Editorial: Revolutionising glaucoma care in Africa: Online circular contrast perimetry

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ABSTRACT

Glaucoma is a leading cause of irreversible blindness worldwide. Sadly, most glaucoma cases in Africa are undetected, with late presentation resulting in irreversible vision loss. Visual field testing is critical to diagnose and monitor glaucoma. Online circular contrast perimetry allows visual field testing on any computer or tablet with no additional hardware, allowing rapid, low cost and easily available testing for glaucoma. Such technology reduces the cost and expands the scope of glaucoma diagnosis and monitoring and could be used for population screening in Africa.

INTRODUCTION

Glaucoma is a leading cause of irreversible blindness worldwide, with cases expected to rise dramatically in the coming decades. By 2040, an estimated 111.8 million people globally will be affected by glaucoma, with disproportionate impacts in Asia and Africa[1]. In low-resource settings like many African countries, lack of access to eyecare often leaves glaucoma undiagnosed or inadequately treated. This represents a tragic missed opportunity, as early detection and proper management can prevent blindness in many cases[2].

Visual field testing is critical for diagnosing glaucoma and monitoring disease progression. However, conventional perimetry machines used for visual field testing are expensive, bulky, and often unavailable outside of major hospitals in Africa. This lack of accessible testing equipment contributes significantly to high rates of undetected glaucoma across the continent despite numerous efforts from governments, local and international organisations. Additionally, Africa's rapidly growing population, exacerbates the demand for alternative glaucoma testing strategies, with online perimetry being a leading solution.

Online perimetry has recently been developed to enhance both accessibility and affordability, bringing these testing close to patient and in developing settings. One notable innovation is the Online Circular Contrast Perimetry (OCCP, Eyeonic), which has been the first of its kind to be tested in East Africa. This test allows patients to conduct visual field assessment of the 24-2, 10-2, 30-2 and driving test, using internet web application on any computer or tablet with similar results to the standard automated perimety. This innovative, cloud-based application developed by a team of Australian researchers lead by Ophthalmologist A/ Prof Simon Skalicky whose passion is to provide evidence based glaucoma care to all through global research. By making visual field testing more accessible, affordable, and user-friendly, OCCP has the potential to revolutionise glaucoma screening and care across Africa. This article will explore how online perimetry can improve glaucoma care in Africa, increasing eye health outcomes across the continent.

The birth of online circular contrast perimetry

The journey to develop OCCP began in 2019, when A/ Prof Simon Skalicky became increasingly aware of the limitations of conventional testing of glaucoma. COVID-19 has significantly disrupted patient follow-up and monitoring practices. The pandemic necessitated reduced in-person visits, leaving many patients without regular check-ups and proper disease management. This unexpected challenge prompted A/Prof. Skalicky.

There needed to be a way to make visual field testing more accessible, efficient, and enjoyable for patients, while still being clinically accurate and cost-effective.

Inspired by the success of telemedicine and remote healthcare delivery, Skalicky envisioned an online visual field application that could provide testing on any internet-connected computer or tablet. This would offer several key advantages:

1. Improved patient convenience by reducing required clinic visits
2. Streamlined clinic operations and reduced waiting room congestion
3. Expanded access to screening in rural and low-resource areas
4. More frequent monitoring for high-risk patients
5. Reduced patient anxiety around testing
6. Cost-effectiveness compared to conventional machines

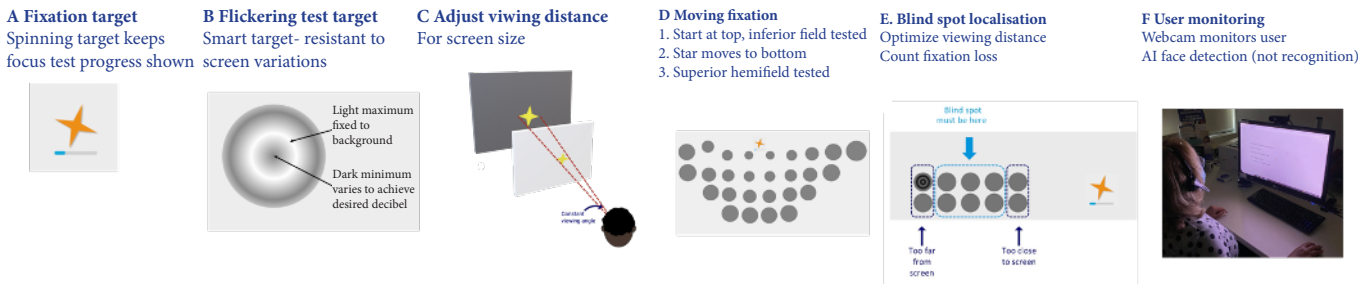
After extensive development and optimization, with support from the Microsoft for Startups program, the OCCP prototype was born. This online visual field test can be operated via any standard web browser on any computer.

Figure 1: Use of online circular contrast perimetry globally

How Online Circular Contrast Perimetry works

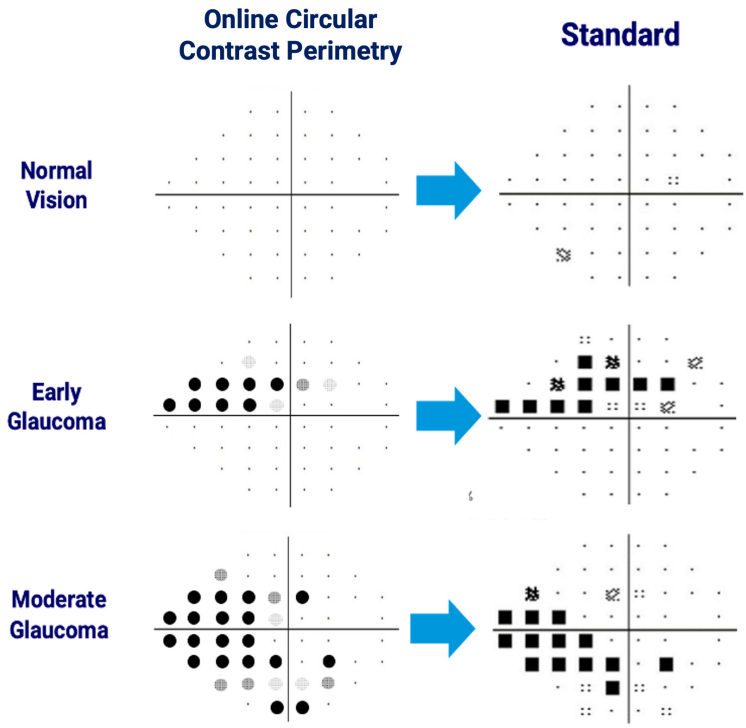
OCCP assesses 52 points over 24 degrees of visual field eccentricity (10-degree and 30-degree strategies are also available). Users are presented with a series of flickering targets consisting of alternating light and dark rings. They fixate on a spinning golden star in the centre of the screen and click when they see the flickering target in the peripheral vision. The test maps the user's blind spots and uses webcam monitoring with facial detection AI to track head position and ensure proper fixation. Verbal cues and audio feedback guide the user throughout the 3-5 minute test. Multiple languages are made available to remove language barriers for non-English-speaking patients. Importantly, Eyeonic does not require any additional hardware or equipment support beyond a standard computer or tablet.

Figure 2: The features of online circular contrast perimetry, from A to F, allowing online visual field testing on any computer or tablet



The AI-powered software analyses the results and produces detailed visual field maps and metrics comparable to conventional perimetry output. In validation studies[3-5], OCCP has demonstrated strong diagnostic accuracy similar to Standard Automated Perimetry (SAP), with high levels of agreement, reliability and repeatability. Figure 3 compares OCCP (Eyeonic) and SAP for patient with normal, early and moderate glaucoma. Eyeonic is able to detect field defect comparable to that from conventional perimetry.

Figure 3: Online circular contrast perimetry (left) visual field test result compared with SAP (right)



Addressing the need in Africa

The potential for OCCP to address gaps in glaucoma care became even clearer when A/Prof Skalicky connected with Dr. Deus Bigirimana, an ophthalmologist from Burundi who had relocated to Melbourne. Dr. Bigirimana was passionate about improving glaucoma services in Africa and painfully aware of how sparse testing resources were in African hospitals.

In many African regions, visual field testing was non-existent in routine clinical care, available only in some large urban Eye hospitals or private practices. He saw immense potential for the Eyeonic technology to revolutionise glaucoma screening and monitoring across Africa by eliminating the need for expensive, stationary perimetry machines.

This insight led to connecting A/Prof Skalicky with key collaborators in Uganda - Dr. Honorine Nizeyimana, an ophthalmology trainee, and her supervisor Dr. Simon Arunga, a respected lecturer at Mbarara University of Science and Technology and Assistant Professor at London School of Hygiene and Tropical Medicine. Together, they initiated a research project to validate the Eyeonic technology in the African context.

Validation study in Uganda

In 2022, the team in Uganda began a study aiming to collect data on 180 consecutive patients attending the university hospital. The goal was to compare results from the online OCCP visual field test to conventional visual field testing.

Despite challenges and pivots, the team persevered and continued recruiting patients and collecting data. By June 2024, data from 184 patients had been collected. The data is strong – showing OCCP via a computer to be as good as, and potentially better than, conventional visual field testing. The team is now preparing to publish their findings, which could have major implications for expanding visual field-testing access across Africa.

Figure 4: Summary statistics of Eyeonic online visual field testing compared to machine-based visual field testing among adult patients (n=184) at Mbarara University and Referral Hospital Eye Centre (MURHEC)

Visual Field Metric	Sensitivity (95% CI)	Specificity (95% CI)	AUC (95% CI)
MD	87.5 (75.9 - 94.8)	85.9 (78.7 - 91.4)	0.87 (0.81 - 0.92)
PSD	88.2 (63.6 - 98.5)	84.4 (78.0 - 89.6)	0.86 (0.78 - 0.95)
VI	73.9 (51.6 - 89.8)	87.0 (80.8 - 91.7)	0.80 (0.71 - 0.90)

MD: Mean Deviation; PSD: Pattern Standard Deviation; VI: Visual Index; AUC: Area under the Curve; CI: Confidence Interval.

Analysis of the above comparative data reveals promising performance metrics for the Eyeonic online visual field test when benchmarked against conventional machine-based testing. Using the global visual field indices of Mean Deviation (MD), Pattern Standard Deviation (PSD) and Visual Index (VI) the Eyeonic test demonstrated robust specificity, exceeding 80% for MD, PSD, and VI. Sensitivity was similarly impressive, surpassing 80% for both MD and PSD.

The AUC, a comprehensive metric combining sensitivity and specificity, showed strong results across all parameters: 0.87 for MD, 0.86 for PSD, and 0.80 for VI.

These findings indicate that OCCP may offer comparable sensitivity and specificity to conventional machine-based tests in detecting visual field defects.

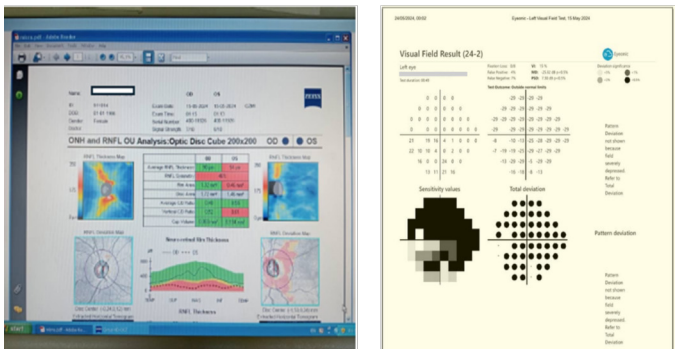
Real-world implementation

In 2023 A/Prof Skalicky was invited as an international speaker to the South African Glaucoma Congress to introduce the technology and discuss its applicability in Africa. Having received official endorsement by the SAGS committee, the test is now used routinely in many optometry and ophthalmology practices in South Africa. Similarly in Ghana, where A/Prof Skalicky had the privilege of addressing members of the Ghanaian Ophthalmology, Optometry and Ophthalmic Nurses association about Online Visual Field Testing, dozens of clinicians have signed up to the system and are using it in their routine clinical practices.

The team has also partnered with the Oromia Health Bureau in Ethiopia to work on the revolutionary Online Visual Field Test. Oromia is the largest and the most populous region in Ethiopia and Oromia Regional Health Bureau is one of the major sector bureaus in the region responsible for providing a comprehensive package of preventive, promotive, curative, and rehabilitative health services to the community at large through decentralised and democratised health system in collaboration with all stakeholders. Oromia Health Bureau is working closely with Eyeonic to deliver the Online Visual Field application to improve the availability of diagnosis and management for glaucoma. Following a successful pilot study involving a team of nine ophthalmologists in Oromia now using the Eyeonic Online Visual Field application in Oromia hospitals, the plan is to roll it into the major hospitals and remote clinics throughout Oromia.

In one illustrative case of a 46-year-old female in Oromia, the patient was evaluated with asymmetric findings suggestive of glaucoma in the left eye. Visual acuity and intra-ocular pressure were 6/6 and 14 mmHg in RE, and 6/9- and 24-mm HG in LE, respectively. The vertical cup to disc ratio was 0.3 and 0.9 in RE and LE respectively.

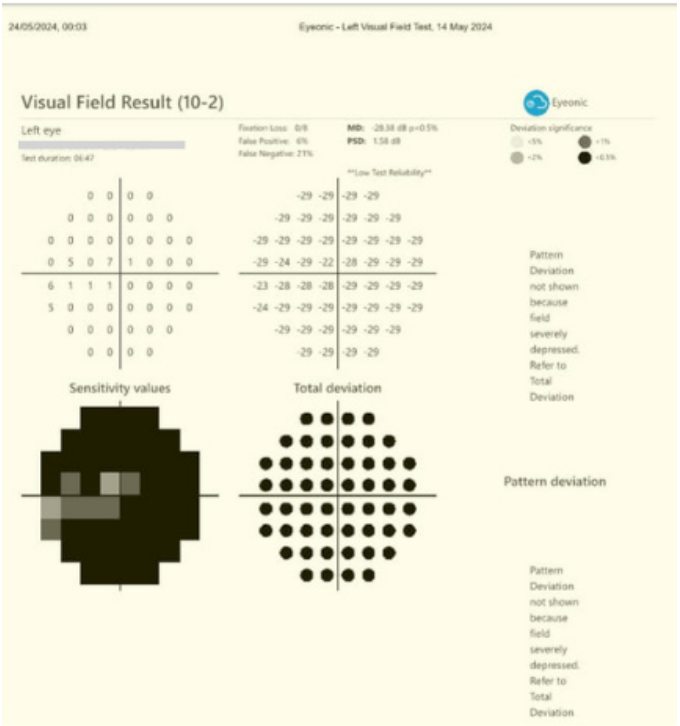
Figure 5: OCT of the RNFL, severely affected nerve in left eye



The 24-2 online visual field test (OCCP) showed severe visual field loss in the left eye, while the right eye test was normal. These results were consistent with the generalised thinning of the retinal nerve fibre layer (RNFL) in LE.

As the central 4 points are affected in the 24-degree field, it is therefore necessary to perform a central 10-2 OCCP test, which gives better assessment of the central 10-degree field for localised defects. Results are shown in Figure 6.

Figure 6: Left eye central 10-2: severe loss of vision



This case highlights OCCP's ability to detect severe glaucomatous damage and provide consistent, comprehensive visual field assessment across different test strategies. By providing detailed, quantitative visual field data using computers or tablets for visual field testing, it empowers clinicians to more accurately diagnose glaucoma and monitor progression over time that was previously unavailable in many African clinical settings.

Expanding access across Africa

The successful implementation in Uganda, South Africa, Ghana and Ethiopia has generated excitement about the potential to expand access to visual field testing across Africa. Unlike conventional perimetry machines which cost tens of thousands of dollars, require specialised maintenance, and take up significant clinic space, OCCP can be deployed anywhere there is a computer and internet connection. The low cost and ease of implementation make it feasible to dramatically increase the availability of visual field testing across Africa. This could enable earlier detection of glaucoma through expanded community screening programs, more frequent monitoring of patients, even in remote areas, improved clinical decision, and reduced burden on tertiary eye care centres by enabling follow-up testing locally.

In Uganda, East Africa, Dr. Arunga is already working to integrate the OCCP application into a new social enterprise hospital and network of glaucoma screening centres in Uganda. This model could be replicated in other African countries to rapidly scale up access to visual field testing. Such a program is also being planned in Western Francophone Africa. Cote D'Ivoire, where Eyeonic's impact also emerges, addressing critical needs in glaucoma care.

Driving licence standards

Road safety is a critical issue globally and ensuring motor vehicle drivers have adequate vision for road driving is a key part of achieving this. At-risk individuals require a binocular wide field Esterman visual field test to ensure they have sufficient field of vision for driving. Up until now this required access to a traditional visual field machine which are few and far-between in Africa. However, the OCCP system also offers a binocular suprathreshold visual field test online, with sufficient width of field for licencing requirements, and can be performed on any computer. The ease and accessibility of the system has led to Eyeonic being chosen by a leading research team in Senegal to evaluate truck drivers' binocular visual field for a landmark nationwide road safety study.

Combined with its success in Uganda, Ethiopia, Ghana and South Africa, OCCP's expansion into countries like Côte d'Ivoire and Senegal demonstrates its growing presence and potential impact across Africa. The technology's ability to provide accessible, cost-effective visual field testing is proving valuable in addressing the continent's significant eye care challenges, particularly in regions with limited resources and high glaucoma prevalence.

Patient experience and acceptance

Beyond the clinical benefits, studies have shown that patients generally find the online test more comfortable, less stressful, and more user-friendly than traditional visual field testing[3].

The familiar computer interface, the ability to take breaks if needed, and the progress bar indication reduce anxiety for many patients. The option for home-based testing is also highly valued, as it can reduce travel burden and costs associated with frequent clinic visits.

Patients readily adapt to using OCCP despite varying levels of computer literacy. The simple interface and clear audio instructions allowed even elderly patients and those with limited technology experience to successfully complete the tests.

The multi-language voice instruction capability enhances the global applicability in diverse healthcare settings. By offering instructions and interfaces in various languages, the system aims to improve accessibility for patients and healthcare workers across different linguistic backgrounds. This feature may reduce language-related barriers, potentially enhancing patient comprehension and test administration accuracy. While further research is needed to quantify its impact, this linguistic adaptability may contribute to expanding eye care services in regions where language differences have historically presented challenges. As with any medical technology, the effectiveness of this feature in improving patient outcomes and expanding access to care requires ongoing evaluation and validation in diverse clinical settings.

This high level of patient acceptance is crucial for improving compliance with visual field testing, which is a cornerstone of proper glaucoma management. By making the testing process more convenient and less intimidating, the OCCP online perimetry system may help improve long-term adherence to recommended testing schedules.

Challenges and future directions

While the potential benefits of the OCCP system in Africa are significant, there are some challenges to be considered in the future direction:

(i) Internet connectivity: Reliable internet is needed during the test to upload results and access the cloud-based analysis. This may limit use in some extremely remote areas. An app-based version of the test allowing off-line usage is currently planned for development.

(ii) Computer/tablet access: The test requires basic computing equipment, which may not be universally available in all healthcare settings.

(iii) Training requirements: While the system is user-friendly, some basic training is still needed for healthcare workers to properly administer the test and interpret results.

(iv) Integration with existing workflows: Incorporating a new testing modality into established clinical practices can be challenging.

Despite these challenges, the Eyeonic team is actively working to address them and expand the capabilities of the system. The low cost, high accessibility and high impact potential of the OCCP application make it a promising solution for expanding glaucoma care in resource-limited settings across Africa.

CONCLUSIONS

The OCCP Online Visual Field Test is a transformative technology for addressing the growing burden of glaucoma in Africa. By providing affordable high quality visual field testing, it opens new possibilities for expanded screening, earlier detection of glaucoma, and improved disease monitoring across the continent. Its successful implementation and validation in some African countries demonstrates the feasibility and acceptability of this approach. As the technology continues to be refined and more widely adopted, it has the potential to significantly improve eye care delivery and outcomes for people at risk of glaucoma-related vision loss.

While challenges remain, the OCCP system offers a promising path forward in the fight against glaucoma related blindness in Africa. By leveraging the power of cloud computing, artificial intelligence, and ubiquitous technology, it represents an innovative approach to overcoming long standing barriers to care. As we look to the future, technologies like OCCP will play an increasingly important role in expanding access to high-quality eye care in resource-limited settings. Through continued collaboration between technologists, clinicians, and public health experts, governments, we can work towards a future where preventable vision loss from glaucoma is truly a thing of the past - in Africa and around the world.

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