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Mini Review

Potential Applications of New Headsets for Virtual and Augmented Reality in Urology

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Article info

Article history:

Accepted December 18, 2023

Associate Editor: Christian Gratzke

Keywords:

Virtual reality
Augmented reality
Medical enhanced virtual reality
Artificial intelligence
Metaverse
Urology

Abstract

Virtual and augmented reality (VR/AR) technologies hold great promise in various medical fields. The release of a new generation of headsets for medical enhanced VR/AR (MER) opens new possibilities for applications in medicine, particularly in urology, to improve accessibility to everyone. These innovative headsets offer deep immersion without requiring a controller, which represents a novel approach to VR/AR engagement. The potential of these headsets applies to all aspects of urology, including surgical training, virtual meetings, communication between health care providers, patient counseling, telemedicine, delivering patient advice, and pain control. MER has the potential to improve operative planning and enhance intraoperative navigation and spatial awareness. The surgeon's visualization and overall experience can be significantly enhanced via improved guidance and visualization, ultimately leading to greater precision and safety. This cutting-edge technology has the potential to reshape urology practice, communication methods, and medical procedures, and ultimately to improve patients' experience of their urological condition.

Patient summary: This mini review explores how a new generation of headsets for medical enhanced virtual reality could revolutionize urology by improving surgical planning, assistance during procedures, and medical education. Patients can benefit from better pain management and a deeper understanding of their conditions. However, challenges such as costs, accuracy, and ethical concerns must be addressed. This technology holds promise for transforming urological practice and patient care.

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1. Introduction

Augmented reality (AR) and virtual reality (VR) have emerged as powerful tools for opening new frontiers in medical practice [1]. Adoption of these medical technolo-

gies, specifically headsets for medical enhanced VR/AR (MER), has incredible potential for various medical specialties, including urology. The release of VR/AR headsets, such as the Apple Vision Pro and Oculus headsets, has the potential to revolutionize numerous medical applications

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<https://doi.org/10.1016/j.euf.2023.12.003>

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on integration into clinical practice. These MER headsets are equipped with high-definition microscopic organic light-emitting diode displays for each eye, providing an immersive and high-quality viewing experience. They also incorporate cutting-edge features, such as eye tracking, hand gestures, three-dimensional (3D) cameras, infrared sensors, light detection and ranging (LiDAR) scanners, and TrueDepth sensors, eliminating the need for traditional physical controllers. This advanced hardware allows precise and intuitive interactions in the VR/AR environment, making it a game-changer for urological applications. Health care professionals can now immerse themselves in highly interactive virtual environments enriched with patient-specific data and precise anatomical renderings. This dynamic integration empowers surgeons with enhanced visualization and spatial understanding, augmenting their dexterity. The potential advantages apply not only to health care professionals but also to patients. In this context, we present possible applications of MER and discuss its potential impact on urology (Table 1 and Fig. 1).

2. Enhanced preoperative planning

Accurate preoperative planning is of paramount importance for successful urological procedures. MER allows urologists to access detailed 3D visualizations of the patient anatomy, seamlessly merged with magnetic resonance imaging (MRI) and computed tomography (CT) scans. These virtual reconstructions provide crucial insights into complex anatomical structures, aid in identifying potential challenges, and facilitate precise planning of the surgical approach. Surgeons can visualize and interact with patient-specific 3D models, which provide a personalized and detailed understanding for each case. Preliminary results showed better oncological outcomes when VR models are used in surgical planning for robotic prostatectomy, particularly for trifecta outcomes [2].

3. AR for intraoperative assistance

In laparoscopic surgery, the ability of MER to overlay CT images on the operative field will simplify and increase the precision of laparoscopic urological procedures [3]. These benefits are highly valuable in complex surgical procedures in which accuracy is crucial for successful outcomes. MER technology also shows promise in endourology, with seamless overlap of 3D MRI scans with the patient anatomy to guide the surgeon during percutaneous kidney puncture [4]. Using MER, essential information such as vital signs, laboratory results, and images can be overlaid directly on the surgeon's field of view to assist in making informed decisions during procedures. This integration eliminates the need to shift focus between the patient and external monitors and could improve situational awareness and decision-making during surgery.

4. Surgical education and training

The immersive capabilities of MER can revolutionize surgical education by allowing 3D video learning, interactive medical education, and immersive anatomy exploration. Trainee surgeons could benefit from realistic virtual simula-

tions, which might accelerate their learning and boost their confidence in urological surgery [5]. Experienced surgeons could refine their skills and keep up to date on new techniques, while nontechnical training and interactive case studies would enhance competency. Growing evidence supports the effectiveness of immersive VR, with trainees showing higher scores for procedural times, task completion, accuracy, user ratings, and cost effectiveness [6].

5. Digital therapeutics

MER has practical utility beyond medical professionals and can benefit patients in various scenarios. It can serve as an adjuvant to anesthesia during outpatient procedures, such as prostate biopsies and cystoscopy, alleviating anxiety and discomfort via immersive environments and contributing to pain control [7]. In the near future, patients could use MER for pain management and mental restoration exercises for chronic pelvic pain or during hospital stays after significant surgeries, with headsets providing immersive entertainment to reduce boredom and stress. MER could enable patients to visualize and collect 3D images of their medical condition to aid in understanding and recall for health care professionals during medical image analysis and improve their outcomes [8]. Patients could navigate hospitals virtually to explore layouts and facilities, which might ease any anxiety before in-person consultations. MER could facilitate virtual therapy sessions and provide personalized and effective mental health support. Remote patient monitoring could become more feasible, and patients could access personalized health education tailored to their needs. MER holds great potential for enhancing pediatric health care experiences and education. Tailored virtual experiences could make learning enjoyable and effective for children. During medical procedures, distraction techniques specific to children could reduce anxiety and discomfort to deliver a more positive and less stressful experience. MER can simulate pediatric surgeries to familiarize children with the process. Interactive virtual play offers a therapeutic outlet for emotional expression and healing. For motion-impaired individuals, MER provides AR aids that allow eye-tracking communication. For those with hearing or visual impairments, the headsets could support captioning and sign language interpretation to improve communication and understanding in various settings.

6. Communication

MER integration in communication technology provides new possibilities for immersive and enriching telehealth experiences, with enhanced connections between health care professionals and patients [9]. Future televisits with health care providers could be more engaging, and remote consultations between experts and health care professionals could become more effective and convenient [2]. Virtual patient support groups may foster a sense of community and shared experiences. Online scientific meetings will become more manageable, stimulating, and interactive thanks to complete immersion and multiple-screen visualization. MER is poised to shape the metaverse by providing tools and experiences to create a helpful interconnected VR space [10].

Table 1 – Summary of potential applications of new headsets for medical enhanced virtual reality/augmented reality

Area of interest			Possible application
Patient	Preoperative	Patient care	<ul style="list-style-type: none"> – Preparation for surgery – Patient guidance – Virtual therapy – Personalized health care – Education
		Patient recall	<ul style="list-style-type: none"> – Patient education
		Health care navigation	<ul style="list-style-type: none"> – Indoor navigation (large hospitals)
		Assisted living	<ul style="list-style-type: none"> – Elderly care and support – Medication reminders – Fall detection and prevention – Personal emergency response
	DTx	Mental health care	<ul style="list-style-type: none"> – Stress management – Anxiety and depression support – Mindfulness and meditation
		Pediatric	<ul style="list-style-type: none"> – Pediatric patient education – Distraction techniques for children – Pediatric surgery preparation
		Group with specific requirements	<ul style="list-style-type: none"> – Visual impairment rehabilitation – Low vision/low hearing assistance – Eye tracking communication
		Pain control	<ul style="list-style-type: none"> – Mental restoration – Outpatient procedures
	Postoperative	Rehabilitation	<ul style="list-style-type: none"> – Physical therapy – Sexual therapy
		Remote monitoring	<ul style="list-style-type: none"> – Monitoring of vital signs – Telehealth assessments – Remote home care
		Assisted living	<ul style="list-style-type: none"> – Elderly care and support – Medication reminders – Fall detection and prevention – Personal emergency response
		Patient care	<ul style="list-style-type: none"> – Entertainment during recovery
		Communication	<ul style="list-style-type: none"> – Patient support groups
	Urologist	Preoperative	<ul style="list-style-type: none"> – Televisits – Online meetings – Remote consultations
		Planning	<ul style="list-style-type: none"> – Realistic virtual surgical simulations – 3D image visualization and collection – Surgical planning
		Postoperative	<ul style="list-style-type: none"> – Televisits – Online meetings – Remote consultations – Patient support groups
			<ul style="list-style-type: none"> – 3D image visualization and collection – Medical image analysis
		Patient care	<ul style="list-style-type: none"> – Remote patient monitoring
	Intraoperative		<ul style="list-style-type: none"> – Augmented reality surgical assistance – Remote surgery
		Research	<ul style="list-style-type: none"> – Augmented reality data analysis – Data visualization for health care analytics
	Education		Simulated medical and surgical procedures
			Nontechnical skills training <ul style="list-style-type: none"> – Interactive medical case studies – 3D video learning – Interactive medical education – Virtual anatomy exploration

3D = three-dimensional; DTx = digital therapeutics.



Fig. 1 – Possible application of new headsets for medical enhanced virtual reality/augmented reality.

7. Rehabilitation

MER can aid in rehabilitation by facilitating virtual physical and sexual therapy sessions. After a procedure such as radical prostatectomy or urinary diversion, MER could assist patients in addressing issues related to sexuality and self-confidence, helping them adapt to new anatomical conditions. Remote monitoring allows personalized care and timely interventions. In mental health care, MER could improve support for stress, anxiety, and depression, with incorporation of mindfulness exercises and VR exposure therapy to effectively promote emotional wellbeing [10].

8. Limitations, dangers, and pitfalls

Medical enhancement headsets are a new technology with the potential to revolutionize health care [10]. However, there are some important limitations to consider before widespread adoption. Medical headsets are likely to be expensive, both to purchase and to maintain. This could make them inaccessible to many, especially individuals in developing countries. The accuracy of medical enhancement headsets is still being optimized and it is possible that they could provide inaccurate or misleading information, which could lead to misdiagnosis or mistreatment. Indeed, many AR systems rely on complex AI algorithms for tasks such as object recognition, tracking, and spatial mapping that are still under investigation. Ethical issues can arise in algorithmic decision-making, including biases in data and algorithms, which may lead to unfair or discriminatory outcomes in AR applications. Therefore, it is crucial for developers and policymakers to engage in discussions and research related to “algorithethics” to ensure that AR technologies are designed and used in an ethically responsible manner. It is possible that medical enhancement headsets could have negative side effects, such as headaches, nausea, and

dizziness. More research is needed to understand the long-term effects of the use of these devices. The headsets could collect a lot of personal user data, such as health information and personal preferences. These data could be misused by governments or corporations. The limited data available for most proposed applications of medical enhancement headsets add a layer of uncertainty to these already pressing concerns. Researchers, developers, and health care professionals need to work collaboratively to gather more data, conduct rigorous studies, and address these limitations to ensure safe and effective integration of this technology into health care. Given the potential limitations and dangers of medical enhancement headsets, it is important to conduct rigorous pilot-phase evaluations before widespread adoption. Pilot-phase evaluations can identify and address any potential problems with the headsets and gather feedback from users to improve their overall usability and safety.

Conflicts of interest: The authors have nothing to disclose.

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