevant distensibility.

Author's Statement

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References

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