3D-Printed head Model

- Sculpting Solutions: 3D-Printed Models Transform Osteotomy Planning in Monteggia Fractures
- Presentation of complex laryngotracheal surgeries using CT-based 3D models and 3D printing: a technical note
- Exploratory assessment of an endolaryngeal surgical model with a novel hyperangulated 3D printed laryngoscope
- Outcomes of Orbit Reconstructive Surgery Utilizing 3D-Printed Surgical Guides
- A novel technique of brachytherapy for carcinoma of the buccal mucosa-Thinking out of the box!
- Embodiment of an artificial limb in mice
- Three-Dimensional-Printed Models and Shared Decision-Making: A Cluster Randomized Clinical Trial
- 3D printing individualized augments prosthesis and acetabular implant for the treatment of Crowe type III developmental dysplasia of the hip

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Intracranial surgery can be complex and high risk. Safety, ethical and financial factors make training in the area challenging. Head model 3-dimensional (3D) printing is a realistic training alternative to patient and traditional means of cadaver and animal model simulation.

Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and 3D reconstruction from Digital Subtraction Angiography (DSA) are currently used in clinical consultations for patients diagnosed with intracranial aneurysms; however, they have limitations in helping patients understand the disease and possible treatments. This study investigates the use of a 3D-printed model of the patients' neurosurgical anatomy and vascular pathology as an educational tool in outpatient clinics.

Methods: A 3D-printed model of a middle cerebral artery aneurysm was created for use during patient consultations to discuss microsurgical treatment of unruptured cerebral aneurysms. In total, 38 patients and 5 neurosurgeons were included in the study. After the consultation, the patients and neurosurgeons received a questionnaire to assess the effectiveness of the 3D-printed model as an educational tool.

Results: The 3D model improved the patients' understanding of the diagnosis, the aneurysm's relationship to the parent artery; the treatment process as well as the risks if left untreated. The patients found the 3D model to be an interesting tool (97%). The neurosurgeons were satisfied with the 3D-printed model as a patient encounter tool, they found the model effective during consultation (87%) and better than the conventional education tools used during consultations (97%).

Conclusion: Using a 3D model improves communication, enhances the patient's understanding of the pathology and its treatment and potentially facilitates the informed consent process in patients undergoing intracranial aneurysm surgery [1)]

Maclachlan et al. described important factors relating to the 3D printing of human head models and

how such models perform as simulators.

Searches were performed in PubMed, The Cochrane Library, Scopus and Web of Science. Article screening was conducted independently by three reviewers using Covidence software. Data items were collected under five categories: 'Study information', 'Printers and processes' 'Head model specifics,' 'Simulation and evaluations' and 'Costs and production times'.

Results: Forty articles published over the last 10 years were included in the review. A range of printers, printing methods and substrates were used to create head models and tissue types. Complexity of the models ranged from sections of single tissue type (e.g., bone) to high-fidelity integration of multiple tissue types. Some models incorporated pathology (e.g., tumours, aneurysms) and artificial physiology (e.g., pulsatile circulation). Aneurysm clipping, bone drilling, craniotomy, endonasal surgery and tumour resection were the most commonly practiced procedures. Evaluations completed by those using the models were generally favourable.

Conclusions: This review's findings indicate that those who practice surgery and surgical techniques on 3D printed head models deem them to be valuable assets in cranial surgery training. Understanding how surgical simulation on such models impacts on surgical performance and patient outcomes, whilst considering cost-effectiveness, are important future research endeavours [2)].

3D-printed skull model for enhancing training in external ventricular drainage within medical education

Type of study: Simulation-based training model development and preliminaryy evaluation study

Reference: Scheidt K, Kropla F, Winkler D, Möbius R, Vychopen M, Wach J, Güresir E, Grunert R. 3D Print Med. 2025 Apr 3;11(1):16. doi: 10.1186/s41205-025-00263-0.

Critical Review

Scheidt et al.'s publication presents a sophisticated training phantom designed for the simulation of external ventricular drainage (EVD), a core neurosurgical procedure. Developed collaboratively by clinicians and engineers at the University Hospital of Leipzig, the model aims to bridge the gap between theoretical knowledge and hands-on skill acquisition [3)].

The phantom replicates the human skull and ventricular anatomy through three core elements: a 3D-printed skull model using polyamide (PA12), a ventricular system printed in flexible Elastic Resin 50A, and brain tissue simulation using cast gelatin. The use of 3D printing allows for high anatomical fidelity, and the model realistically simulates the sensation of trephination and cerebrospinal fluid (CSF) dynamics.

One of the strengths of this model is its modular and reproducible design, which enables iterative improvements and adaptation to different teaching environments. The authors report successful simulation of CSF flow and adequate material performance during cannulation and drilling exercises.

The realistic mechanical properties of gelatin at 30g/L as brain tissue mimics are particularly promising for novice training.

However, the study has some limitations. The evaluation was restricted to a subjective Likert-scale assessment by a limited number of neurosurgeons. Quantitative validation of procedural accuracy, skill acquisition, and comparative outcomes against existing EVD training tools is necessary for broader adoption. Moreover, the need for additional material to accommodate chip formation during drilling suggests further optimization is required.

In conclusion, this model represents a substantial step forward in neurosurgical simulation and training. It offers a cost-effective, reproducible, and anatomically faithful alternative to cadaver-based training. Further studies are warranted to quantify its educational impact and improve its technical design. This work aligns well with modern pedagogical shifts toward hands-on learning and low-risk surgical practice environments.

3D-printing external_ventricular_drain neurosurgery simulation_model phantom medical_education surgical_training Leipzig

3D-printed head Model in skull base surgery training

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Maclachlan LR, Alexander H, Forrestal D, Novak JI, Redmond M. Properties and characteristics of 3-dimensional printed head models used in simulation of neurosurgical procedures: a scoping review. World Neurosurg. 2021 Sep 24:S1878-8750(21)01422-4. doi: 10.1016/j.wneu.2021.09.079. Epub ahead of print. PMID: 34571242.
3)
Scheidt K, Kropla F, Winkler D, Möbius R, Vychopen M, Wach J, Güresir E, Grunert R. 3D-printed skull model for enhancing training in external ventricular drainage within medical education. 3D Print Med. 2025 Apr 3;11(1):16. doi: 10.1186/s41205-025-00263-0. PMID: 40178708.