CNS 2018 ANNUAL MEETING
HOUSTON, TEXAS
OCTOBER 6-10, 2018

Customizable 3D Printed Simulation Model of Aneurysms in the Circle of Willis: A Step Closer to Reality.

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Introduction

The aim of this project was to construct a low cost customizable simulation system of aneurysms in the circle of Willis and its branches.

Methods

DICOM images from an MRA head were used to create a Stereolithography model of the circle of Willis using Materialise InPrint. A desktop 3D printer utilizing fused deposition modeling technology was used for 3D printing. Water-soluble polyvinyl alcohol (PVA) was used as the printing material for the arterial network. Two different concentrations of silicone in solvent were applied to the outer layer of the model, with the more flexible silicone applied to a desired area, such as the basilar tip, which would lead to development of aneurysm. Immersing the final product in water dissolved PVA, leaving a hollow elastic vascular model with thin walls. The designated open ends of the model were connected to a pressure-adjustable closed-circuit liquid circulation pump in order to simulate blood flow.

Results

The wall of the vascular system developed in this current technique, allows for a more realistic simulation when compared to models where the flexible vessel walls are directly 3D printed with PolyJet technology. This is due to the ability to create thinner walls as well as the ability to create larger and more complex vascular anatomy since no support material is needed for the long hollow tubular structure with overhanging edges. Furthermore, the aneurysms are the result of true wall protrusion with a tensile force developed in the walls of the aneurysm.

Conclusions

The hollow vascular system can be embedded in a soft model of brain parenchyma created through molding techniques to allow neurosurgical trainees to practice clipping of aneurysms that are truly the result of bulging of the vascular wall as opposed to the traditional directly 3D printed thick-walled static aneurysms.

Learning Objectives

Give trainees and surgeons an opportunity to study and practice the anatomy and steps for successful treatment of cerebral aneurysms.

References

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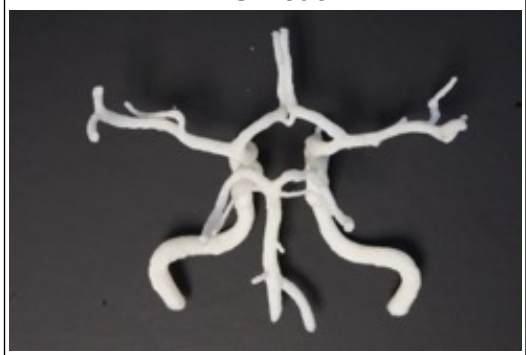
MRA

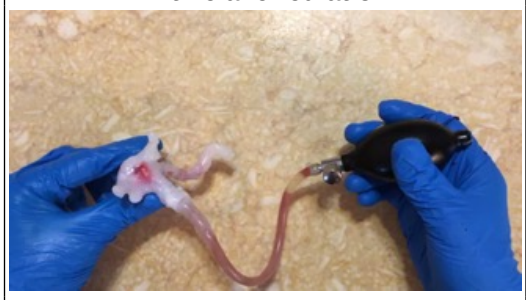
MRA model of the Circle of Willis

ABS model



3D printed ABS model.

Artificial circulation



Artificial circulation for the 3D printed model.