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Abstract

3D-printed aneurysm models for studying endovascular treatment efficacy

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Intracranial aneurysms (IAs) can be treated with flow-modulation devices (FMDs) with good success. Still, complications occur so that improvements are being investigated. Developing novel FMDs is difficult, often including extensive animal testing. Patient-specific IA models allow testing FMDs in vitro easier and prior to animal trials, however, are not widely established yet. Here, we present a protocol to produce patient-specific IA models and their use in evaluating the treatment efficiency of a novel FMD – the Contour Neurovascular System (CNS).

IA models were constructed by [1]: a) segmenting vessels from medical radiological images (region growing, marching cube's algorithms, MevisLab, MeVis Medical solution); b) manual correction of segmentation errors; c) addition of vessel wall and flow connectors. In total, 14 basilar artery bifurcation tip aneurysm models were designed and 3D printed with stereolithography (Form 3, Clear Resin, Formlabs). IA treatment was performed by placing 10 CNS devices into IA models under fluoroscopy [2]. IA models were integrated into a flow loop and subjected to digital subtraction angiography (DSA, Allura Xper, Philips), 4D flow MRI (3T, Philips), and numerical flow simulations (StarCCM+2021, Siemens) [3].

All CNS were successfully implanted and led to a reduced intra-aneurysmal flow confirmed qualitatively by 4D flow MRI and quantitatively by increased contrast agent stasis time on DSA (mean w/o = 0.5s, mean w/ = 2.3s) and reduced intra-aneurysmal velocity as calculated by numerical simulations (mean w/o = 0.12m/s, mean w/ = 0.03m/s). The presented protocol allows the production of complex patient-specific IA models with vessel diameters greater than 1 mm, replicating the aneurysm geometry and main flow features for testing FMDs under standardized conditions.

AUTHOR'S STATEMENT

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