3D Virtual Reality

3D Virtual Reality (VR) is a technology that creates immersive, computer-generated environments where users can interact with a three-dimensional space as if they were physically present in it. Here’s a detailed overview of 3D VR:

Key Components of 3D Virtual Reality: Immersive Environments:

3D Graphics: VR systems generate three-dimensional environments that users can explore and interact with. These environments are often designed to be realistic or fantastical, depending on the application. Spatial Audio: To enhance immersion, VR systems often include spatial audio, which simulates how sound travels in real life, making it seem as though sounds are coming from specific locations within the virtual environment. Hardware:

Head-Mounted Displays (HMDs): These are wearable devices, like the Oculus Rift, HTC Vive, or PlayStation VR, that provide users with a stereoscopic view of the virtual world. HMDs often include built-in motion sensors to track head movements. Motion Controllers: Handheld devices that allow users to interact with the virtual environment. These controllers track hand movements and can simulate physical actions, like grabbing or pointing. Tracking Systems: Sensors or cameras that track the user’s movements within the VR space, such as external sensors or inside-out tracking systems in the HMDs. Software:

VR Applications: These include games, simulations, educational programs, and virtual meetings. Software developers use specialized tools and platforms to create these immersive experiences. Development Platforms: Tools like Unity or Unreal Engine are commonly used to build and design VR experiences. They provide the necessary framework and assets to create interactive 3D environments. Applications of 3D Virtual Reality: Entertainment and Gaming:

Immersive Gaming: VR games offer highly interactive and engaging experiences where players can physically move, manipulate objects, and interact with other players in a virtual space. Virtual Tours: Users can explore virtual versions of real-world locations, museums, or historical sites. Education and Training:

Simulations: VR is used for training in fields like aviation, medicine, and military, providing realistic simulations of real-world scenarios without the associated risks. Educational Tools: Interactive VR can help students visualize complex concepts in subjects like science, history, or engineering. Healthcare:

Therapy and Rehabilitation: VR is used for exposure therapy, pain management, and physical rehabilitation by creating controlled environments for patients to practice skills or cope with anxiety. Surgical Training: Surgeons can practice procedures in a risk-free virtual environment. Design and Architecture:

Virtual Prototypes: Architects and designers use VR to create and explore virtual models of buildings or products, allowing for interactive reviews and modifications before physical construction. Social Interaction:

Virtual Meetings: VR can facilitate remote meetings and collaboration by creating virtual spaces where users can interact as if they were in the same room. Social VR Platforms: Applications like VRChat or AltspaceVR allow users to meet and interact in a shared virtual environment. Challenges and Future Directions: Technical Limitations:

Resolution and Latency: High-resolution displays and low latency are crucial for a comfortable VR experience. Advances in technology continue to improve these aspects. Field of View and Comfort: Ensuring a wide field of view and minimizing motion sickness are ongoing challenges in VR development. Accessibility and Cost:

Affordability: High-quality VR equipment can be expensive, which limits accessibility for some users. Usability: Developing user-friendly interfaces and ensuring that VR experiences are accessible to people with various disabilities are important considerations. Content Creation:

Diverse Content: Expanding the range of VR content to include more educational, cultural, and recreational options is key to broadening VR's appeal. In summary, 3D Virtual Reality offers a powerful way to create immersive and interactive experiences across various fields. Its applications continue to expand as technology advances, making VR an increasingly integral part of entertainment, education, healthcare, and more.

3D Virtual Reality in neurosurgery

- The Impact of Virtual-, Augmented- and Mixed Reality during Preoperative Informed Consent: A Systematic Review of the Literature
- The impact of nuchal ligament ossification resection on cervical stability after modified laminoplasty: a long-term follow-up study
- Utilizing virtual reality for resection of recurrent ventral, extramedullary cervical meningioma
- Skull Base Anatomy Presented in 360° Photogrammetry 3-Dimensional Models
- Realistic 3D-Printed Lumbar Spine Model for Non-cadaveric Surgical Training: A Proof of Concept Study
- Neurosurgical training model in bovine brain for resection of intraaxial tumors
- Frequently asked questions and answers on Visually-Provoked (Photosensitive) epilepsy
- Intraoperative Augmented Reality Visualization in Endoscopic Transsphenoidal Tumor Resection Using the Endoscopic Surgical Navigation Advanced Platform (EndoSNAP): A Technical Note and Retrospective Cohort Study

A narrative review that synthesizes and evaluates existing literature and research on the integration of 3D visualization and reality technologies in skull base surgery. It aims to provide a comprehensive understanding of current advancements, practical applications, and future prospects in this area, making it a valuable resource for clinicians and researchers interested in the impact of these technologies on surgical practice [1)]

A exploratory and applied research investigation examines the integration of advanced 3D technologies into neurosurgical planning to enhance surgical preparedness and safety. It focuses on the practical application and potential benefits of these technologies in improving surgical outcomes [2)].

Descriptive, narrative review and proof-of-concept studies

In a descriptive narrative review and proof-of-concept study on the integration of emerging technologies (3D virtual reality and 3D printing) in neurosurgical preoperative planning, González-

López et al. — from the Department of Neurosurgery, Hospital General Universitario de Alicante, Spain; the Department of Clinical Neurosciences, Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland; and the Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, London, UK — explore how this combination can enhance the preoperative planning process in neuro-oncology, going beyond conventional 2D imaging by improving spatial understanding, surgical preparation, and patient safety.

They conclude that traditional 2D imaging is limited in visualizing complex neuroanatomy. In contrast, the integration o3D VR]] and 3D printing allows for more intuitive and realistic preoperative planning. These technologies support virtual rehearsals and hands-on simulation, improving surgical preparedness and potentially enhancing patient safety.

This approach represents a paradigm shift in how neurosurgical interventions can be planned, especially in the field of neuro-oncology.

 Takeaway Message for Neurosurgeons The integration of 3D virtual reality and 3D printing provides neurosurgeons with highly realistic, patient-specific models for preoperative simulation. This enables better spatial orientation, practice of complex approaches, and ultimately, safer and more precise surgeries—especially valuable in tumor cases with delicate anatomical surroundings.

While González-López et al. attempt to portray the integration of 3D virtual reality and 3D printing in neurosurgical preoperative planning as a “paradigm shift”, the article falls short of offering any rigorous evidence to justify such a claim. What is presented as innovation is, in reality, a descriptive overview devoid of quantitative validation, comparative outcome data, or clinical impact metrics.

First and foremost, the study is not a study in the strict scientific sense—it is a narrative commentary masked as a proof-of-concept, without prospective data, cohort analysis, or even a structured methodology section. There is no control group, no patient series, no operative outcomes, and no statistical analysis. Claims about improved spatial understanding and patient safety are purely speculative and remain unsupported by empirical findings.

The authors recycle well-known ideas—that 2D imaging is cognitively demanding and that 3D reconstructions can aid comprehension—yet they offer no novel insights beyond these banalities. Moreover, the article fails to address critical limitations of these technologies, such as:

Cost-effectiveness in routine clinical practice

Learning curves for surgeons and residents

Limited reproducibility across centers with different infrastructures

The lack of clinical trials demonstrating improved morbidity or mortality rates

There is also a concerning technophilic bias: the assumption that newer technology inherently improves outcomes. The authors do not reflect on the risk of overreliance on VR or printed models, nor do they assess whether this “enhanced realism” translates to better decision-making in real-world settings.

Finally, the label of “paradigm shift” is overstated. A true paradigm shift in neurosurgery would require robust evidence of changed outcomes, altered standards of care, and widespread adoption—none of which are documented here.

□ Verdict:

An aesthetic showcase of tools without scientific substance. Until these technologies are tested through well-designed studies demonstrating measurable benefits for patients and surgeons alike, this article belongs more in the realm of promotional material than serious academic literature.

1)

Isikay I, Cekic E, Baylarov B, Tunc O, Hanalioglu S. Narrative review of patient-specific 3D visualization and reality technologies in skull base neurosurgery: enhancements in surgical training, planning, and navigation. Front Surg. 2024 Jul 16;11:1427844. doi: 10.3389/fsurg.2024.1427844. PMID: 39081485; PMCID: PMC11287220.

2)

González-López P, Kuptsov A, Gómez-Revuelta C, Fernández-Villa J, Abarca-Olivas J, Daniel RT, Meling TR, Nieto-Navarro J. The Integration of 3D Virtual Reality and 3D Printing Technology as Innovative Approaches to Preoperative Planning in Neuro-Oncology. J Pers Med. 2024 Feb 7;14(2):187. doi: 10.3390/jpm14020187. PMID: 38392620; PMCID: PMC10890029.