Acta Scientific Ophthalmology (ISSN: 2582-3191)

Volume 7 Issue 12 December 2024

Clinical Report

Frontiers in Vision: The Transformative Power of Virtual and Augmented Reality in Eye Care

Nandan Bali[1]* and Jatinder Bali[2]

[1]*Birla Institute of Technology and Science, Pilani, Rajasthan, India*

[2]*Department of Ophthalmology, Hindu Rao Hospital, Delhi, India*

***Corresponding Author:** Nandan Bali, Birla Institute of Technology and Science, Pilani, Rajasthan, India.

Received: October 25, 2024

Published: November 30, 2024

Abstract

According to world statistics, blindness caused by corneal pathology is one of the most significant and relevant health issues. Scarring and vascular changes develop in the cornea, while the neural receptors of the eye are healthy, leading to lifelong disability. For several years, some corneal pathologies have replaced keratoplasty with amniotic membrane transplantation. Indications for its use depend on the stage of the disease and the volume of the damaged area of the cornea. It is believed that after the transplantation of the amniotic membrane, a cessation of pathological vascularization, healing of scars, corneal opacity, recovery from inflammatory processes, and active regeneration of corneal tissue takes place. So, antibiotic resistance is recognized as a global problem nowadays, and phage therapy is indispensable. We decided to use cryopreserved amniotic membrane impregnated with liquid bacteriophage during the surgical treatment of corneal and mucosal diseases in antibiotic-allergic and antibiotic-resistant patients. We examined the postoperative antimicrobial effect of a pure amniotic membrane compared to an impregnated amniotic membrane (stored in the Pyo-bacteriophage for 30 minutes) in 54 ophthalmologic patients with a history of antibiotic resistance or allergy. Laboratory studies revealed the superior antimicrobial effect of the impregnated amniotic membrane over non-impregnated amniotic membranes.

Keywords: Amniotic Membrane; Antibiotic Resistance; Allergy to Antibiotics; Impregnation; Pyo-Bacteriophage

Introduction

Virtual reality (VR), extended reality (XR), mixed reality (MR) and augmented reality (AR) are transforming modern ophthalmology, opening new avenues in clinical training, patient care, and diagnosis. The journey traces its roots to Morton Heiling's groundbreaking "Sensorama" in 1962 [1]. Since then VR technology has come a long way. Heiling's vision of a fully immersive experience was further advanced by Ivan Sutherland's head-mounted display in 1968, marking the start of VR's journey toward mainstream application. Today, VR and AR have become essential tools in ophthalmology, bridging gaps in surgical training and offering immersive educational opportunities [2].

This editorial explores the current landscape of VR and AR in ophthalmology, their applications, challenges, and promising future directions.

Understanding VR, AR and their differences

Virtual reality (VR) seeks to simulate real-world experiences using computer-generated environments, allowing users to feel completely immersed. This immersion relies on three core components: sensory feedback, interaction, and immersion. Augmented reality (AR), on the other hand, enhances the physical world with digital overlays, providing real-world settings with added information or graphics.

These technologies fall along the "reality-virtuality continuum" introduced by Milgram, which spans from fully real environments to entirely virtual ones, with mixed reality occupying the space in between [3]. VR and AR are integral to the development of the "metaverse," a concept popularized by Neal Stephenson in his epic novel “Snow Crash” [4]. Today, the metaverse is a 3D interconnected virtual space concept where people can work, learn, socialize, and interact. In ophthalmology, the metaverse can support new forms of patient-doctor interactions, revolutionize clinical education and provide an immersive virtual environment for surgical training.

The Role of 6G in the metaverse and its impact on ophthalmology

With the advent of 6G technology, the metaverse is set to become a distributed neural network merging the physical and virtual worlds. By enabling enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communications, 6G technology is expected to support real-time AI applications. This has significant implications for ophthalmology, as it could improve communication between healthcare providers, enhance the quality of telemedicine, and make real-time holographic surgical guidance a possibility [5].

The Total Experience (TE) strategy, incorporating employee, customer, user, and multi-experience, could also influence ophthalmology practice by fostering patient trust, enhancing educational experiences, and supporting innovative approaches in healthcare. Studies already explore holographic construction, emulation, and virtual-reality integration, which promise to elevate ophthalmology's educational and procedural standards.

VR and AR applications in ophthalmology: Redefining boundaries

In recent years, VR and AR have become critical tools in ophthalmology. These technologies help simulate eye anatomy, allow patients to understand their treatment plans, and improve surgical training. Notable applications include:

- Augmented Reality (AR): AR offers substantial aid to patients with low vision by using AR glasses to highlight objects in bright colors, thereby enhancing perception. This technology is especially beneficial for conditions such as retinitis pigmentosa, where field of view is compromised.
- Virtual Reality (VR): VR is instrumental in patient education and engagement, allowing users to visualize their eye condition and treatment pathways through computer-generated simulations. VR simulators, like the Eyesi surgical system and the MicroVisTouch, are widely used to train ophthalmologists in the delicate maneuvers needed for ophthalmic microsurgery.
- Mixed Reality (MR) and Extended Reality (XR): These tools are beginning to blend AR and VR applications, creating comprehensive experiences. MR holograms, for example, help in studying eye anatomy, while XR platforms are expected to become a crucial part of the metaverse, supporting new clinical and educational applications in ophthalmology [3,5,6].

Training and skill assessment with VR and AR in ophthalmology

Training with VR and AR has proven effective in ophthalmology, where precision is essential. Studies have validated simulators like the Eyesi for vitreoretinal and cataract surgery training, noting that experienced surgeons score higher than novices. This skill acquisition translates well into real-world surgical performance, with studies reporting improved performance among novice surgeons after VR training [6-9].

In addition, researchers have explored skill transferability to the operating room (OR), with findings indicating that simulators reduce the incidence of errors, enhance surgeons' dexterity, and shorten learning curves. Such technologies allow ophthalmologists to practice and refine their skills in a risk-free environment, ultimately enhancing patient outcomes.

Beyond Training: Expanding horizons with VR and AR

While VR and AR are primarily used for training, their applications extend far beyond skill acquisition. Researchers have used VR simulators to test the effectiveness of robot-assisted surgery and assess the impact of environmental factors like auditory noise or fasting on surgical performance.

As VR and AR devices become lighter and more user-friendly, their potential applications are likely to broaden. For example, AR-based slit lamp prototypes and VR tools like the Eyesi Direct Ophthalmoscope have already shown promise in clinical training and education for optometry and ophthalmology students [6,7].

Potential and Limitations of VR and AR in ophthalmology

Despite their potential, VR and AR technologies have limitations, particularly concerning device weight, user comfort, and safety concerns. Prolonged use of head-mounted displays (HMDs) can strain the neck and back, and cybersickness, a form of motion sickness, remains a common issue. Researchers have begun exploring ways to mitigate cybersickness through optimized display characteristics and frame rates, but more investigation is necessary to fully understand the long-term impact of VR/AR on eye health, especially in children.

Additionally, the high costs associated with VR and AR equipment pose a significant barrier to widespread adoption. For VR and

AR to become more than a niche tool, it will be essential to lower costs, improve device comfort, and gather more clinical data validating their effectiveness in ophthalmology.

COVID-19 impact on VR and AR in ophthalmology

The COVID-19 pandemic has accelerated the adoption of VR and AR technologies. Telemedicine and virtual consultations became essential, and these tools offered ophthalmologists a safe way to connect with patients. VR headsets, with their portability and ease of sanitization, became invaluable for remote training and education.

Looking forward, VR/AR devices are being developed for potential use in patients' homes, enabling remote monitoring and follow-up care, which could be invaluable for high-risk patients or those with limited mobility. With advancements in hardware and software, the quality of virtual experiences is expected to improve, enhancing VR/AR's integration into ophthalmic practice.

Paving the way for the future

VR and AR technologies have proven to be transformative tools in ophthalmology, enhancing surgical training, clinical diagnostics, and patient engagement. While challenges remain, ongoing research and advancements in device ergonomics, AI integration, and network capabilities like 6G are paving the way for VR and AR's widespread adoption.

To harness these technologies' full potential, the field must address existing limitations, lower costs, and focus on rigorous research. By incorporating VR and AR into the curriculum, Ophthalmology training programs can better prepare future ophthalmologists for the rapidly evolving technological landscape. As VR and AR become more sophisticated and cost-effective, ophthalmology stands to benefit tremendously, making eye care more accessible, accurate and immersive.

Figure 1

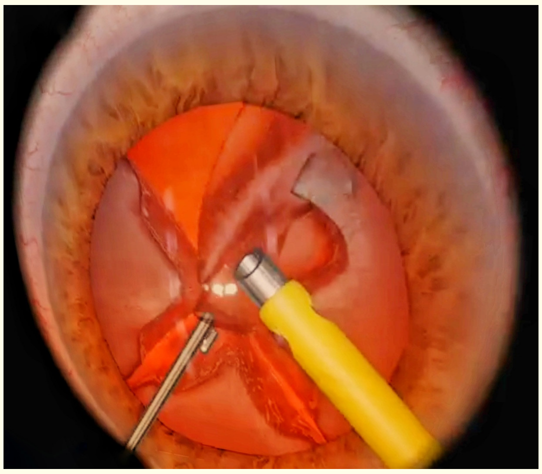

Figure 2

Conflict of Interest

None Declared.

Bibliography

1. Thomsen ASS., *et al*. "Update on simulation-based surgical training and assessment in ophthalmology: a systematic review". *Ophthalmology* 122 (2015): 1111-1130.
2. Lee R., *et al*. "A systematic review of simulation-based training tools for technical and non-technical skills in ophthalmology". *Eye* 34 (2020): 1737-1759.
3. Iskander M., *et al*. "Virtual reality and augmented reality in ophthalmology: a contemporary perspective". *The Asia-Pacific Journal of Ophthalmology* 10.3 (2021): 244-252.
4. Stephenson N. "Snow Crash". New York: Bantam Books; (1993).
5. Yang D., *et al*. "Expert consensus on the metaverse in medicine". *Clinical eHealth* 5 (2022): 1-9.
6. Menozzi M., *et al*. "Development of ophthalmic microsurgery training in augmented reality". *Klinische Monatsblätter für Augenheilkunde* 237 (2020): 388-391.
7. Cissé C., *et al*. "EYESI surgical simulator: validity evidence of the vitreoretinal modules". *Acta Ophthalmology* 97 (2019): e277-e282.
8. Ropelato S., *et al*. "Augmented reality microsurgery: a tool for training micromanipulations in ophthalmic surgery using augmented reality". *Simulation in Healthcare* 15 (2020): 122-127.
9. Spiteri A., *et al*. "Development of a virtual reality training curriculum for phacoemulsification surgery". *Eye* 28 (2014): 78-84.