Exploring the Potential Role for Extended Reality in Mohs Micrographic Surgery

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Introduction

- Augmented reality (AR) and virtual reality (VR) has entered healthcare settings. They overlay digital information onto the real-world environment, enhancing engagement and perception of surroundings.[1,2]
  - **AR-** provides real-time direct or indirect view of the physical world, amplified with virtual computer-generated information.[3]
    - Applies to multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory.[3]
    - Key components: interactive 3D elements + real-world and virtual objects.[3]
  - **VR-** immerses users in a synthetic 3D computer-generated environment using wearable headsets.[4]
    - Key components: response to user-actions + real-time 3D graphics + a sense of immersion.[5]
- Medical applications include: overlaying medical data + anatomical structures onto a surgeon's view of a patient, and providing surgical guidance for diagnostics, therapeutics, and training.[1,2]

Objectives

1. Investigate the current state of AR/VR in MMS, assessing benefits, challenges, and transformative possibilities.
2. Explore the role of AR/VR technologies in medical settings, particularly in MMS.
3. Identify gaps in existing research to pave the way for future investigations.
4. Promote further innovation and collaboration to advance dermatological surgery and raise patient care standards.

Methods

- SEARCH STRATEGY:
  - Conducted a PubMed search with the following keywords: "augmented reality" OR "virtual reality" AND "Mohs" OR "augmented reality" OR "virtual reality" AND "surgery"
- CRITERIA:
  - Inclusion criteria- Peer-reviewed articles in English discussing these technologies in medical settings, especially with a surgical focus
  - Exclusion criteria- Non-peer-reviewed sources, non-English articles, and those not addressing these technologies in a medical context
- DATA COLLECTION & ANALYSIS:
  - Extracted data on study objectives, methodologies, findings, and conclusions of included articles
  - Categorized articles based on key themes: extended reality in MMS, technological advancements, challenges, and reported outcomes

Results

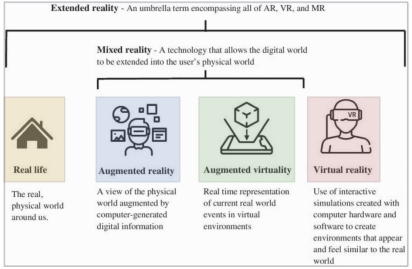

Figure 1. Components of extended reality

Adapted from Zhang J, Lu Y, Khanduja V. The impact of extended reality on surgery: a scoping review. Int Orthop. 2023;47(3):611-621. doi:10.1007/s00264-022-05663-z

Advantages of AR/VR in Healthcare Settings

Advantage	Key Points
Training and Skill Assessment	- Proves effective for training surgical residents and medical staff[6] - Simulators offer diverse scenarios and objective skill measures[6]
Remote Guidance and Telementoring	- Virtual Interactive Presence and Augmented Reality (VIPAR) system= facilitates ongoing surveillance and real-time transmission of surgical site visuals between 2 distant locations --> enables remote guidance and telementoring[7,8] - Allows for real-time interaction and visualization
Preoperative Planning and Surgical Procedure	- Used for 3D reconstructions, incision planning, trocar placement, and tumor detection - Applied in various surgeries (e.g. trauma reconstructions, bone resections, osteotomies, arthroscopic surgery, Kirschner wire placement, neurosurgery, joint replacement, and tumor removal.[9-15]
Robotic Surgery	- Rapidly integrating into robotic surgery consoles for improved navigation and identification[16]

Potential for AR/VR in Mohs Micrographic Surgery

Potential Advantages
1. Alleviate patient anxiety --> has been reported to minimize patient-reported feelings of anxiety, as well as pain, via addressing comprehension gaps regarding surgical procedures, particularly complex techniques like flap reconstruction[17,18]
2. Benefit physician training --> has been used for preoperative incision planning through real-time analysis of cutaneous lesions, ensuring precise and optimal results[19]
3. Enhance surgical precision & structure visualization --> has been show to 1) provide accurate margin assessments, real-time guidance, streamlined preoperative planning, ultimately enhancing patient outcomes, and 2) reconstruct subcutaneous veins for injection and incision safety[20]
4. Facilitate communication between surgeons and pathologists --> has been shown to be beneficial especially in team-based MMS situations where direct examination of pathology slides by the surgeon is not possible, potentially saving time during the procedure[18]
5. Provide remote guidance for residents --> has provided real-time guidance during surgery, enhancing learning and allowing senior staff to oversee multiple surgeries simultaneously.[21]
6. Increase healthcare accessibility --> has been reported to offer a shared platform for patients to receive real-time preoperative guidance and postoperative care from Mohs surgeons across various demographic regions allowing for efficient consultations[21]
7. Serve as an educational tool --> applications, such as the Mobile Augmented Reality Blended Learning Environment (mARble) app, have been shown to benefit medical students in the recognition of dermatologic lesions by visually presenting them directly on the skin[22]

Discussion

- **Application of AR/VR in MMS:**
  - Real-time guidance and visualization for precise cancerous tissue removal.
  - Provides various perspectives during pre-op planning, aiding streamlined procedures.
  - Facilitates collaboration among surgeons in different locations.
  - MMS complexity on sensitive areas like the face makes AR/VR beneficial.
- **Transformative potential:**
  - AR/VR technologies show potential in managing patient anxiety, surgical precision, and medical training.
  - Addresses resource constraints and geographical disparities, facilitating remote guidance and teleconsultations.
  - Overcomes barriers to healthcare accessibility, reducing the need for in-person visits.
- **Challenges in implementation:**
  - "Cybersickness"= a potential complication consisting of nausea, vomiting, and headache.
  - Technical challenges including integrating different imaging modalities and addressing limitations like restricted range of motion.

Conclusion

- AR/VR demonstrates promise in various aspects of MMS and the field of dermatology.
- Areas requiring further investigation:
  - Long-term safety, efficacy, and cost-effectiveness, especially in small healthcare settings
  - Anxiety alleviation and improved surgical outcomes→ need for randomized controlled trials to substantiate claims
  - Ethical implications, including patient consent and data privacy

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Scan for references: