Perimetry Goes High-Tech and Mobile

Perimetry is a critical part of managing glaucoma, but traditional testing can present a challenge, especially for any patient who is unable to hold still long enough—or press the right buttons—for an accurate test. Moreover, the equipment used for standard automated perimetry (SAP) testing is costly and bulky.

Enter several novel platforms based on smartphone and virtual reality (VR) technology. As these high-tech, mobile systems are still in development, their eventual role has yet to be defined. For instance, will they replace SAP, or serve as an adjunct? Will they be used primarily in resource-poor areas? And what about individual home-based monitoring—or, at the other extreme, glaucoma screening in large populations?

Tracking Eye Movements

Eyecatcher, a tablet-based visual field (VF) test with a built-in eye-tracking camera, assesses how well a patient's reflexes respond to flashing lights onscreen.[1]

"When it comes to speeding up the way we can offer new therapies to patients, what we need is a very efficient way of measuring change in patients on a certain therapy," said David P. Crabb, PhD, MSc, head of the Crabb Lab at City, University of London (CUL), where Eyecatcher was developed. "One of the main aims of the Eyecatcher is to simplify how this measurement is done and make it more accessible."

When using the Eyecatcher, patients don't need to press buttons; they simply follow a spot of light on the tablet. The person's eye movements are then used to assess the VF. "It's not a replacement for current testing technology, but it does have potential as a case-finding or triage-type device to better direct resources toward people suspected to be at risk for loss of vision," Dr. Crabb said. The Eyecatcher also might allow clinicians to focus their energy and skills on treatment instead of screening. "One of our goals is to create a perimetry assessment that doesn't require glaucoma specialists," Dr. Crabb said.

FAST AND RELIABLE. *The smartphone-based PeekCS test offers an easy, rapid, and reliable way to test contrast sensitivity.*

Cost. "The traditional instruments that clinicians use cost $15,000 to $30,000, and we're offering a lower cost, more patient-friendly alternative," Dr. Crabb said. "Eyecatcher is a $400 tablet computer with a $100 eye-tracker camera."

Given the Eyecatcher's other advantages—small size, portability, and ease of use—it may well prove to be useful in low-resource communities. And Dr. Crabb believes that the Eyecatcher could be especially helpful in areas in which patients must pay for part of their care. "A challenging test is even more of a concern when patients have to pay [out of pocket] to perform a test they find very difficult to do," he said.

Next step: Home monitoring? CUL researchers also are researching the validity of home testing to gather accurate data, with patients taking Eyecatcher tablets home to test their own vision more frequently. "We've deliberately not supported them too much, other than giving them basic instructions, so next year we'll find out if they're actually using it or not," Dr. Crabb said.

"Home monitoring for people with glaucoma hasn't yet been studied with real scientific validity, such as discovering what patients actually do when you send them home with a new high-tech device," he noted. In a previous home monitoring study that used a web-based diary tool, a number of patients reported feeling anxious about their glaucoma, and one wanted to leave the study because it led to obsessive rumination about visual loss.[2]

"Glaucoma clinics are already very busy, which will get worse as the pop-

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ulation ages," Dr. Crabb said. "Home monitoring is likely to be better than eye exams once or twice a year, but we need to get the assessments and technology right. More research is needed to see if the benefits outweigh the monetary and clinical costs."

He added, "A lot of the tests we use in the clinic would benefit from being upgraded into technology we now have in our homes, such as smartphones and tablet computers."

Putting VR to Work

Another approach to VF testing involves a VR headset and a smartphone. This system uses frequency doubling technology (FDT), which is thought to stimulate the retinal ganglion cells most sensitive to glaucomatous damage.[3] A head-mounted VR display, a high-resolution smartphone, and a Bluetooth-enabled remote combine to run a mobile application based on the FDT C-20 screening protocol.[3]

"This screening device is part of the Portable Ophthalmologist Project (POP) at the Lee Lab to create portable, environment-hardened, low-cost technologies for vision screening and diagnosis that are critical for international and community ophthalmology in low-resource, remote, or large populations," said Richard K. Lee, MD, PhD, head of the Lee Lab at the Bascom Palmer Eye Institute in Miami. "The goal is ultimately an ophthalmologist's office in a backpack."

The device produces frequency doubling stimuli at 30 Hz with contrasts similar to the Humphrey Zeiss FDT.[3] In one study, testing on 19 eyes showed no significant difference in detecting glaucoma compared to the Humphrey Zeiss FDT; the authors suggested that primary open-angle glaucoma patients could be identified using a smartphone-based VR headset.[3]

Cost. This mobile virtual perimetry FDT device cost less than $130 to build. Patient data are stored locally on the smartphone or transferred to the cloud for integration into an electronic health record. An additional benefit: It can be used in areas without reliable electricity.

"This low-cost, portable technology is self-contained within a VR goggle and can upload data to the cloud in a HIPAA-compliant manner for longitudinal care in any type of environment around the world," Dr. Lee said. "It can also be used for handicapped patients who cannot sit in a regular station for formal VF testing, for ICU patients in bed, and for other patients with physical limitations or medical issues."

Testing Contrast Sensitivity

Another high-tech, mobile option for glaucoma screening: a smartphone-based contrast sensitivity (CS) test called the PeekCS.

"It's based on the PRCS (Pelli-Robson Contrast Sensitivity test), the gold standard for testing contrast sensitivity," said Nigel M. Bolster, PhD, with Peek Vision in London, developer of the PeekCS. "Currently, all of our global blindness metrics are based on measurement of distance visual acuity (VA), but that only tells part of the picture of a patient's vision." And although CS testing can help measure visual defects in glaucoma patients, it is infrequently measured in routine clinical practice.[4]

The PeekCS uses the Android OS with a "tumbling E" format. With a smartphone mounted on a tripod, the tester swipes the screen in the direction the participant pointed—a useful methodology for cross-cultural or low-literacy patients. The test was recently validated in a study of 147 patients with a mean age of 50.3 years (range, 18-82 years) who had been affected by trachoma.[4] The PeekCS measurements were highly correlated with those obtained with the PRCS test.

Why focus on contrast sensitivity? Dr. Bolster offered one scenario: "After cataract surgery, some patients receive a tiny increase in VA [postoperatively] and can't thank that doctor enough, whereas others come in and get a big increase in VA but aren't nearly as happy," he said. "We hypothesize that a lot of this is due to a lack of perceiving contrast."

An increase in the number of aging adults is expected to increase the number of cases of impaired CS due to glaucoma, macular degeneration, and diabetic retinopathy, even when patients have normal VA.[4] "We think CS testing, when combined with other low-cost tests, could be useful for detecting potential glaucoma cases and other degenerative eye diseases, and of great advantage in determining a more accurate view of quality of life based on a patient's vision," he said.

The overall goal? "We're seeking to address the looming global eye health crisis, with 2.2 billion people who have vision impairment or blindness worldwide," he said.

Additional VA test. The team has also developed a VA test called Peek Acuity. "We've been able to quickly train nonclinical staff to conduct the test with a high degree of accuracy and repeatability," Dr. Bolster said.

He added, "Peek Acuity has been classified as a Class 1 medical device and is available as a free download from the Google Play Store. It's part of a broader suite of technology-enabled tools and processes designed for eye care providers in remote and low-resource settings."

1 Jones PR et al. *Trans Vis Sci Tech.* 2019;8(1):17.
2 McDonald L et al. *J Ophthalmol.* 2017;2017:8452840.
3 Alawa KA et al. *Br J Ophthalmol.* Published online Sept. 17, 2019.
4 Habtamu E et al. *Trans Vis Sci Tech.* 2019;8(5):13.

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