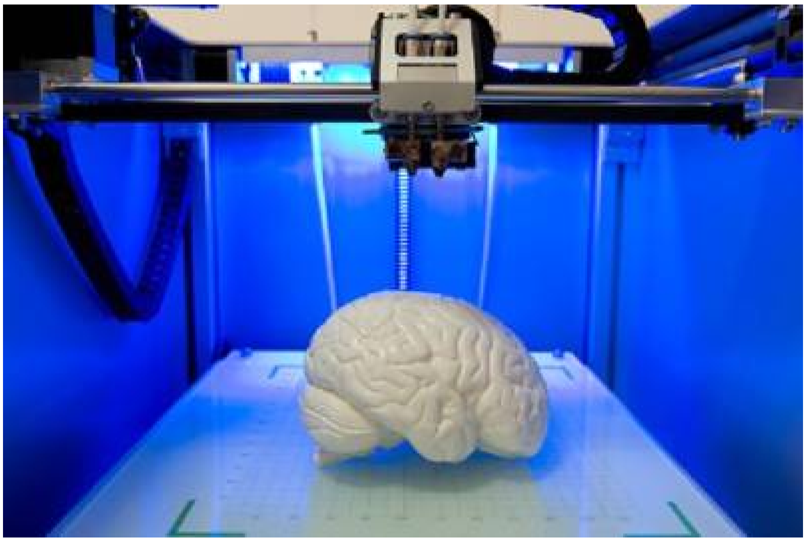
3D printing



- Additive Manufacturing, Thermoplastics, CAD Technology, and Reverse Engineering in Orthopedics and Neurosurgery-Applications to Preventions and Treatment of Infections
- Using Patient-Specific 3D-Printed C1-C2 Interfacet Spacers for the Treatment of Type 1 Basilar Invagination: A Clinical Case Report
- 3D-Printed Patient-Specific Models of the Aortic Arch for Advanced Visualization of Complex Neurointerventional Cases
- Reshaping neurosurgical training: a novel simulation-based concept for structured skill acquisition and curriculum integration
- 3D Printing Technology-Assisted Precise Surgery for a Cryptic Hemangioma of Cranial Bone
- Wet-adhesive and antibacterial PAH-TPP coacervates with self-mineralizing capability for cranial flap fixation
- An Osmosis-driven 3D-printed brain implant for drug delivery
- Enhancing skull base tumor management: the combination of 3D printing technology and endoscopic surgical techniques

Three-dimensional printing is an innovative technology that has gained prominence in recent years due to its attractive features such as affordability, efficiency, and quick production. The technology is used to produce a three-dimensional model by depositing materials in layers using specific printers. In the medical field, it has been increasingly used in various specialties, including neurosurgery, cardiology, and orthopedics, most commonly for the pre-planning of complex surgeries. In addition, it has been applied in therapeutic treatments, patient education, and training of medical professionals [1)]

Three-dimensional (3D) printing is an affordable aid that is useful in neurosurgery. It allows for better visualization and tactile appreciation of the individual anatomy and regions of interest and therefore potentially lowers the risk of complications. There are various applications of this technology in the field of neurosurgery.

Vezirska et al. presented a basic methodology for the creation of a 3D printed model using only open-source software for medical image editing, model generation, pre-printing preparation, and analysis of the literature concerning the practical use of this methodology.

The literature review on the current applications of 3D printed models in neurosurgery shows that they are mostly used for preoperative planning, neurosurgical training, and simulation, closely followed by their use in patient-specific implants and instrumentation and medical education. MaterialiseTM Mimics is the most frequently used commercial software for a 3D modeling for preoperative planning and surgical simulation, while the most popular open-source software for the same applications is 3D Slicer.

They present the algorithm that they employ for 3D printing using HorosTM, Blender, and Cura software packages which are all free and open-source.

Three-dimensional printing is becoming widely available and of significance to neurosurgical practice. Currently, there are various applications of this technology that are less demanding in terms of technical knowledge and required fluency in medical imaging software. These predispositions open the field for further research on the possible use of 3D printing in neurosurgery [2)].

In 3D printing, successive layers of material are formed under computer control to create an object.

These objects can be of almost any shape or geometry and are produced from a 3D model or other electronic data sources.

Futurologists such as Jeremy Rifkin believe that 3D printing signals the beginning of a third industrial revolution, succeeding the production line assembly that dominated manufacturing starting in the late 19th century. Using the power of the Internet, it may eventually be possible to send a blueprint of any product to any place in the world to be replicated by a 3D printer with "elemental inks" capable of being combined into any material substance of any desired form.

3D printing in the term's original sense refers to processes that sequentially deposit material onto a powder bed with inkjet printer heads. More recently, the meaning of the term has expanded to encompass a wider variety of techniques such as extrusion and sintering-based processes. Technical standards generally use the term additive manufacturing for this broader sense.

The implementation of cost-efficient 3D printing resulted in successful patient treatment with excellent outcomes. Our practice guide offers a 3D printing workflow and could be adapted to fit the needs of other specialties like neurosurgery, orthopedic surgery as well [3)]

Anatomical knowledge is a key tenet in graduate medical and surgical education. Classically, these principles are taught in the operating room during live surgical experience. This puts both the learner and the patient at a disadvantage due to environment, time, and safety constraints. Educational adjuncts such as cadaveric courses and surgical skills didactics have been shown to improve resident confidence and proficiency in both anatomical knowledge and surgical techniques. However, the cost effectiveness of these courses is a limiting factor, and in many cases prevents implementation within institutional training programs. Anatomical simulation in the form of "desktop" 3D printing provides a cost-effective adjunct while maintaining educational value [4)]

Previous works took the construction of the burr hole ring as an example, described the process of using softwares like computer aided design (CAD), Pro/Engineer (Pro/E) and 3D printer to construct physical products. That is, a total of three steps are required, the drawing of 2D-image, the construction of 3D-image of burr hole ring, and using a 3D printer to print the physical model of burr hole ring. This protocol shows that the burr hole ring made of carbon fiber can be rapidly and accurately molded by 3D printing. It indicated that both CAD and Pro/E softwares can be used to construct the burr hole ring via integrating with the clinical imaging data and further applied 3D printing to make the individual consumables [5)].

Two patients with cranial defects were presented to describe the 3D printing technique for cranial reconstruction. A digital prosthesis model is designed and manufactured with the aid of a 3D computed tomography. Both the data of large sized cranial defects and the prosthesis are transferred to a 3D printer to obtain a physical model in poly-lactic acid which is then used in a laboratory to cast the final customised prosthesis in polymethyl methacrylate (PMMA).

A precise compliance of the prosthesis to the osseous defect was achieved. At the 6 month postoperative follow-up no complications were observed i.e. rejection, toxicity, local or systemic infection, and the aesthetic change was very significant and satisfactory. Customized 3D PMMA prosthesis offers cost advantages, a great aesthetic result, reduced operating time and good biocompatibility [6)].

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see 3D printing for craniosynostosis.

see 3D printing for spine surgery.

see 3D printing for aneurysm

3-Dimensional Printed Spinal Implants

3-Dimensional Printed Spinal Implants.

3D-printed scaffold

3D-printed scaffold.

Three-dimensional printing in vascular neurosurgery

see also Intracranial aneurysm surgery

Three-dimensional printing in vascular neurosurgery is trending and is useful for the visualization of intracranial aneurysms for both neurosurgeons and trainees. The 3D models gives the surgeon time to practice beforehand and plan the surgery accordingly. The study of Ozgıray et al. aimed to examine the effect of preoperative planning with 3D printing models of aneurysms in terms of surgical time and patient outcomes.

Forty patients were prospectively enrolled in this study and divided into two groups: Groups I and II. In group I, only the angiograms were studied before surgery. Solid 3D modeling was performed only for group II before the operation and was studied accordingly. All surgeries were performed by the same senior vascular neurosurgeon. Demographic data, surgical data, both preoperative and postoperative modified Rankin Scale scores (mRS), and Glasgow Outcome Scores (GOS) were evaluated.

The average time of surgery was shorter in Group II, and the difference was statistically significant between the two groups ($p < 0.001$). However, no major differences were found for the GOS, hospitalization time, or mRS.

This study is the first prospective study of the utility of 3D aneurysm models. They show that 3D models are useful in surgery preparation. Shortly, these models will be used widely to educate trainees and pre-plan surgical options for senior surgeons [7].

3D-printed head Model in skull base surgery training

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