

Head-mounted augmented reality in head and neck surgery: From technical innovation to clinical translation

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Madam, We read with great interest the recent announcement of a \$2.5 million NIH grant awarded to investigators at Vanderbilt University Medical Center and the Vanderbilt School of Engineering for the development of a head-mounted augmented reality (AR) system to guide tumour resection in head and neck cancer.¹ Margin status remains a decisive prognostic factor in head and neck squamous cell carcinoma, with reported positive margin rates ranging from 10% to 30%.² Positive margins are consistently associated with higher rates of local recurrence and decreased disease-specific survival, underscoring the need for more precise intraoperative margin assessment.

Recent developments in AR-assisted navigation in other surgical fields highlight the transformative potential of this technology. In neurosurgery, head-mounted display systems have demonstrated a mean target registration error between 1.4 and 2.2 mm, comparable to conventional neuro navigation.³ In orthopaedic oncology, AR-guided techniques have improved resection accuracy by up to 50% relative to freehand methods.⁴ These gains are partly attributable to 3D mapping, which reduces reliance on imperfect mental visualisation of resection planes. Collectively, these data suggest that AR has matured sufficiently for clinical translation in complex anatomical regions such as the head and neck.

A key challenge involves managing intraoperative soft-tissue deformation, which remains a major source of inaccuracy in surgical navigation. Conventional systems rely on static preoperative imaging and do not account for tissue shift during resection, leading to navigation drift. AR systems must incorporate dynamic deformation modelling to maintain sub-2 mm accuracy, which is necessary to influence intraoperative decision-making.⁵ The Vanderbilt initiative's emphasis on modelling heterogeneous tissue shrinkage directly addresses this limitation.

Another important consideration is surgeon trust and

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human–technology interaction. Latencies can significantly undermine user confidence, prolong operative duration, and reduce the likelihood of adoption. AR guidance must seamlessly integrate into the surgeon's visual field without introducing cognitive overload and becoming potentially distracting. Structured training, objective performance metrics, and standardised interfaces will be essential to ensure safety and consistency across varying levels of experience.

Finally, accessibility must be considered from the outset. High-cost AR infrastructure risks widening disparities in cancer care, particularly in low- and middle-income countries where positive margin rates are already higher. To maximize its global impact, AR technology must be interoperable with existing navigation systems, cost-conscious, and adaptable to diverse surgical environments.

The Vanderbilt initiative exemplifies the intersection of engineering innovation and surgical precision. By addressing deformation modelling, usability, training, and equity in parallel with technological development, this work may set a benchmark for future AR integration in oncologic surgery, moving the field beyond reliance on subjective mental mapping and towards quantifiable, image-guided margin control.

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