The State of Virtual Reality for Glaucoma Care

Virtual reality (VR) is emerging as a potentially powerful tool to diagnose, monitor, and treat glaucoma. Some VR devices for glaucoma are already on the market, while others are in development or subjects of clinical research. How satisfactory are the products that are available today? Beyond that, what are the pros and cons of using VR for glaucoma care? And what does the future hold?

The Promise of VR

"I think virtual display perimetry is the future," said Felipe Medeiros, MD, PhD, at the Bascom Palmer Eye Institute in Miami, "because you can do so many things with these devices. They're portable, they have a more controlled environment, they reduce the need for a technician.

"However, I don't think the evidence is there at this point for clinicians to be transitioning to the existing devices out there and abandoning conventional perimetry," he added.

Home testing. Portability is an asset when it comes to monitoring glaucoma outside the clinic. Both Yvonne Ou, MD, at the University of California, San Francisco, and Lama Al-Aswad, MD, MPH, at Scheie Eye Institute, University of Pennsylvania, coauthored studies exploring the feasibility of patients using VR devices to test themselves at home.

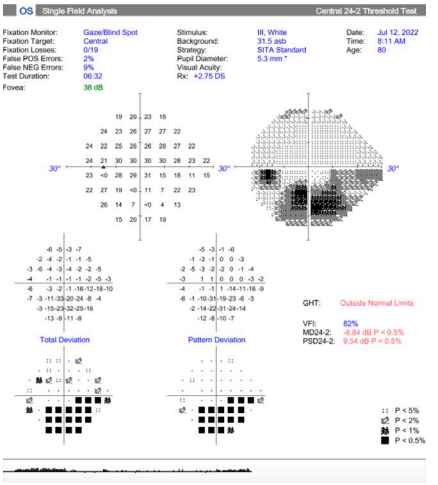
In Dr. Ou's study,[1] glaucoma patients were trained remotely on how to use a VR headset and test software, then they were instructed to complete 10 sessions over a 14-day period. Results showed that patients successfully trained remotely without interactions with caregivers or study staff and their VR test results showed good repeatability.

In Dr. Al-Aswad's study,[2] glaucoma patients used a VR visual field device three times within a week. Results—based on device usage and quality of responses to perimetry tests—showed that a small cohort of motivated subjects could successfully monitor themselves at home.

Patient information. In her clinic, Dr. Al-Aswad experienced firsthand the psychological impact that home monitoring could have on her patients. "A patient I'd known for many years came to me and said, 'Doc, I feel powerless between visits. I have to wait for six months, and the whole time I'm scared as hell until I hear you say the holy words that I'm stable.'"

More frequent monitoring. Aside from psychological benefits, home testing enables more frequent monitoring of field of vision.[3] That allows for earlier detection. Dr. Al-Aswad remarked, "One of our patients wasn't scheduled to come to the office for six months. Because he had the VR device, we saw data showing a change and told him to come in right away."

Expanding access. And because VR goggles are light, portable, and relatively inexpensive, they may be able to fill gaps in eye care by providing access where none would exist otherwise, said Dr. Ou, noting that this would be especially useful for remote rural populations.



THE GOLD STANDARD. *Can VR headsets for virtual perimetry rival standard automated perimetry?*

Simon K. Law, MD, of the Stein Eye Institute at University of California, Los Angeles (UCLA), identified other people who could be served in this way. "We want all our patients to take visual field tests, but we can't force a patient in a wheelchair to come to the clinic. VR allows us to do it differently."

Dr. Al-Aswad pointed out that the lower cost of VR devices can help financially overburdened clinics stay open. "If a practice cannot maintain itself financially, the patient will suffer: No margin, no mission. So even in the U.S., we need to cut our costs so we can take care of our population."

BY JUDY MYERS, INTERVIEWING **LAMA AL-ASWAD, MD, MPH, SIMON K. LAW, MD, FELIPE MEDEIROS, MD, PHD,** AND **YVONNE OU, MD.**

Room for Improvement

Nascent technology. Many of the current VR headset devices administer standard automated perimetry tests. "These tests are similar to the Humphrey field analyzer (HFA) in terms of the locations they test in the visual field, how they are performed by the patients, and the printout that is created," said Dr. Ou. "However I would argue that there's still quite a bit of clinical research that needs to be done before you can say this is ready for prime time."

Some unfounded conclusions. While numerous studies claim good to excellent correlation between these devices and standard automated perimetry (SAP), Dr. Medeiros said that many of these studies may lack the data to support such a conclusion. In a 2023 talk[4] at the American Glaucoma Society, Dr. Medeiros delivered a critical analysis of some of these studies. For example, although one study[5] claimed excellent correlation between a certain VR device and SAP, he noted that the device had a much lower dynamic range compared with the HFA (from 3 to 120 candela/meter^2 for the VR device; from 10 to 3183.1 cd/m^2 for HFA). According to Dr. Medeiros, the smaller dynamic range of the VR device "quickly leads to a floor of what you can measure." About that same study, as well as another,[6] he noted that the limits of agreement between the VR device and SAP were up to 5 dB for mean sensitivity. "That's quite a lot of difference for an average metric; with 5 dB, the agreement is really not that good."

Dr. Medeiros noted, "I'm afraid that a lot of clinicians may be transitioning to these devices without clear evidence that they can actually perform accurate and reliable perimetry or detect visual field deterioration over time, which is the cornerstone of glaucoma management. I am unaware of any studies showing that VR perimeters can effectively detect glaucoma progression at this time."

No standard for VR headsets. Having a widely accepted standard provides doctors with a common language and shareable data, but there is as yet no common standard for VR headsets, said Dr. Ou, adding that this presents a problem for specialists who need to confer. "The field would have to agree on calibration and background of the devices, but that's going to be challenging because there are so many devices on the market with a lot of variability," she said.

Dr. Law pointed out that variability between devices creates a problem between the patient and their doctor. "Visual field is very tricky. You can't use a new device and then compare the results to one you used before and say, 'It looks like you have progression.' You need to have reliable testing before diagnosing a patient with glaucoma because it's a significant diagnosis with psychological and treatment burden on the patient."

VR: Enhancing Function

Treating VF defects. In 2021, researchers investigated whether binocular VR training could repair visual field defects in glaucoma patients.[7] After training for three months, 30 subjects who received training showed significant improvement of visual field defects compared with 24 controls who received conventional treatment. The authors suggest that binocular VR training can provide a new therapeutic strategy for treating glaucoma, though they recommend further study with a larger sample size.

Functional ability. In a study to test visual acuity, contrast sensitivity, and visual field, 98 glaucoma patients and 50 healthy patients "navigated" five VR environments simulating the real world.[8] Using their VR headsets, they went supermarket shopping and walked up and down city streets and stairs in daytime and nighttime. The researchers measured how long it took subjects to complete the simulation, the number of items they incorrectly identified, and the number of times they collided with objects in the simulations.

Dr. Law said that this study provides "a new perspective of how visual impairment affects patients."[9] A logical next step, he said: VR real-world simulations tailored to a patient's own home or neighborhood. Training in such targeted environments can help patients stay safe by learning how to function better.

"As glaucoma specialists," he said, "we limit our understanding to just the eye. But function is not just about the eye, it's about coordination and cognitive function. Virtual reality can give us a way to look at the whole picture. When you give your patient mobility, you give them freedom, you give them hope. Nothing can be more valuable than that."

1 Chia Z et al. *Ophthalmol Glaucoma.* Published online Aug. 22, 2023.
2 Galen Y et al. *Ophthalmol Glaucoma.* 2023; 6(2):121-128.
3 Anderson AJ et al. *Ophthalmology*. 2017; 124(12):1735-1742.
4 Medeiros FA. New visual field algorithms, techniques, and beyond. Presented at American Glaucoma Society; March 3, 2023; Austin, Texas.
5 Razeghinejad R et al. *J Glaucoma*. 2021;30(1): 17-23.
6 Stapelfeldt J et al. *Translational Vision Science & Technology.* 2021;10(10).
7 Fan J et al. *Cyberpsychol Behav Soc Netw.* 2021;24(10):683-689.
8 Lam AKN et al. *JAMA Ophthalmol.* 2020;138(5): 490-498.
9 Law S. *JAMA Ophthalmol.* 2020;138(5):499-500.

Dr. Al-Aswad is Irene Heinz Given and John LaPorte Given Research Professor of Ophthalmology, Vice Chair for Quality and Safety, Director of Teleophthalmology, AI and Innovations, Scheie Eye Institute, University of Pennsylvania, and President and CEO for Envision Health Technologies and Visi Health Technologies. *Relevant financial disclosures: Al Optics: PS; Bausch + Lomb: C; Envision Health Technologies: EO; iCare USA: C; Save Vision Foundation: S; Sensory Sciences: US; Visi Health: EO; World Care Clinic: C.*
Dr. Law is HS Clinical Professor of Ophthalmology at UCLA David Geffen School of Medicine and a glaucoma specialist at the UCLA Stein Eye Institute. *Relevant financial disclosures: None.*
Dr. Medeiros is Vice Chair for Translation Research at the Bascom Palmer Eye Institute and Professor of Ophthalmology at the University of Miami Miller School of Medicine. *Relevant financial disclosures: Carl Zeiss Meditec: C; Heidelberg: C,S; Ngoggle: PS.*
Dr. Ou is Professor of Ophthalmology, Academic Director of the Glaucoma Division, and Vice Chair for Postgraduate Education in the UCSF Department of Ophthalmology. *Relevant financial disclosures: NEI: S.*

See disclosure key, page 7. **For full disclosures,** see this article at aao.org/eyenet.