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Comparison of a Novel Head-Mounted Objective Auto-perimetry (Gaze Analyzing Perimeter) and Humphrey Field Analyzer

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Purpose: To evaluate the agreement between 24-2 visual field (VF) test results obtained using the gaze analyzing perimeter (GAP; Findex) and the Humphrey field analyzer (HFA; Carl Zeiss Meditec).

Design: Cross-sectional study.

Participants: Patients underwent HFA 24-2 for suspected or confirmed VF loss and were treated at the Kyoto University Hospital between December 2022 and July 2023.

Methods: Patients underwent consecutive VF tests on the same eye using HFA and GAP 24-2 tests. Bland–Altman analysis was used to compare GAP and HFA results. Examination points where the sensitivity measured using GAP was $\geq$ 10 dB higher than that measured using HFA were re-evaluated by referring back to the original gaze data; 2 ophthalmologists assessed whether the gaze moved linearly toward the new test target.

Main Outcome Measures: Mean deviation (MD) and elapsed time on an individual basis and sensitivity on an examination point basis.

Results: Forty-seven eyes of 47 patients were analyzed. The correlation coefficient of the MD using HFA and GAP was 0.811 (95% confidence interval [CI]: 0.683–0.891). Bland–Altman analysis showed good agreement between HFA and GAP tests. The mean difference (95% limits of agreement) in MD between HFA and GAP results was −0.63 dB (−5.81 to 4.54 dB). Although no statistically significant differences were observed in the elapsed time ($P = 0.99$), measurements completed within 200 seconds were observed only in the GAP group (11 cases, 23.4%), who had significantly better HFA MD value than others ($P = 0.001$). On an examination point basis for sensitivity, the correlation coefficient between HFA and GAP was 0.691 (95% limits of agreement, 0.670–0.711). Original gaze data assessment revealed that the gaze moved linearly toward the new test target for 70.2% of the examination points with a sensitivity discrepancy.

Conclusions: The results indicate that the GAP provides VF assessment outcomes comparable to those of the HFA. The GAP exhibited advantages in terms of testing time, particularly in patients with minimal VF impairment. Furthermore, the GAP records all eye movements, enabling the objective determination of VF abnormalities based on gaze patterns and facilitating easy posthoc verification.

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Supplemental material available at www.ophthalmologyglaucoma.org.

Visual field (VF) deterioration can arise from various pathologic conditions. Notably, in ophthalmology, glaucoma is an important cause of VF deficits.[1] The Tajimi study revealed that approximately 5% of individuals aged 40 years and older showed manifestations of glaucoma.[2] Within this subset, 90% evaded diagnostic recognition for glaucoma, emphasizing the possible undertreatment of glaucoma. The World Health Organization acknowledges that timely and judicious intervention to arrest progression remains pivotal in averting preventable ocular impairment.[3] As such, early detection and timely treatment of glaucoma are crucial because of the irreversible visual impairment caused by the condition. Visual field testing is essential for diagnosing and monitoring glaucoma. Therefore, quick and accurate VF tests that can be easily performed are needed. Furthermore, scrutiny of VFs is relevant not only in ophthalmology but also in neurology and neurosurgery.[4] Profiling VF aberrations facilitates discernment of the cerebral locations of neurologic pathologies through the distinctive patterns of VF deficits.

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Visual field assessment is of paramount significance in evaluating VF impairment. Kinetic and static VF tests are conducted for this purpose.[5,6] Owing to the enhanced precision of static VF testing in evaluating the VF, it is considered the gold standard. Among static perimetry devices, the Humphrey field analyzer (HFA) (Carl Zeiss Meditec) and Octopus perimeter (Haag-Streit) are widely used globally, with the HFA being considered the de facto standard in both clinical and research settings.[7] However, these instruments are relatively large and stationary, rendering them unsuitable for assessments involving immobile individuals, such as bedside evaluations. To overcome these limitations, the recent introduction of a relatively compact head-mounted static automated perimetry (SAP) device, "imo" (CREWT Medical Systems), has garnered attention.[8]

Although SAP is the gold standard, it has several limitations. For instance, in SAP, sustaining fixation to a point during examination is obligatory, and target visibility is determined by patient manual switch activation. These introduce elements that compromise examination objectivity. Therefore, in SAP, the indices of examination reliability encompass false-positive, false-negative, and fixation instability monitoring. Conversely, the gaze analyzing perimeter (GAP) (FINDEX) is an objective automated perimetric instrument that follows a novel measurement principle (note that the GAP is sold as FIELDNavigator in Europe). The GAP employs a head-mounted display, tracking ocular movements at up to 240 frames per second (fps) while the subject gazes at sequentially presented test targets. The assessment hinges on discerning whether the gaze moves decidedly and linearly toward the new test target, indicating target visibility. The advantages of the head-mounted perimetric apparatus include the fact that it is mobile and does not require a dark room. Notably, the judgment of target visibility occurs promptly in response to ocular movements, circumventing the need for button presses.

Therefore, the GAP is a novel device with the potential to overcome the shortcomings of existing VF testing equipment. In this study, we conducted a comparative analysis between the GAP and HFA. Comparisons of these 2 devices using different measurement principles will provide new insights into VF testing.

Methods

This study was approved by the Institutional Review Board of Kyoto University Graduate School of Medicine (C1410). Informed consent was obtained from all patients before the start of the study. This study adhered to the principles of the Declaration of Helsinki and was registered in the University Hospital Medical Information Network (UMIN) Clinical Trials Registry (registration number: UMIN000035335).

Study Participants

This study included consecutive patients who underwent HFA Swedish interactive threshold algorithm (SITA) standard 24-2 testing for suspected or confirmed VF loss at Kyoto University Hospital between December 2022 and July 2023, consented to GAP evaluation, and completed examinations using gaze-tracking assessment. Exclusions from the analysis were made to ensure reliability of both VF tests. The exclusion criteria were (1) individuals aged 90 and above because their result might be compromised, (2) individuals with frequent blinking leading to imprecise gaze-tracking evaluation, and (3) individuals with compromised HFA reliability (false positive ≥ 0.15, false negative ≥ 0.33, or fixation loss $\geq 20\%$). One eye per individual (the eye with worse VF defects) was included in the study. A case was considered a frequent blinking case when the number of blinks during the presentation of test targets exceeded 30% of the total number of test targets.

Gaze Analyzing Perimetry

The GAP is an automated perimetry instrument founded on a novel measurement principle, which determines target visibility based on gaze movement instead of manual switch activation. It consists of a head-mounted display and a dedicated software (Figs S1–S4; available at www.ophthalmologyglaucoma.org). that obtained marketing approvals in Japan (38B2X10003000002, 38B2X10 003000003) and Europe (Basic UDI-DI: 458251532GAPH 00001M5). The fundamental specifications of the GAP are listed in Table S1; available at www.ophthalmologyglaucoma.org). The weight of the head-mounted display is 400 g, rendering it lighter than the 1.8-kg imo. Spherical refractive power can be adjusted within the range of −10.0 D to +10.0 D, and cylindrical refractive power is tunable up to 6 D by the included corrective lens. Eye tracking at a maximum rate of 240 fps is feasible, and the peak luminance is 10 000 apostilbs, which is the same as that of the HFA. The specialized software is typically installed on a Windows PC with a graphics board compatible with DirectX. Detailed information about the device is provided in Supplementary Notes (available at www.ophthalmology glaucoma.org).

Visual Field Assessment

After donning and securing the GAP apparatus, a calibration process for eye-tracking was initiated. Upon commencement of the examination, the test target was displayed on the screen. Participants were instructed to align their gaze with the test target. Once the gaze converged on the test target, the initial test target disappeared and was replaced with a new test target at a new coordinate. The coordination and luminosity of the new test target were algorithmically controlled, and the cycle was iterated. All examination points were tested at least once and repeatedly tested until the sensitivity for each examination point was determined. If the gaze did not reach the target within 1.5 seconds, it was considered a timeout. However, under certain conditions, the timeout period was extended up to a maximum of 2.5 seconds. The determination of whether the newly presented test target at the altered coordinates was perceptible depended on gaze analysis. This determination algorithm was developed by employing machine learning founded on 1035 gazes of 172 individuals who underwent concurrent HFA and GAP assessments at Kyoto University Hospital between January 2019 and March 2019. Although the precise intricacies of the algorithm were confidential, by considering the HFA-evaluated sensitivity as the ground truth, the discriminating accuracy (i.e., whether GAP correctly identifies gazes to test targets exceeding the sensitivity evaluated by HFA as "linear movement") within the internal dataset was 96.7%. The current version of GAP does not include indicators of reliability such as false negatives or false positives in HFA. In this investigation, the Swedish interactive threshold algorithm standard mode of the HFA was used, whereas for the GAP, the examination was performed using GIFIT 24-2, which is comparable with the Swedish interactive threshold algorithm standard mode of the HFA. Details of the GIFIT mode are explained in the Supplementary Methods section. The GAP tests

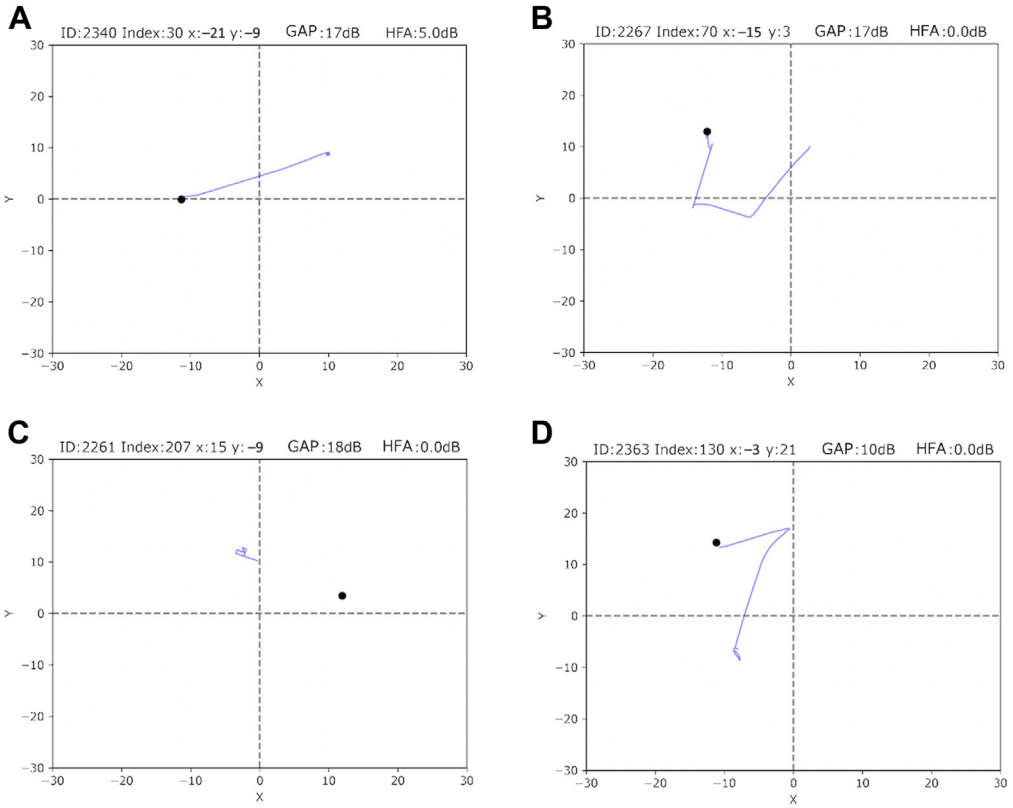

Figure 5. Representative gaze movements. When a test target is not visible, individuals are unable to move their gaze linearly toward it. Conversely, linear gaze movement indicates target visibility. **A,** Humphrey field analyzer (HFA) sensitivity was 5 dB, and the test target was 17 dB. In this case, the patient could reasonably move his/her gaze linearly toward the test target. This gaze indicates the visibility of the test target at this examination point. **B,** The HFA sensitivity was 0 dB, and the test target was 17 dB. Although the gaze finally reached the test target, 2 saccadic movements were observed before it did, indicating invisibility. **C,** The HFA sensitivity was 0 dB, and the test target was 18 dB. The gaze did not reach the test target, indicating invisibility. **D,** The HFA sensitivity was 0 dB, and the test target was 10 dB. The gaze moved in a direction different from that of the test target and subsequently shifted toward the target. This gaze movement indicated invisibility. GAP = gaze analyzing perimeter.

were performed immediately after performing HFA tests at the same visit.

Statistical Analysis

We compared the mean deviation (MD) and elapsed time individually. The correlation between the MD values of both tests was evaluated using Pearson's correlation coefficient. Furthermore, a Bland−Altman plot was used to assess the agreement of MD values between the 2 tests. The elapsed time was visualized using scatter plots and compared between the GAP and HFA groups using a paired *t* test. The sensitivity of each test point was evaluated using Pearson's correlation coefficient, and the agreement of sensitivity between both tests was assessed using a Bland−Altman plot.

Assessment of the Cause of Discrepancy

To evaluate the underlying cause of the observed discrepancy, examination points where the sensitivity measured using the GAP exceeded that of the HFA by 10 dB or more were systematically identified. Next, we conducted a meticulous examination of the actual ocular movements. If a new test target was perceptible to the patient, their gaze manifested a linear trajectory directed toward the test target (Fig 5). To evaluate the linearity of eye movements, 2 independent ophthalmologists (M. M. and Y. M.) assessed ocular movements. In cases where there was a difference in opinion between the assessors, the final decision was made through consensus. In addition, we evaluated the original gazes for the examination points where the sensitivity measured using the HFA was 10 dB or more and that measured using the GAP was 0 dB.

Results

Among the 64 patients who met the inclusion criteria, those aged 90 years (n = 1), those with frequent blinking leading to imprecise gaze-tracking evaluation (n = 2), and those with compromised HFA reliability (n = 14) were excluded from the analysis. Individuals with severe neurologic deficits or nystagmus that might compromise the GAP result were not present. Finally, 47 patients were included in the analysis. The participants' backgrounds are listed in Table 2. The mean age of the participants was 65.0 ± 12.7 years (mean ± standard deviation), with women representing 44.7% and the right eye accounting for 48.9%. The elapsed time of the HFA examination was 324.91 ± 70.05 seconds, with an accompanying MD value of −3.47 ± 4.48 dB.

Figure 6 depicts a Bland−Altman plot illustrating the agreement between individual-level MD values obtained from GAP and HFA assessments. As shown, the mean difference between the 2 methods was −0.63 dB. The limits of agreement, ranging

Table 2. Background of Patients

Characteristics	Values
N	47
Age, years	64.94 (12.66)
Sex, female (%)	21 (44.7)
Laterality, right (%)	23 (48.9)
Diagnosis (glaucoma/others)	29/18
Humphry field analyzer	
Elapsed time, second	324.91 (70.05)
Mean deviation, dB	−3.47 (4.48)
False positive	0.02 (0.02)
False negative	0.03 (0.04)

Mean (standard deviation) is presented.

from −5.81 to 4.54 dB, showed that the majority of differences between the methods were confined within this interval. In addition, no apparent proportional errors were observed. The correlation coefficient was 0.811 (95% confidence interval [CI], 0.683−0.891). The mean calibration time was 30.5 ± 9.7 seconds. A comparison of the elapsed time between the GAP and HFA is shown in Figure 7. The average elapsed time for the GAP was 325 ± 142 seconds, and there was no statistically significant difference compared with that for the HFA (P = 0.99). Among the 47 patients, most examinations were completed within 500 seconds. Although no measurements within a 200-second timeframe were observed in HFA examinations, 11 cases (23.4%) were completed within 200 seconds using GAP. All patients who completed the GAP measurement within 200 seconds exhibited HFA MD values greater than or equal to −3 dB. The comparison between these 11 cases and others are shown in Table 3, which showed significant difference in HFA MD value (P = 0.001). Representative examples comparing the results of the HFA and GAP for the same case are provided in Figs S8−S10; available at www.ophthalmologyglaucoma.org).

Figure 11 illustrates a comparison of the sensitivities at the examination points based on the HFA and GAP. The correlation coefficient was 0.691 (95% CI, 0.670−0.711). In general, the data points were aligned along the y = x line. However, among examination points with a discrepancy of ≥ 10 dB between HFA and GAP sensitivities, cases where GAP sensitivity exceeded HFA sensitivity were observed more frequently than those where HFA sensitivity exceeded GAP sensitivity. In particular, in cases where HFA measurements indicated 0 dB sensitivity, GAP measurements often showed sensitivities ranging from 4 dB to 35 dB. Conversely, examination points where the GAP and HFA recorded sensitivities of 0 and > 0 dB, respectively, were infrequent. Figure 12 depicts a Bland−Altman plot illustrating the agreement between the examination point-level sensitivities obtained from GAP and HFA assessments. The mean difference between the 2 methods was −0.22 dB. The limits of agreement ranged from −12.0 to 11.5 dB, indicating that the major differences between the methods were confined within this interval. Again, examination points where the HFA recorded 0 dB sensitivity and the GAP recorded > 0 dB sensitivity were frequently observed. Stratified analysis according to region (i.e., superior, inferior, temporal, nasal, and paracentral) also showed good agreement between the GAP and HFA (Fig S13; available at www.ophthalmologyglaucoma.org).

An evaluation of the original gaze for the examination points where the sensitivity measured using the GAP exceeded that of the HFA by 10 dB or more revealed that 99 of the 141 gazes (70.2%) exhibited a linear gaze movement toward the new test target. Figure 14 shows a representative example of a gaze that was determined to move linearly. These 99 gazes (subsequently referred to as "HFA-negative/GAP-positive gazes") were obtained from 21 eyes of 21 patients. Each patient exhibited between one and 12 instances of "HFA-negative/GAP-positive gazes," with a median of 4 occurrences. We divided the 21 patients into 2 groups: those who had fewer "HFA-negative/GAP-positive gazes" than the median and those who had equal to or more

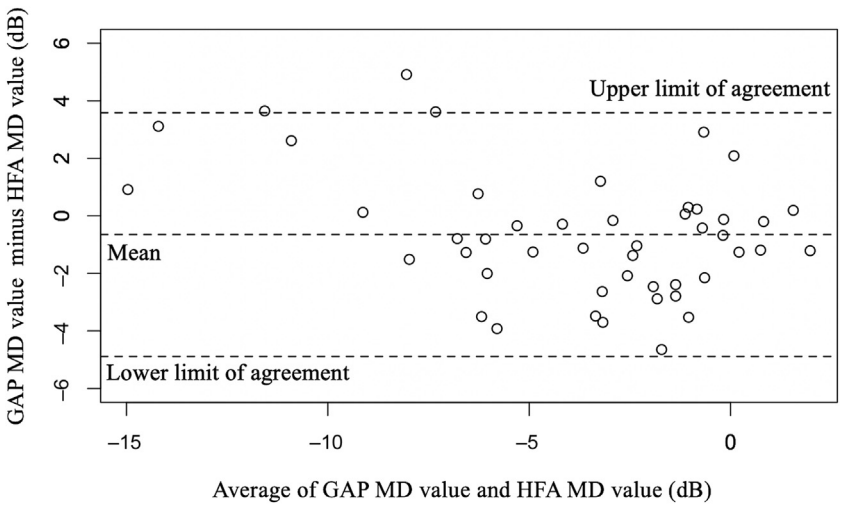

Figure 6. Bland−Altman plot illustrating the agreement between individual-level mean deviation values obtained from the gaze analyzing perimeter and the Humphrey field analyzer. The mean difference in mean deviation (MD) between the gaze analyzing perimeter (GAP) and the Humphrey field analyzer (HFA) was observed to be −0.63 dB (MD using the GAP − MD using the HFA). The limits of agreement spanned from −5.81 to 4.54 dB. No apparent proportionality errors were observed. This result suggests good agreement between the 2 methods without systematic bias. The central broken line indicates the mean difference, and the upper and lower broken lines indicate the upper and lower limits of agreement, respectively.

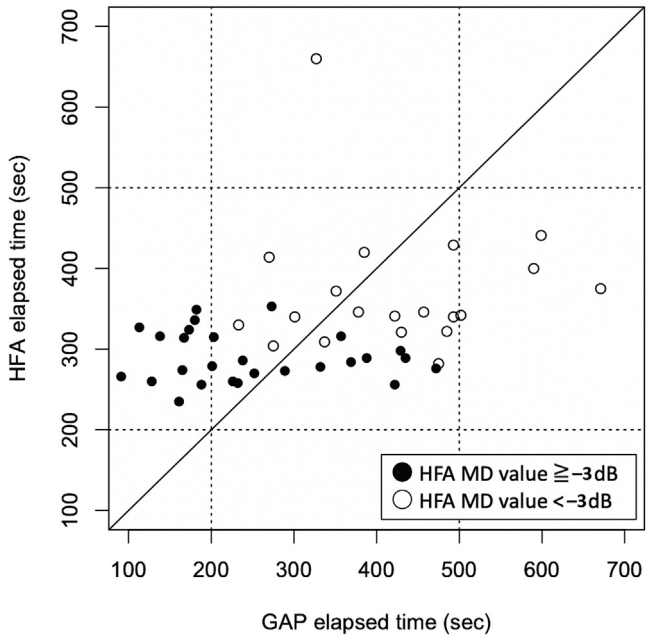

Figure 7. A scatter plot comparing elapsed time between the gaze analyzing perimeter and the Humphrey field analyzer. The average elapsed time for the gaze analyzing perimeter (GAP) was 325 ± 142 seconds, which was not significantly different from that for the Humphrey field analyzer (HFA) ($P = 0.99$). Most examinations were completed within 500 seconds. Although no measurements within a 200-second timeframe were observed in HFA examinations, 11 cases (23.4%) were completed within 200 seconds using the GAP. All patients who completed GAP measurements within 200 seconds exhibited HFA MD values greater than or equal to −3 dB.

"HFA-negative/GAP-positive gazes" than the median. The results are shown in Table 4. Patients with a higher number of "HFA-negative/GAP-positive gazes" demonstrated a higher rate of false positives ($P = 0.026$) and false negatives ($P = 0.005$) in the HFA measurements. Conversely, we identified 5 examination points (22 gazes) where the GAP measured a sensitivity of 0 dB and the HFA measured a sensitivity of more than 10 dB. The gazes (i.e., "HFA-positive/GAP-negative gazes") for these examination points are presented in Figure S15 (available at www.ophthalmologyglaucoma.org). The gazes reproducibly exhibited nonlinear movements toward a new test target.

Discussion

This study (UMIN registration number: UMIN000035335) evaluated the performance of the novel automated perimetry system, the GAP, compared with that of the HFA. Our findings showed that the GAP yields VF assessment outcomes comparable with those of the HFA, with a notable advantage in terms of testing time for patients with minimal VF impairments.

Although the HFA is considered the gold standard for VF testing, it has drawbacks of being stationary and not portable. Therefore, head-mounted VF analyzers have been developed. Currently, in addition to the GAP, imo is a head-mounted VF analyzer with regulatory approval. A detailed comparison of these instruments is shown in Table S5. A previous study reported a correlation coefficient of 0.82 to 0.83 between HFA and imo MD values.[9] This was comparable with the correlation coefficient between HFA and GAP MD values in our study. Bland−Altman analysis showed lower CIs for the MD difference between GAP and the HFA (−5.81 to 4.54 dB), compared with that of MD difference between imo and the HFA(−6.49 to 5.19 dB).

Table 3. Comparison of the Characteristics Between Patients With GAP Elapsed Time < 200 seconds and Others

	Elapsed Time of GAP Measurement		
	≧ 200 Seconds	*< 200 Seconds*	***P***
Number of patients	36	11	NA
Age (years)	63.4 (13.3)	70.0 (9.2)	0.13
Sex, female (%)	15 (41.7)	6 (54.5)	0.69
Elapsed time of HFA measurement (sec)	334 (75.4)	296 (38.6)	0.12
MD values measured by HFA (dB)	−4.58 (4.52)	0.16 (1.42)	0.001
False positives in HFA (%)	0.02 (0.03)	0.01 (0.02)	0.53
False negatives in HFA (%)	0.03 (0.05)	0.02 (0.03)	0.24

HFA = Humphrey field analyzer; MD = mean deviation; GAP = gaze analyzing perimeter.
Mean ± standard deviation is presented.

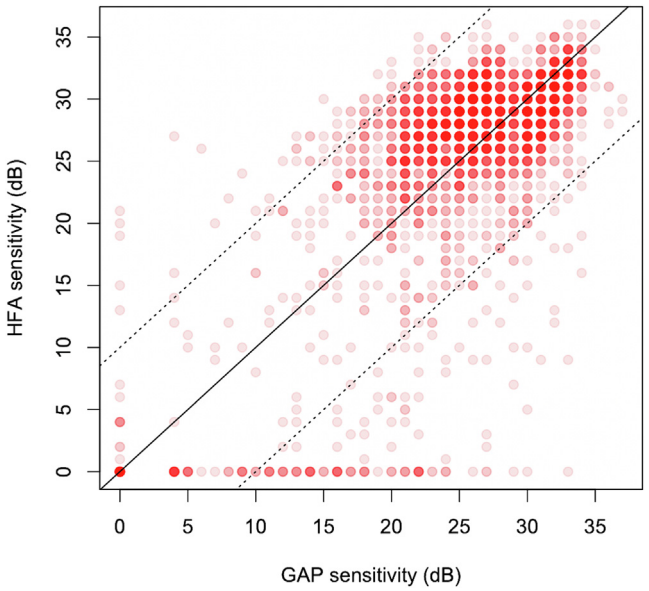

Figure 11. Comparison of sensitivities on examination point basis between the gaze analyzing perimeter (GAP) and the Humphrey field analyzer (HFA). The correlation coefficient was 0.691 (95% confidence interval, 0.670–0.711). Among examination points with ≥ 10 dB discrepancy between HFA and GAP sensitivities, those where GAP sensitivity exceeded HFA sensitivity (right lower triangle) were observed more frequently than those where HFA sensitivity exceeded GAP sensitivity (left upper triangle). In cases where HFA measurements indicated 0 dB sensitivity, GAP measurements often showed sensitivities ranging from 4 to 35 dB (y = 0 line). Conversely, examination points where GAP recorded 0 dB sensitivity and HFA recorded > 0 dB sensitivity were infrequent (x = 0 line). The solid line indicates the y = x line, and broken lines indicate y = x ± 10 lines. Each data point is depicted by a transparent filled circle. The degree of opacity of the circle increases with the number of overlapping points within the same coordinates.

Although a direct comparison is not feasible owing to the different conditions, the GAP may have lower variability.

The recently reported Toronto portable perimeter (TPP) is a virtual reality-based perimeter that requires smartphone connection for monitoring and coupling, with a wireless clicker for operation.[10] In a pilot study, the correlation coefficient between MD values obtained from the TPP and HFA was 0.83, showing parity with the correlation coefficient between MD values of the GAP and HFA in our study. Bland–Altman analysis revealed a slightly

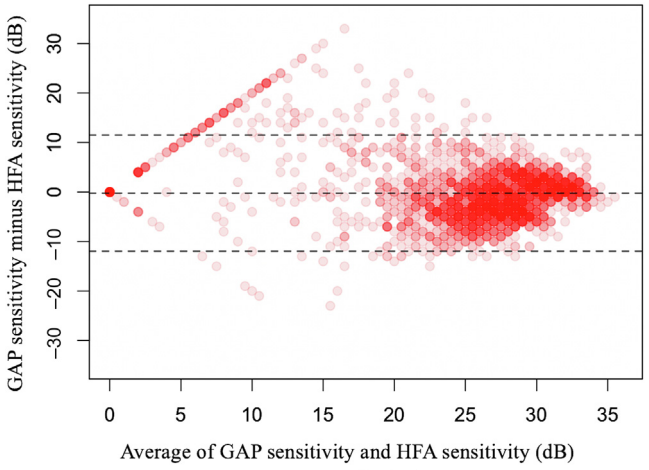

Figure 12. A Bland–Altman plot illustrating the agreement between examination point-level sensitivities obtained from the gaze analyzing perimeter (GAP) and the Humphrey field analyzer (HFA). The mean difference in sensitivity between the 2 methods was −0.22 dB (sensitivity using the GAP − sensitivity using the HFA). The limits of agreement spanned from −12.0 to 11.5 dB. No apparent proportionality errors were observed. This result suggests good agreement between the 2 methods without systematic bias. Each data point is depicted by a transparent filled circle. The degree of opacity of the circle increases with the number of overlapping points within the same coordinates. The central broken line indicates the mean difference, and the upper and lower broken lines indicate the upper and lower limits of agreement, respectively.

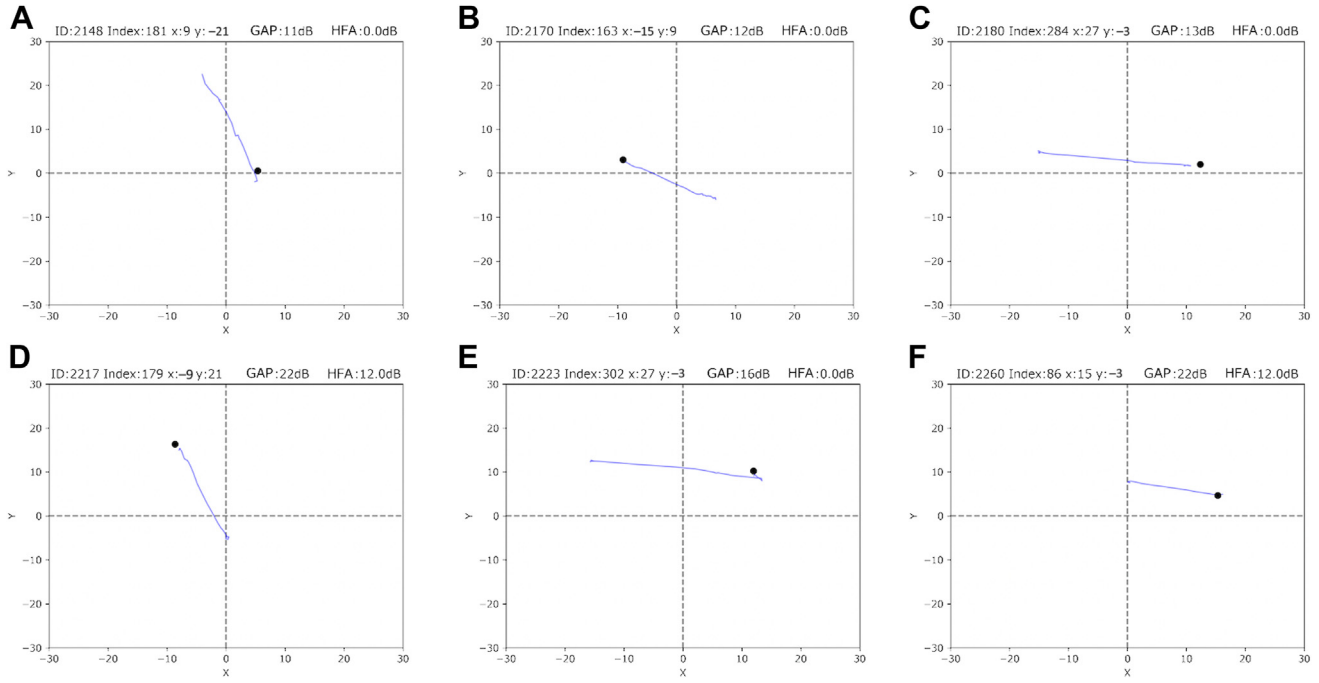

Figure 14. Representative original gazes for examination points where the sensitivity measured using the gaze analyzing perimeter (GAP) exceeded that of the Humphrey field analyzer (HFA) by 10 dB or more. Examination points where the sensitivity measured using the GAP exceeded that of the HFA by 10 dB or more were systematically identified. The original gaze data were re-evaluated by 2 ophthalmologists. As a result, 70.2% of the examination points displayed confirmed linear gaze movements. (**A**)−(**F**) are the representative linear gazes. The solid circle indicates the coordinates of a new test target.

lower variability in the MD value difference between the TPP and HFA, with a 95% CI of −4.25 to 4.67 dB. However, unlike the GAP and imo, the TPP currently lacks regulatory approval. In addition, the TPP may face challenges, such as inadequate luminance, owing to the smartphone-based monitor, which can hinder the detection of subtle discrepancies in low-sensitivity regions.

Thus, GAP measurements yielded results comparable with those of existing methodologies on an individual basis. Even on an examination point basis, it demonstrated a high correlation coefficient of 0.691 with the sensitivity measured using the HFA. However, examination points where GAP sensitivity exceeded HFA sensitivity were observed more frequently than those where HFA sensitivity exceeded GAP sensitivity. Additionally, instances where GAP measured a sensitivity $>$ 0 dB despite the HFA indicating 0 dB sensitivity were often observed, with the reverse rarely observed. Because the GAP assesses whether the examination point is visible based on ocular movement, we can retrospectively validate the results. Hence, we scrutinized the examination points for these discrepancies. When a test target is not visible, individuals are unable to move their gaze linearly toward it. Conversely, linear gaze movement indicates target visibility. From our validations, among the examination points where the GAP-measured sensitivity exceeded that of the HFA by 10 dB or more, 70.2% displayed confirmed linear gaze movements (Fig 14). This implies that at least 70.2% of the validated examination points were sensitive, indicating a false-negative HFA result rather than a GAP measurement error. This is supported by the finding that these gazes were more frequently observed in patients with a higher rate of false-negative

Table 4. Clinical Characteristics of the Eyes for Which the GAP Was Able to Detect a Higher True Sensitivity

	The Number of HFA Negative/GAP Positive Gazes		
	< median	*≧ median*	***P***
Number of patients	10	11	NA
Age (years)	63.50 (12.03)	64.09 (13.86)	0.92
MD values measured using the GAP (dB)	−5.82 (4.27)	−7.33 (2.76)	0.34
MD values measured using the HFA (dB)	−4.60 (4.49)	−8.84 (3.85)	0.031
False positives in HFA tests (%)	1 (1)	3 (3)	0.026
False negatives in HFA tests (%)	1 (2)	7 (6)	0.005

HFA = Humphrey field analyzer; MD = mean deviation; GAP = gaze analyzing perimeter; NA = not applicable.
Mean (standard deviation) is presented.

HFA results ($P = 0.005$; Table 4). Furthermore, for all 5 examination points where the GAP measured a sensitivity of 0 dB while HFA measured a sensitivity of more than 10 dB, the gazes reproducibly showed nonlinear movement toward the new test target (Fig S15). Thus, it is reasonable to consider the sensitivity of these points to be 0 dB, rather than a GAP measurement error.

As previously mentioned, the GAP has many strengths. Unlike conventional VF examinations in which participants press a button when they perceive a test target, the GAP determines visibility based on ocular movement. Thus, it offers an objectivity superior to that of existing VF tests, coupled with the advantage of easy retrospective validation. Furthermore, as a head-mounted display system, it is very portable, enabling bedside implementation, and the apparatus is lightweight. Moreover, the examination time is less in cases of relatively mild VF impairment. However, it has the following limitations. Given the necessity of capturing targets, precise measurements are unattainable in cases of profound central VF impairment. Excessive blinking or narrow palpebral fissures may impede accurate ocular tracking and consequently hinder precise measurements. Although not assessed in this study, nystagmus may also potentially impact gaze analysis. In addition, the GAP is not applicable in patients with severe ocular motility disorders. Although there is an option to measure the switch activation in such scenarios, this precludes the benefits of gaze analysis. The other limitation is the black box nature of the algorithm used for determining gaze linearity, which makes it more challenging to identify or improve potential errors in its functioning. Reliability indices for the result should be implemented. This study has strengths and limitations. It is a cross-sectional study in which participants were prospectively enrolled. The design ensured stable settings and high reliability compared with that of a retrospective design. However, the small sample size was a major limitation. Secondly, because the current study included patients with relatively mild VF defect, generalizability to those with more severe VF defect needs further investigation. Last, because GAP was performed immediately after HFA in all patients, patients' fatigue might have compromised the GAP result. Therefore, future studies with larger sample sizes and random sequence are warranted.

This study conducted an investigation to compare the performance of a novel-automated perimetry system, the GAP, with that of an established HFA. The results revealed that the GAP yielded VF assessment outcomes comparable with those of the HFA. In particular, in cases with minimal VF impairment, the GAP exhibited substantial advantages in terms of examination time. Additionally, the GAP records the entire ocular movement, enabling objective determination of VF impairments and facilitating postvalidation. Although there are cases in which the GAP may not be suitable, its utility is inferred across many instances.

Footnotes and Disclosures

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This study was conducted in collaboration with FINDEX Inc. Kazutaka Yamada and Ryo Shiraishi are employees at FINDEX Inc. The funding agency provided the devices used.

HUMAN SUBJECTS: Human subjects were used in this study. This study was approved by the Institutional Review Board of Kyoto University Graduate School of Medicine (C1410). Informed consent was obtained from all patients before the start of the study. This study adhered to the principles of the Declaration of Helsinki and was registered in the University Hospital Medical Information Network (UMIN) Clinical Trials Registry (registration number: UMIN000035335).

No animal subjects were used in this study.

Author Contributions:

Conception and design: Miyake, Akagi, Aibara, Tamura, Tsujikawa

Data collection: Miyake, Mori, Wada, Numa, Suda, Kameda, Ikeda, Akagi, Aibara, Tamura, Tsujikawa

Analysis and interpretation: Miyake, Yamada, Shiraishi, Aibara, Tamura

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Abbreviations and Acronyms:

GAP = Gaze analyzing perimeter; **HFA** = Humphrey field analyzer; **MD** = mean deviation; **SAP** = static automated perimetry;

SITA = Swedish interactive threshold algorithm; **TPP** = Toronto portable perimeter; **UMIN** = University Hospital Medical Information Network; **VF** = visual field.

Keywords:
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