Skull base surgery simulated training

- Simulating Endonasal Endoscopic Skull Base Surgery on Animal Carcasses: A Prospective Observational Study
- Development of a virtual dissection environment integrated into cadaveric dissection for skull base anatomy education
- Enhancing skull base tumor management: the combination of 3D printing technology and endoscopic surgical techniques
- The Development and Validation of Novel 3-Dimensional Models for Simulation Training in Sinonasal and Skull Base Surgery
- Training in Endoscopic Endonasal Neurosurgical Procedures: A Systematic Review of Available Models
- Anatomical Step-by-Step Dissection of Complex Skull Base Approaches for Trainees: Surgical Anatomy of the Translabyrinthine and Transcochlear Approaches
- Evaluating the impact of a hand-crafted 3D-Printed head Model and virtual reality in skull base surgery training
- Cross-Cultural Validation of the Chronic Rhinosinusitis Patient-Reported Outcomes (CRS-PRO) Questionnaire in Portuguese

Simulated training in skull base surgery is an innovative educational approach that enables neurosurgeons and trainees to refine their surgical skills in a controlled, safe, and reproducible environment. Below are the key aspects of simulated training in skull base surgery:

1. Simulation Technologies

Virtual Reality (VR): VR allows surgeons to interact with a 3D surgical environment using VR headsets. Specific procedures, such as transnasal approaches, lateral craniotomies, or complex techniques for lesions in critical areas, can be simulated.

3D-Printed Anatomical Models: These are physical replicas of the skull and surrounding tissues created from CT or MRI images. They are particularly useful for practicing bone drilling, craniotomies, and reconstructive procedures.

Hybrid Simulators: These combine physical and virtual technologies. For example, simulators using anatomical models paired with digital interfaces to provide real-time feedback.

2. Benefits of Simulated Training

Patient Safety: Provides hands-on experience without risk to real patients.

Repetition and Feedback: Procedures can be repeated multiple times to perfect techniques. Immediate feedback helps identify mistakes and improve precision.

Enhanced Anatomical Understanding: Simulation reinforces knowledge of the complex skull base anatomy, improving spatial orientation and surgeon confidence.

Preparation for Complex Scenarios: Rare or highly complicated cases can be simulated to prepare the surgeon for any eventuality.

3. Procedures Covered

Transnasal endoscopic approaches (e.g., resection of pituitary adenomas). Lateral craniotomies and retrosigmoid approaches. Management of arteriovenous malformations (AVMs) and tumors such as meningiomas or schwannomas. Reconstruction of skull base defects using grafts or flaps.

4. Integration into Training Programs

Workshops and Courses: Hands-on sessions with simulators, guided by expert neurosurgeons.

Structured Curricula: Simulation should be incorporated into neurosurgery training programs as a mandatory component, complementing live practice.

Objective Assessment: Tools such as OSATS (Objective Structured Assessment of Technical Skills) can evaluate participants' competence.

5. Future of Simulated Training

AI Integration: Artificial intelligence will enable more personalized and detailed simulations, adapting to the user's skill level.

Mixed Reality Techniques: Combining augmented and virtual reality will provide even more advanced immersive experiences.

Global Accessibility: Portable or cloud-based simulators will democratize access to specialized training.

Simulated training in skull base surgery not only enhances technical skills but also builds confidence and ensures patient safety, leading to better clinical outcomes.

Prospective educational intervention studies

While cadaveric dissections remain the cornerstone of education in skull base surgery, they are associated with high costs, difficulty acquiring specimens, and a lack of pathology in anatomical samples.

A study of Mellal et al. evaluated the impact of a hand-crafted three-dimensional (3D)-printed head model and virtual reality (VR) in enhancing skull base surgery training.

Research question: How effective are 3D-printed models and VR in enhancing training in skull base surgery?

A two-day skull base training course was conducted with 12 neurosurgical trainees and 11 faculty members. The course used a 3D-printed head model, VR simulations, and cadaveric dissections. The 3D model included four tumors and was manually assembled to replicate tumor-modified neuroanatomy. Trainees performed surgical approaches, with pre- and post-course self-assessments to evaluate their knowledge and skills. Faculty provided feedback on the model's educational value and accuracy. All items were rated on a 5-point scale.

Trainees showed significant improvement in understanding spatial relationships and surgical steps, with scores increasing from 3.40 ± 0.70 to 4.50 ± 0.53 for both items. Faculty rated the educational value of the model with a score of 4.33 ± 0.82, and a score of 5.00 ± 0.00 for recommending the 3D-printed model to other residents. However, realism in soft tissue simulations received lower ratings.

Virtual reality and 3D-printed models enhance anatomical understanding and surgical training in skull base surgery. These tools offer a cost-effective, realistic, and accessible alternative to cadaveric training, though further refinement in soft tissue realism is needed [1)]

1)
Mellal A, González-López P, Giammattei L, George M, Starnoni D, Cossu G, Cornelius JF, Berhouma M, Messerer M, Daniel RT. Evaluating the impact of a hand-crafted 3D-Printed head Model and virtual reality in skull base surgery training. Brain Spine. 2024 Dec 12;5:104163. doi: 10.1016/j.bas.2024.104163. PMID: 39802866; PMCID: PMC11718289.