3D Printing and Rapid Prototyping in Neurosurgery: Present and Future Directions

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Introduction

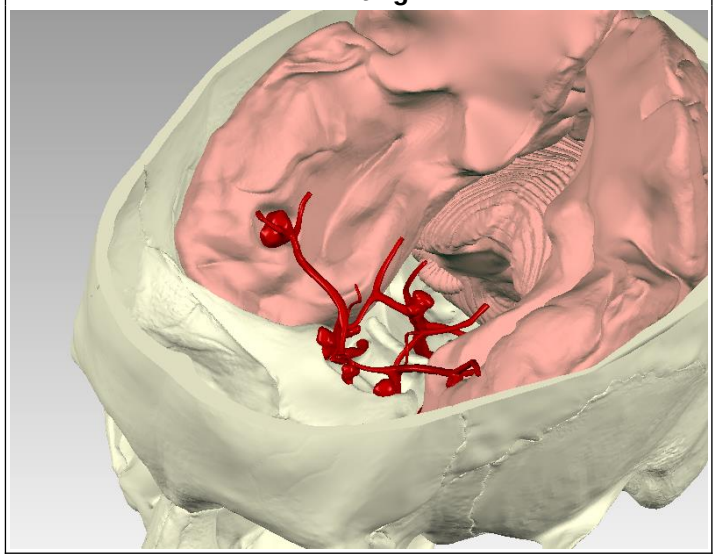
With an accelerating cycle of innovation, novel manufacturing techniques and a new variety of base materials added every year, rapid prototyping and 3D printing applications are expanding in all aspects of medicine, most notably the neurosurgical discipline. In fact, the added value of such technologies has led to the possibility of enhancements in neurosurgical practices, better surgical training programs and improved health outcomes for patients. We aim to present a synopsis of the current state of rapid prototyping and 3D printing in neurosurgery.

Methods

A comprehensive literature review was performed using the Pubmed online database through March 2015. Articles encompassing rapid prototyping and 3D printing in neurosurgery were reviewed and subsequently systematized.

Objet 500 3D printer

3D Computational Modeling of Aneurysms before Printing



Results

The use of rapid prototyping and 3D printing has permeated every subspecialty of neurosurgery. Its most prominent uses involve surgical pre-planning and procedural training on a patient specific physical model before a particular operation. In addition, it is increasingly being used for the creation of surgical implants, most importantly for craniofacial defects, pediatric skull anomalies, and spinal surgeries. On the education front, 3D printed models, including skulls for craniotomy, aneurysm clipping, lumbar puncture and skull base modules are increasingly being used in residency programs. Moreover, this modality has been utilized to construct patient specific frames for stereotactic surgery and has been also applied in studying patient specific aneurysms hemodynamically. Additional applications include: device innovation and improvement, basic neuroscience tool manufacturing, and finally patient education. These advances in 3D print applications, however, are currently limited by print fidelity, available materials and high cost.

Conclusions

As the rate of innovation in computer and manufacturing technologies accelerates, so will the uses, speed and resolution of 3D printing technologies. This will in turn have a significant potential benefit in the form of neurosurgical patient specific simulations as outlined above.

Learning Objectives

Highlight the current added value of 3D printing and rapid manufacturing in the neurosurgical field.

3D Printing in Neurosurgery

Patient Specific Simulation and Preoperative Planning
Device Innovation
Surgical Implant and Tool Manufacturing
Simulation Education
Patient Education
Patient Specific Stereotactic Surgical Frames
Intracranial Hemodynamic Analysis