Performance of an iPad Application to Detect Moderate and Advanced Visual Field Loss in Nepal

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• PURPOSE: To evaluate the accuracy and efficiency of Visual Fields Easy (VFE), a free iPad app, for performing suprathreshold perimetric screening.
• DESIGN: Prospective, cross-sectional validation study.
• METHODS: We performed screening visual fields using a calibrated iPad 2 with the VFE application on 206 subjects (411 eyes): 210 normal (NL), 183 glaucoma (GL), and 18 diabetic retinopathy (DR) at Tilganga Institute of Ophthalmology, Kathmandu, Nepal. We correlated the results with a Humphrey Field Analyzer using 24-2 SITA Standard tests on 373 of these eyes (198 NL, 160 GL, 15 DR).
• RESULTS: The number of missed locations on the VFE correlated with mean deviation (MD, $r = 0.79$), pattern standard deviation (PSD, $r = 0.60$), and number of locations that were worse than the 95% confidence limits for total deviation ($r = 0.51$) and pattern deviation ($r = 0.68$) using SITA Standard. iPad suprathreshold perimetry was able to detect most visual field deficits with moderate (MD of -6 to -12 dB) and advanced (MD worse than -12 dB) loss, but had greater difficulty in detecting early (MD better than -6 dB) loss, primarily owing to an elevated false-positive response rate. The average time to perform the Visual Fields Easy test was 3 minutes, 18 seconds (standard deviation = 16.88 seconds).
• DISCUSSION: The Visual Fields Easy test procedure is a portable, fast, effective procedure for detecting moderate and advanced visual field loss. Improvements are currently underway to monitor eye and head tracking during testing, reduce testing time, improve performance, and eliminate the need to touch the video screen surface. (Am J Ophthalmol 2017;182:147–154. © 2017 Elsevier Inc. All rights reserved.)

GLAUCOMA AND DIABETIC RETINOPATHY ARE 2 causes of blindness and visual impairment that are commonly missed[1–6] and are the fourth and fifth most common causes of blindness.[7] Currently 2.71 million people in the United States have open-angle glaucoma, expected to increase to 7.32 million in 2050.[8] By 2040 there will be 111.8 million persons with glaucoma worldwide, with a disproportionate number in less developed countries.[9] Similarly, it is estimated that 93 million people worldwide have diabetic retinopathy, a number that will increase in the future.[10]

In developed regions, 60% of all glaucoma is undetected,[11–14] while in areas in Asia, India, Nepal, and West Africa over 90% is undetected.[15–20] Both developed and developing nations must detect glaucoma and diabetic retinopathy before it causes visual disability. It has been reported that screening is not a cost-effective or useful method of identifying vision impairment,[21–24] although examinations to detect glaucoma and other visual impairment conditions are important.[23] Targeting at-risk populations can achieve a degree of success comparable to other procedures for detecting other disease processes. Population-based screening for glaucoma has been questioned,[25–28] and the U.S. Preventive Services Task Force Recommendations concluded that there was insufficient evidence to assess the value of vision screening.[28] However, many investigators have assessed vision screening for a variety of ocular and neurologic disorders.[29–33]

The purpose of this investigation was to evaluate the performance of the Visual Fields Easy screening procedure on an iPad (Apple, Cupertino, California, USA) for clinic-based visual field testing, and to compare the results to the 24-2 SITA Standard procedure on the Humphrey Field Analyzer (Carl Zeiss Meditec Inc, Dublin, California, USA). A Topcon Mydriatic Camera (TRC 50 DX; Topcon, Oakland, New Jersey, USA) and a Volk Pictor nonmydriatic camera (Volk Optical Inc, Mentor, Ohio, USA) were used to obtain photographs of the posterior pole (macula and optic nerve) of each

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eye. The photography results will be presented in a companion paper.

METHODS

THIS INVESTIGATION WAS CONDUCTED IN ACCORDANCE with the tenets of the Declaration of Helsinki and was approved prospectively by the local Institutional Review Board, and participants signed a written informed consent document prior to entering the study. Individual results were de-identified and HIPAA compatible. Participants were individuals living near Kathmandu, Nepal, who attended the Tilganga Institute of Ophthalmology, and all participants were able to provide a correct assessment of their age. All subjects underwent a comprehensive ophthalmic examination for glaucoma and diabetic retinopathy, which included best-corrected visual acuity; biomicroscopy of the anterior segment; gonioscopy; an ophthalmoscopic examination of the macula, optic nerve head, and retinal nerve fiber layer; measurement of intraocular pressure (IOP); and other features of a conventional ophthalmic eye examination. Nonmydriatic optic disc and posterior pole photographs were obtained prior to dilation. Three groups of participants were evaluated: (1) normal control subjects with healthy eyes and visual pathways except for corrected refractive errors, (2) patients with clinically confirmed glaucoma, and (3) patients with diabetes and evidence of diabetic retinopathy. All glaucoma and diabetic patients and healthy controls were examined by a fellowship-trained glaucoma specialist (author S.T.). Participants were excluded if they had a best-corrected visual acuity of 20/60 or worse; had an uncorrected refractive error of greater than 4 diopters sphere and/or 3 diopters cylinder; had other ocular, neurologic, or systemic conditions that may affect visual field sensitivity; or were taking medications that were known to affect visual field sensitivity. Healthy control participants had an IOP of less than 21 mm Hg and a normal retina, optic nerve, and retinal nerve fiber layer. Glaucoma patients had an IOP of 21 mm Hg or greater and evidence of optic nerve abnormalities (cupping, notching, rim thinning, vessel displacement, etc) and retinal nerve fiber layer loss. Diabetic patients had a diagnosis that was based on hemoglobin A1C levels and the retinal appearance. Both eyes were tested for each participant, unless 1 of the eyes was no light perception, where only the seeing eye was evaluated. A total of 210 normal control healthy eyes were tested (198 had Humphrey Field Analyzer 24-2 SITA Standard test results), along with 183 eyes with glaucoma (160 had Humphrey Field Analyzer 24-2 SITA Standard results) and 18 diabetic retinopathy eyes (15 with Humphrey Field Analyzer 24-2 SITA Standard results).

Visual Fields Easy (VFE) is an application that is available for the iPad that can be downloaded for free. The VFE test procedure evaluates 96 test locations (24 per visual field quadrant) throughout the central 30-degree radius. The testing distance is 33 cm. A red fixation point is presented in the lower left corner, and the examinee's eye and head are centered on the fixation point. The examinee presses the iPad's surface each time he or she detects a target. Targets are presented for a fixed duration of 200 ms with an interval of approximately 1 second between target presentations, and these values can be modified in the setup menu. Once the first quadrant is evaluated, the fixation point moves to the lower right corner to evaluate another visual field quadrant and the examinee is again recentered. This continues until all 4 quadrants are evaluated. The background luminance of the VFE test is 10 cd/m^2 (31.5 asb) and a Goldmann size V stimulus is presented at 16 dB intensity. False-positive and false-negative catch trials are also presented. The results can be either directly printed or e-mailed using Wi-Fi from the iPad. Figure 1 presents the test locations for a right eye, indicating the location of the 96 stimulus positions. Several iPads were calibrated with a Photo Research Spectracan Model 670 Photometer/Radiometer (Photo Research Inc., Chatsworth, California) to verify the background and stimulus luminance values and evaluate consistency from one iPad to another. Additionally, the diameter of the stimulus displayed was measured to verify that it corresponded to a Goldmann size V target at the 33 cm viewing distance.

Participants were tested with the VFE screening procedure for visual fields at 33 cm, which was established with a 33-cm-long string positioned between the iPad and the patient's eyelid. Testing was monocular, beginning with the right eye first and the left eye second. The nontested eye was occluded with an eye patch. The tablet was calibrated and positioned on a holder oriented so that the participant's eye and head location were positioned directly in line with the red fixation target. The participant pressed the display each time a target was detected. Testing was completed and a printout of the results (targets detected, targets missed, false-positive responses, false-negative responses) was created.

The majority of participants in this study were tested with the Humphrey Field Analyzer 24-2 SITA Standard test procedure after the iPad screening. The perimetrists for the iPad were masked as to the diagnosis. Again, testing was monocular, beginning with the right eye and continuing with the left eye. The nontested eye was occluded with an eye patch, and an optimal refractive correction for the testing distance was employed. A printed output of test results was created for each eye after testing was completed and was e-mailed to the testing center.

Optic disc photographs were also obtained with both a Topcon mydriatic camera (Topcon TRC 50 DX; Topcon, Oakland, New Jersey, USA) and Volk Pictor nonmydriatic camera (Volk Optical Inc Mentor, Ohio, USA) prior to dilation, and the results were evaluated by a group of fellowship-trained glaucoma specialists to evaluate the