The Role of Virtual and Augmented Reality in Ophthalmic Surgical Training: A Systematic Review

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BACKGROUND

- Extended reality (XR) includes virtual reality (VR) and augmented reality (AR).
- XR simulates realistic surgical scenarios, enabling trainees to learn and practice in a safe and controlled environment.
- There are a few VR training modalities available for ophthalmic training such as EyeSi, HelpMeSee, and MicroVis.
- Despite significant advancements in XR technologies, its role in ophthalmic surgical training remains unclear.
- To the best of our knowledge, this is the first systematic review that assesses the utility of XR in ophthalmic surgical training.

PURPOSE

This systematic review aims to investigate the effectiveness of XR in enhancing the skills of ophthalmic surgeons and improving patient outcomes.

METHODS

- A systematic search of Embase, MEDLINE, Scopus, Web of Science, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, CINAHL, and ProQuest Dissertations & Theses Global yielded 1354 references.
- Of 1354 studies identified, 562 duplicates were removed automatically and manually.
- The titles and abstracts of 792 studies were screened and 746 studies were excluded due to not meeting inclusion criteria or for meeting exclusion criteria.
- Full texts of the remaining 46 studies were retrieved and underwent screening, which resulted in 36 studies to be included in the systematic review after excluding an additional 10 studies.

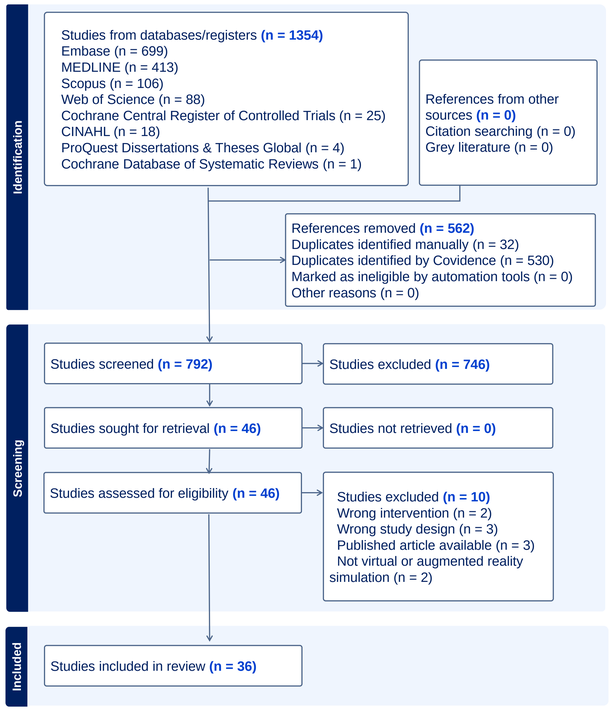

Figure 1. A PRISMA diagram depicting the search strategy.

Inclusion criteria

- Studies published from January 1, 2013 to April 6, 2023.
- Primary studies (excluded review studies, letters, commentaries and editorials).
- Use of XR for ophthalmic surgical training.
- Any population undergoing ophthalmic surgical training.

Exclusion criteria

- No training component.
- Non-extended reality simulations.
- Non-human ophthalmic surgery.
- Conference abstracts. published as research paper later.
- Process of constructing an XR program.

RESULTS

Study Type

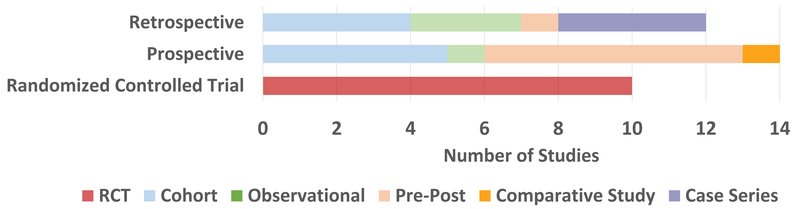

Figure 2. Types of study design used in the 36 primary studies included for review.

Thirty-six studies were included in the review made up of 12 retrospective studies, 14 prospective studies, and 10 randomized controlled trials.

Training Modalities

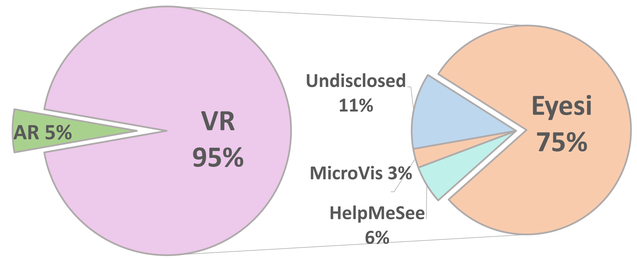

Figure 3. Types of extended reality used in primary studies. VR studies are further subdivided into types of VR in the graph on the right.

Thirty-four studies investigated VR simulations (27 used EyeSi, two used HelpMeSee, one used MicroVis, and four used undisclosed forms of VR) while two studies used AR simulations.

Types of Surgery Trained

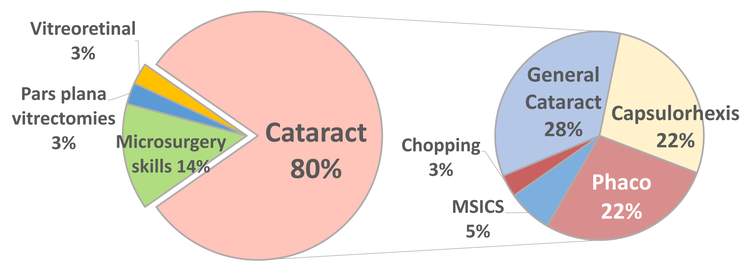

Figure 4. Type of surgery trained using the XR training modality.

Of the 36 studies, five trained general microsurgery skills, one trained pars plana vitrectomies, one trained vitreoretinal surgery, and the other 29 trained cataract surgery procedures, including manual small-incision cataract surgery (MSICS).

Study Population

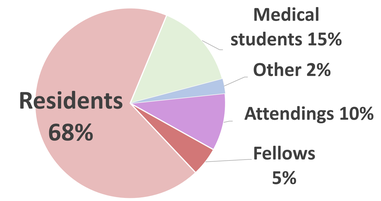

Figure 5. Surgical trainees' level of education.

The study populations involved medical students, residents, fellows, attending physicians, and other scientific faculty.

Primary Outcomes

Table 1. Primary outcomes identified by the studies.

Primary Outcome	Number of Studies
Eyesi score	16
Complication rate	14
Operating time	9
Trainee satisfaction	4
XR performance score rated by blinded observer	4
OR performance score rated by blinded observer	4
Attempts on XR	3
Self-rated skill	2
Self-rated XR usefulness	1
Specialty interest	1
Time to 100 cases	1
Motor skill performance	1
Number of errors	1
Time to performance plateau	1
Clinical skills exam score	1
Written exam score	1
Trainee confidence	1
Number of cases	1

The 36 studies identified a variety of primary outcomes to explore XR efficacy for ophthalmic training.

Concluded Effect

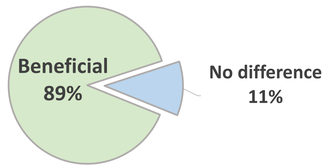

Figure 6. Studies' concluded effect of XR ophthalmic training.

Out of the 36 studies, 32 (89%) studies found a beneficial effect of using XR technologies to train ophthalmic procedures and techniques while 4 (11%) studies found no difference after or compared to XR training.

DISCUSSION & CONCLUSION

Our preliminary analysis demonstrates that there is an overall benefit of XR technology in the training of ophthalmic surgeries at various levels of education. XR training is effective for the purposes of learning new microsurgery skills, learning and practicing new ophthalmic procedures, as well as for pre-training before performing surgeries. XR training improves simulator-rated and observer-rated scores, decreases complication rates, decreases operating time, and improves trainee satisfaction and confidence.

REFERENCES