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REVIEW

# Virtual Reality Visual Field Testing in Glaucoma: Benefits and Drawbacks

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**Importance:** Virtual reality-assisted visual field testing (VRVFT) is a novel modality for evaluating glaucoma progression, offering potential advantages over standard automated perimetry (SAP). To date, no narrative literature review has comprehensively discussed the benefits and drawbacks of VRVFT for glaucoma patients.

**Observations:** A narrative literature review was conducted using PubMed and MEDLINE via EBSCOhost, covering articles published from 2014 to October 2023. The search terms used were “virtual reality visual field” AND “glaucoma”. Filters applied included “Free full text”, “Full text”, and “Peer Reviewed.” Inclusion criteria encompassed studies evaluating VRVFT in relation to glaucoma. Exclusion criteria included duplicates, meta-analyses, literature not discussing glaucoma or VRVFT, and other literature reviews. Sixteen studies met the inclusion criteria, comprising various study designs. VRVFT showed comparable reliability and efficacy to SAP in detecting glaucomatous visual field defects. Benefits of VRVFT included improved accessibility, patient comfort, and resource optimization. Drawbacks included technical limitations such as restricted luminance range, lack of sophisticated eye-tracking in some devices, and implementation challenges like patient technology familiarity and access to equipment.

**Conclusion:** VRVFT presents several benefits, making it a promising alternative or complement to conventional glaucomatous visual field testing in outpatient clinics and remote settings. Addressing technical limitations and standardizing protocols are essential for broader clinical adoption.

**Keywords:** glaucoma, perimetry, virtual reality, visual field, VRVFT, standard automated perimetry, SAP

## Introduction

Glaucoma is a progressive optic neuropathy characterized by irreversible visual field loss, affecting approximately 80 million people worldwide—a number projected to rise to 112 million by 2040.[1] Early detection and monitoring are crucial for preventing vision loss.[2] Diagnosis involves intraocular pressure measurement, anterior chamber assessment, optic nerve evaluation, corneal thickness measurements, and perimetry.[2,3] Perimetry remains the gold standard for detecting glaucomatous visual field defects and monitoring disease progression.[4]

Standard automated perimetry (SAP) tools like the Humphrey Field Analyzer (HFA) and the Octopus 900 are widely used and have proven efficacy.[5,6] However, SAP devices have drawbacks, including high costs, large space requirements, the need for trained technicians, patient discomfort, lengthy testing times, and immobility, leading to potential patient non-compliance.[7–15] In clinics with high patient loads and limited resources, these challenges underscore the need for alternative solutions.

Virtual reality-assisted visual field testing (VRVFT) has become more portable and potentially patient-friendly. The COVID-19 pandemic further highlighted the need for remote and accessible healthcare solutions.[13,14] VRVFT systems offer compatibility with smartphones and portable VR hardware, enabling at-home testing and improved accessibility for patients with mobility limitations.[7–15,] Benefits include optimized resource utilization, the ability to test multiple patients simultaneously, reduced space requirements, and overall cost and time efficiency.[7–15]



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Despite these advantages, VRVFT faces challenges such as decreased test precision in some parameters compared to SAP, technological limitations, and variability in patient familiarity with VR technology.[7–16] This narrative review aims to comprehensively assess and discuss benefits and drawbacks of the rapidly evolving VRVFT for glaucoma patients in outpatient settings.

## Methods

A comprehensive literature search was conducted to identify studies evaluating the use of VRVFT in glaucoma patients. The search covered articles published from January 2014 to October 2023 using PubMed and MEDLINE via EBSCOhost databases. The search terms used were "virtual reality visual field" AND "glaucoma." Filters applied included "Free full text", "Full text", and "Peer Reviewed."

Inclusion criteria were studies evaluating VRVFT in relation to glaucoma, studies assessing VR perimetry for visual field testing, and studies discussing characteristics, reliability, and efficacy of VRVFT. Exclusion criteria included duplicates, meta-analyses, literature not focused on glaucoma or VRVFT, and other literature reviews.

Two independent reviewers screened the titles and abstracts for relevance. Full-text articles were retrieved for studies meeting the inclusion criteria or when relevance was unclear. Discrepancies were resolved through discussion or consultation with a third reviewer.

Data extracted included study design, sample size, VR technology used, comparison with SAP, key findings, benefits, and drawbacks of VRVFT. Findings were synthesized narratively, focusing on the benefits and drawbacks of VRVFT, patient experience, technical limitations, and implementation challenges. Supplementary Tables 1–3 were created to summarize key study characteristics, quantitative comparisons, and findings.

## Results

The initial search yielded 43 articles. After removing 27 duplicates and irrelevant studies, 16 articles met the inclusion criteria (Figure 1). The studies comprised various designs, including prospective cohort studies, cross-sectional studies, proof-of-concept studies, and case series.

The studies utilized different VR technologies, from smartphone-based VR systems to dedicated VR headsets and custom VR perimetry devices. Thirteen studies discussed the HFA; two discussed the Octopus 900, and one discussed an HFA 24–2 perimeter equivalent.

## Benefits and Drawbacks

Multiple studies demonstrated good agreement between VRVFT and SAP in detecting glaucomatous visual field defects.[7–10,14,15,17,18] Benefits of VRVFT included improved accessibility, patient comfort, and resource optimization. Drawbacks included technical limitations such as restricted luminance range, lack of sophisticated eye-tracking in some devices, and implementation challenges like patient technology familiarity and access to equipment.

### Patient Experience and Compliance

VRVFT systems have demonstrated significant advantages in patient comfort and engagement.[17,18] Studies reported improved patient satisfaction with VR-based testing compared to traditional methods.[17–20] The immersive and interactive nature of VR interfaces contributes to ease of use.[17,18] However, some older patients may require additional support due to unfamiliarity with the technology.[12]

Cloud-based data storage in newer VRVFT systems facilitates seamless record-keeping and remote monitoring, enhancing patient compliance and enabling telemedicine applications.[14,17] This feature allows clinicians to track disease progression more efficiently and adjust treatment plans accordingly.

### Technical Limitations

Despite promising benefits, VRVFT faces technical challenges. Current VR systems have a restricted range of background and stimulus luminance compared to SAP devices, potentially affecting test accuracy.[9] Some VRVFT devices lack sophisticated eye-tracking capabilities, impacting fixation monitoring and test reliability.[8] Ensuring consistent

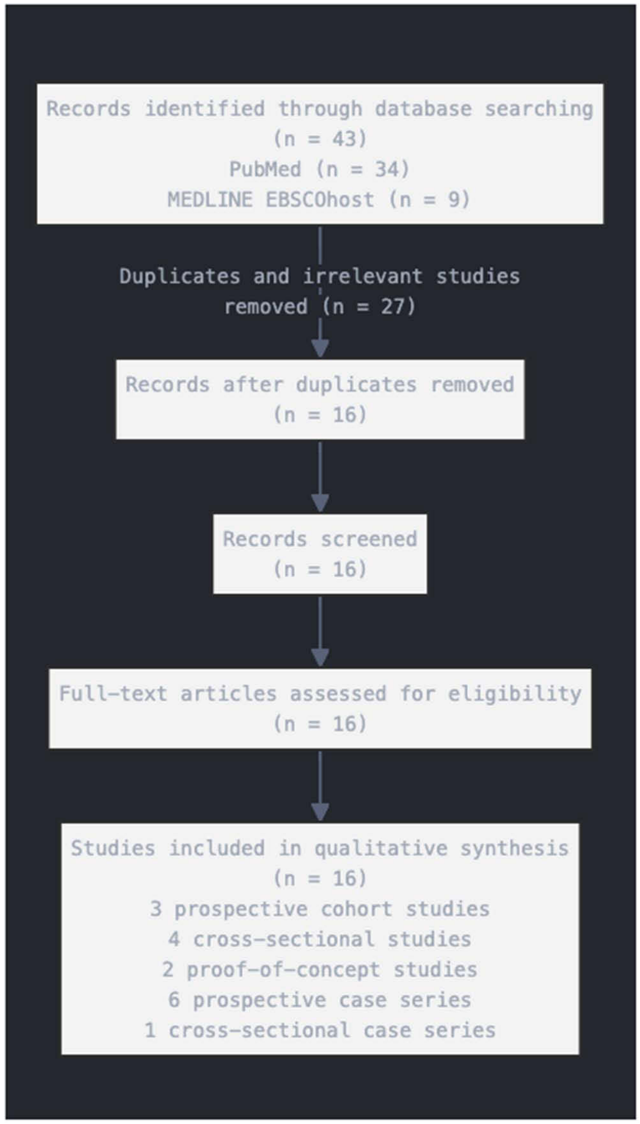


**Figure 1** PRISMA flow diagram illustrating the study selection process.

calibration across devices, especially in non-clinical settings, is challenging due to environmental variability.[9] Additionally, reduced sensitivity in detecting severe visual field defects has been noted, necessitating further refinement in VRVFT technology.[8,18]

## Implementation Challenges

Implementing VRVFT in clinical practice presents practical considerations. Patient familiarity with VR technology varies significantly, potentially affecting test performance and requiring additional training time.[19–23] Limited access to appropriate VR hardware can be a barrier, particularly for home-based testing in underserved populations.[9] Prolonged use of VR headsets may cause discomfort or fatigue, necessitating ergonomic improvements.[10] Furthermore, the lack of standardized protocols across different VRVFT systems complicates clinical adoption and comparison of results.[7,15]

## Discussion

Integrating VR technology into visual field testing represents a significant advancement in glaucoma care. VRVFT offers advantages in accessibility, patient experience, and resource utilization. The good agreement with SAP suggests that VRVFT can potentially serve as a viable alternative or complement to traditional methods.

VRVFT's portability enables testing outside traditional clinical settings, enhancing access for patients with mobility issues, infection concerns, or in remote areas. This can lead to earlier detection of disease progression and improved patient compliance. Clinics can benefit from reduced space requirements, cloud data storage, and the ability to test multiple patients simultaneously, which is particularly advantageous in high-volume settings with limited resources.

However, the technical limitations, such as restricted luminance range and lack of advanced eye-tracking, may impact the precision of visual field assessments. Implementation challenges, including clinic staff training and patient familiarity with technology and equipment access, must be addressed to maximize VRVFT's potential. The heterogeneity of study designs, testing conditions, and VR technologies used in the included studies, along with the evolving nature of VR technology, limits the generalizability of the findings.

## Future Directions

Several areas require attention to optimize VRVFT's role in glaucoma care. Longitudinal non-inferiority studies comparing VRVFT and SAP outcomes are necessary to validate clinical effectiveness. Technical enhancements such as improved eye-tracking capabilities expanded luminance ranges, and refined headset ergonomics can enhance reliability and patient comfort.

Developing standardized testing protocols and evaluation metrics across VRVFT systems would facilitate clinical adoption and interoperability. Implementing strategies to increase access to VR technology, especially in underserved populations, is important. This could include cost-effective hardware solutions or clinic-based loan programs. Creating patient and clinician training programs to improve technology familiarity and test reliability is also essential. Conducting additional survey studies on patient's perspective and acceptance of VRVFT may be beneficial to identify areas of improvement.

## Conclusion

Virtual reality-assisted visual field testing demonstrates considerable promise as an innovative approach to glaucoma monitoring. While technical limitations and implementation challenges exist, the potential benefits of improved accessibility, patient experience, and resource optimization suggest a valuable role for this technology in modern ophthalmology practice. Addressing current limitations through research and development will be crucial in establishing VRVFT as a standard tool in glaucoma care.

## Ethical Considerations

No human or animal subjects were involved in this study. Ethical approval was not required for this narrative literature review.

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