Three-Dimensional Modeling of Anterior Communicating Artery Aneurysm for Surgical Simulation

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Background: A ruptured cerebral aneurysm is a common cause of life-threatening subarachnoid hemorrhage and can be treated using open surgical clipping or endovascular coiling and stenting. Most aneurysms arise on typical sites on the circle of Willis and its terminal branches with the anterior communicating artery being the most common site. The recent shift towards endovascular procedures has decreased the frequency of open surgical aneurysm clipping. This provides less opportunities for neurosurgical residents to develop procedural skills needed to successfully clip an aneurysm. To fill the gap, three-dimensional (3D) modeling and printing can be adapted to create a surgical simulator. 3D models can provide realistic surgical practice in a low acuity setting.

Methods: A preexisting model of a skull was remodeled to print with a pre-cut pterional craniotomy. A 3D model of a circle of Willis with an anterior communicating artery aneurysm was constructed using a patient's computed tomography angiography data. The model was segmented and optimized for 3D printing. A prototype was printed using acrylonitrile-butadiene-styrene (ABS). The ABS skeleton was then coated with silicone containing red pigment. The ABS was dissolved using acetone to create a hollow silicone cast of the aneurysm and the circle of Willis.

Results: Following successful printing and casting, the hollow vascular model was positioned within the skull and a simulation was assembled. Comparing the similarity between the view of the aneurysm model through the pterional craniotomy window and the actual surgical perspective, suggested the necessity to move the craniotomy window more anteriorly.

Future Directions: 3D printing and silicone casting of cerebrovascular models is a feasible method to create surgical simulators as it can approximate the anatomy and tactile characteristics of vasculature. Further models will be created and used to assemble surgical simulators for resident education.