Augmented reality indications

Augmented reality in spinal surgery

Augmented reality (AR) and virtual reality (VR) implementation in spinal surgery has expanded rapidly over the past decade. This systematic review summarizes the use of AR/VR technology in surgical education, preoperative planning, and intraoperative guidance.

Methods: A search query for AR/VR technology in spine surgery was conducted through PubMed, Embase, and Scopus. After exclusions, 48 studies were included. Included studies were then grouped into relevant subsections. Categorization into subsections yielded 12 surgical training studies, 5 preoperative planning, 24 intraoperative usage, and 10 radiation exposure.

Results: VR-assisted training significantly reduced penetration rates or increased accuracy rates compared to lecture-based groups in 5 studies. Preoperative VR planning significantly influenced surgical recommendations and reduced radiation exposure, operating time, and estimated blood loss. For 3 patient studies, AR-assisted pedicle screw placement accuracy ranged from 95.77% to 100% using the Gertzbein grading scale. Head-mounted display was the most common interface used intraoperatively followed by AR microscope and projector. AR/VR also had applications in tumor resection, vertebroplasty, bone biopsy, and rod bending. Four studies reported significantly reduced radiation exposure in AR group compared to fluoroscopy group.

Conclusions: AR/VR technologies have the potential to usher in a paradigm shift in spine surgery. However, the current evidence indicates there is still a need for 1) defined quality and technical requirements for AR/VR devices, 2) more intraoperative studies that explore usage outside of pedicle screw placement, and 3) technological advancements to overcome registration errors via the development of an automatic registration method [1)].

Augmented Reality in Surgical Training

A review aimed to provide an update on the role of augmented reality (AR) in surgical training and investigate whether the use of AR improves performance measures compared to traditional approaches in surgical trainees.

PUBMED, EMBASE, Google Scholar, Cochrane Library, British Library and Science Direct were searched following PRIMSA guidelines. All English language original studies pertaining to AR in surgical training were eligible for inclusion. Qualitative analysis was performed and results were categorized according to simulator models, subsequently being evaluated using Messick's framework for validity and McGaghie's translational outcomes for simulation-based learning.

Of the 1132 results retrieved, 45 were included in the study. 29 platforms were identified, with the highest 'level of effectiveness' recorded as 3. In terms of validity parameters, 10 AR models received a strong 'content validity' score of 2.15 models had a 'response processes' score ≥ 1. 'Internal structure' and 'consequences' were largely not discussed. 'Relations to other variables' was the best assessed criterion, with 9 platforms achieving a high score of 2. Overall, the Microsoft HoloLens received the highest level of recommendation for both validity and level of effectiveness.

Augmented reality in surgical education is feasible and effective as an adjunct to traditional training. The Microsoft HoloLens has shown the most promising results across all parameters and produced improved performance measures in surgical trainees. In terms of the other simulator models, further research is required with stronger study designs, in order to validate the use of AR in surgical training [2)].

Augmented reality in cerebrovascular neurosurgery

Augmented reality (AR) technology has played an increasing role in cerebrovascular neurosurgery over the last two decades. Hence, we aim to evaluate the technical and educational value of head-mounted (HM) AR in cerebrovascular procedures.

Methods: This is a single-center retrospective study of patients who underwent open surgery for cranial and spinal cerebrovascular lesions between April and August 2022. In all cases, the Medivis Surgical AR platform and HoloLens 2 were used for preoperative and intraoperative (pre-incision) planning. Surgical plan adjustment due to the use of HMAR and subjective educational value of the tool were recorded.

Results: 33 patients and 35 cerebrovascular neurosurgical procedures were analyzed. Procedures included: 12 intracranial aneurysm (IA) clippings, six brain and one spinal arteriovenous malformation (AVM) resections, two cranial dural arteriovenous fistula (DAVF) obliterations, three carotid endarterectomies (CEA), two extracranial-intracranial direct bypasses, two encephaloduroangiosynostosis (EDAS) for Moyamoya disease, one biopsy of superficial temporal artery (STA), two microvascular decompressions (MVD), two cavernoma resections, one combined IA clipping and EDAS for Moyamoya disease and one percutaneous feeder catheterization for AVM embolization. Minor changes in the surgical plan were recorded in 16/35 procedures (45.7%). Subjective educational value was scored as: “very helpful” for cranial, spinal AVMs, and CEAs; “helpful” for IA, DAVFs, direct bypass, EDAS, and STA-biopsy; and “not helpful” for cavernoma resection and MVD.

HMAR can be used in cerebrovascular neurosurgery as an adjunctive tool that might influence surgical strategy, enable a 3-dimensional understanding of complex anatomy, and provide great educational value in selected cases [3)].

Augmented Reality in Percutaneous Procedures-Rhizotomy of the Gasserian Ganglion

Strickland BA, Zada G, Lee DJ. Commentary: Application of Augmented Reality in Percutaneous Procedures-Rhizotomy of the Gasserian Ganglion. Oper Neurosurg (Hagerstown). 2021 Jun 7:opab179. doi: 10.1093/ons/opab179. Epub ahead of print. PMID: 34097742.

Spine Surgery Assisted by Augmented Reality

Spine Surgery Assisted by Augmented Reality.

Virtual Reality for Chronic Pain Treatment

Virtual Reality for Chronic Pain Treatment.

Augmented reality for posterior distraction in craniosynostosis

Sakamoto Y, Miwa T, Kajita H, Takatsume Y. Practical use of augmented reality for posterior distraction in craniosynostosis. J Plast Reconstr Aesthet Surg. 2022 Aug 27:S1748-6815(22)00515-0. doi: 10.1016/j.bjps.2022.08.072. Epub ahead of print. PMID: 36057505.

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McCloskey K, Turlip R, Ahmad HS, Ghenbot YG, Chauhan D, Yoon JW. Virtual and Augmented Reality in Spine Surgery: A Systematic Review. World Neurosurg. 2023 May;173:96-107. doi: 10.1016/j.wneu.2023.02.068. Epub 2023 Feb 21. PMID: 36812986.
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Suresh D, Aydin A, James S, Ahmed K, Dasgupta P. The Role of Augmented Reality in Surgical Training: A Systematic Review. Surg Innov. 2022 Nov 22:15533506221140506. doi: 10.1177/15533506221140506. Epub ahead of print. PMID: 36412148.
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Costa M, Pierre C, Vivanco-Suarez J, Baldoncini M, Tymchak Z, Patel A, Monteith SJ. Head-Mounted Augmented Reality in the Planning of Cerebrovascular Neurosurgical Procedures: A Single-Center Initial Experience. World Neurosurg. 2022 Dec 22:S1878-8750(22)01792-2. doi: 10.1016/j.wneu.2022.12.086. Epub ahead of print. PMID: 36566980.