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Value of 10-2 Visual Field Testing for Detecting Progression in Patients with Glaucoma

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Purpose: To determine the value of the 10-2 test of the Humphrey Field Analyzer (Carl Zeiss Meditec) in detecting visual field (VF) progression in early glaucoma.

Design: Prospective longitudinal study.

Participants: Patients with open-angle glaucoma and healthy participants.

Methods: Participants were examined with the 24-2 and 10-2 tests every 4 months. Only those with 5 pairs of tests or more were included. To analyze the same area as the 10-2, only the central 12 test locations of the 24-2 test were included, from which global and quadrant mean deviation (MD) slopes and pointwise total deviation (TD) slopes were computed. A range of criteria for progression based on pointwise TD slope cutoffs was used.

Main Outcome Measures: Measures included the area under the receiver operating characteristic curve (AUC) separating patients with glaucoma from healthy participants for global, sectoral, and pointwise analyses and overlap in the proportion of patients identified by the 2 tests at matched specificity.

Results: One eye each from 96 patients with glaucoma with early visual field damage and 56 healthy participants was included in the analysis. The participants were followed up for a median of 4.69 and 4.49 years with 13 and 11 pairs of tests, respectively. The AUCs of the MD slopes for the 2 tests were not significantly different for global ($P = 0.25$) or quadrant ($P > 0.11$) analysis. At 90% specificity for global MD slope, the overlap in patients classified as progressing with both tests was 53%, whereas for quadrant MD slope, the overlap was less. The AUCs were not different for pointwise slope cutoffs of more than −1.25 dB/year, but were significantly higher for the 10-2 test when cutoffs were −1.25 dB/year or less. Patients showing progression with only the 10-2 test with steeper pointwise slope cutoffs showed worse baseline MD on the 10-2, but not 24-2, test.

Conclusions: For global and sectoral analyses, little evidence showed that the 10-2 test provided additional information about central visual VF compared with the 24-2 test. Pointwise analyses support the use of the 10-2 test for following up patients with selectively worse central VF loss at baseline and who are at risk of faster progression.

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Most published studies of glaucomatous visual field progression report results with tests of either the central 30° or 24° of the visual field.[1–3] However, almost 40% of retinal ganglion cells are located within the macula,[4] and conventional visual field test patterns, such as those of the 24-2 test of the Humphrey Field Analyzer (Carl Zeiss Meditec), contain only a small number of test locations (12 of 54 [22%]) in the central 10°, potentially undersampling the retinal ganglion cell population. Based on this premise, there is considerable debate on whether small paracentral visual field defects escape detection with these tests and whether macular tests (such as the 10-2 test of the Humphrey Field Analyzer) with a higher density of test locations should be used more routinely.[5–7]

Comparative studies on the value of the 24-2 and 10-2 tests for detecting central visual field defects have yielded equivocal results.[5,6,8,9] A limitation of these studies is that they likely contained clinical populations of patients with glaucoma whose initial diagnosis was based on visual field evaluation with the 24-2 test alone, rather than the 10-2 alone, creating a sampling bias that potentially favored the 24-2 test. An objective assessment of the merit of these tests can be made only from patient samples which have not undergone prior visual field

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testing, drawn ideally from population-based studies, where both the 24-2 and 10-2 tests are performed on each participant. Nonetheless, it has been argued that in patients with existing defects shown with the 24-2 test, central visual field testing should be reserved for patients with a threat to central visual field progression.[5,7]

Studies of visual field progression using these test patterns are sparse. Rao et al[10] performed a chart review to compare the rate of mean deviation (MD) change with the 24-2 and 10-2 tests in treated patients with glaucoma. They concluded that the rate of MD change was faster with the 10-2 test compared with the 24-2 test in advanced glaucoma. In a retrospective study focusing on patients with preexisting parafoveal scotomas, Park et al[11] found that the 10-2 test was superior for detecting visual field progression. However, because of the retrospective nature of these studies, the indications for performing the 10-2 test on the selected group of patients were not clear. Wu et al[12] first derived variability estimates from a short follow-up and then used computer simulation to conclude that the time to detect progression with the 10-2 test was slightly shorter than that for the 24-2 test. Neither study included healthy participants to control for false-positive rates of progression (healthy subjects who show progression). Hood et al[13] showed that the 24-2 test can miss progression determined by a reference standard of subjective clinical judgement that included OCT and demonstrated a relatively high rate of false-positive findings; however, no comparison between the 2 perimetric tests was made. Thus, evidence demonstrating that the 10-2 test is superior to the 24-2 test for detecting glaucomatous progression and whether the added test burden can be justified, even in a select group of patients, is limited.

The present study was performed in a cohort of patients with glaucoma followed up prospectively and aimed to address whether the 10-2 test detected visual field progression in significantly more patients compared with the central points of the 24-2 test and whether the rates of progression detected by the 10-2 test were faster in global, sectoral, and pointwise analysis. We derived performance characteristics across a range of criteria for progression and referenced these findings to those in a parallel cohort of healthy participants to control for specificity.

Methods

Participants

The study participants were patients with open-angle glaucoma and healthy control participants in a longitudinal prospective study whose objective was to determine the value of macular imaging and perimetry for detecting progression of early glaucoma. Patients with glaucoma were recruited consecutively from the glaucoma clinics of the Eye Care Centre of Nova Scotia Health in Halifax, Nova Scotia, Canada. They were previously diagnosed and treated according to the referring glaucoma specialist. Healthy control participants were not hospital-based staff and were recruited from advertisements in local media.

The inclusion criteria for patients with glaucoma were: (1) 18 years of age or older, (2) best-corrected visual acuity of 6/12 or better, (3) clinical diagnosis of glaucoma based on evidence of glaucomatous changes of the optic nerve head and retinal nerve fiber layer, and (4) glaucoma hemifield test (GHT) results with the 24-2 test outside normal limits. Exclusion criteria were: (1) MD of less than −6 dB with the 24-2 test, (2) refractive error exceeding 6 diopters (D) spherical equivalent or 3 D of astigmatism, or (3) concomitant systemic or eye disease or medication that could impact the visual field.

The inclusion criteria for healthy control participants were: (1) 18 years of age or older, (2) normal eye examination results with intraocular pressure of 21 mmHg or less, (3) best-corrected visual acuity of 6/12 or better, and (4) normal visual field test results with GHT results within normal limits. Exclusion criteria were: (1) refractive error exceeding 6 D spherical equivalent or 3 D of astigmatism, (2) chronic eye disease, or (3) systemic disease or medication that could impact the visual field.

The study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Nova Scotia Health Research Ethics Board. All participants provided written informed consent for participation. All clinical examinations were performed by a board-certified ophthalmologist. If both eyes were eligible for inclusion, the study eye was chosen randomly.

Testing

All study participants were tested first with the 24-2 test and then the 10-2 test of the Humphrey Field Analyzer with the Swedish Interactive Threshold Algorithm Standard protocol (Carl Zeiss Meditec) with a suitable break between tests. Visual field tests were judged to be reliable based on the perimetrist's observations, using the reliability indices (false-positive or false-negative rates of $\leq$ 15% or fixation losses of $\leq$ 33%) as a guideline but not definitive criteria, because occasionally tests are considered reliable when reliability indices are not within the recommended cutoffs, and vice versa. When tests were deemed unreliable, they were repeated. Both 24-2 and 10-2 tests were performed every 4 months during the entire follow-up. Only participants with at least 5 pairs of 24-2 and 10-2 tests were selected for analysis.

OCT of the retinal nerve fiber layer (RNFL), optic nerve head, and macula was performed with the Spectralis OCT 2 (Heidelberg Engineering) at each visit. Because the purpose of this study was to compare the performance of the 24-2 and 10-2 tests, the OCT results are not detailed.

Data Analysis

Data were exported with perimetry software (FORUM; Carl Zeiss Meditec) for analysis. We selected only the central 12 test locations of the 24-2 test and all 68 locations of the 10-2 test to ensure that the same extent of the visual field was compared. In quadrant analysis, the 24-2 test contained 3 locations in each quadrant, whereas the 10-2 test contained 17 locations in each quadrant. The MDs of the 24-2 test, the central 12 test locations of the 24-2 test, and the 10-2 test are abbreviated as $MD_{24\text{-}2}$, MD_{12}, and $MD_{10\text{-}2}$, respectively. The $MD_{24\text{-}2}$ and $MD_{10\text{-}2}$ values were obtained from the perimetry software, whereas the MD_{12} values were calculated as the unweighted mean of the total deviation (TD) values of the central 12 test locations of the 24-2 test.

In the absence of a suitable external standard for progression, we elected to use receiver operating characteristic (ROC) curve analysis to determine the relative ability of the central 12 test locations of the 24-2 test and all test locations of the 10-2 test to discriminate between patients with glaucoma and healthy control participants. Because glaucomatous progression is not expected in healthy participants and TD values are age corrected, we used these changes as a reference standard against which changes with the 2 tests in patients with glaucoma could be compared. For

Table 1. Study Population Characteristics

Characteristic	Patients with Glaucoma	Healthy Control Participants	P Value
No. of participants	96	56	
Baseline age (yrs)	69.5 (62.3–73.7)	62.8 (56.4–67.7)	<0.01
$MD_{24\text{-}2}$ (dB)	−2.18 (−3.52 to −1.22)	0.80 (0.22–1.31)	<0.01
$MD_{10\text{-}2}$ (dB)	−1.78 (−4.90 to −0.67)	0.82 (0.28–1.22)	<0.01
Follow-up (yrs)	4.69 (4.34–4.98)	4.49 (2.91–4.90)	<0.01
No. of examinations	13 (12–14)	11 (7–13)	0.03
Median interval between examinations (yrs)	0.34 (0.33–0.35)	0.34 (0.33–0.36)	0.72
Maximum interval between examinations (yrs)	0.75 (0.69–0.87)	0.83 (0.61–0.96)	0.29

$MD_{10\text{-}2}$ = mean deviation of the 10-2 test; $MD_{24\text{-}2}$ = mean deviation of the 24-2 test.
Data are presented as median (interquartile range) unless otherwise indicated.

global analysis, we performed a linear regression of MD_{12} and $MD_{10\text{-}2}$ over time and used the full range of possible slopes to derive ROC curves for either test. The same approach was used for quadrant analysis in which slopes of quadrant MD_{12} and $MD_{10\text{-}2}$ were analyzed. For pointwise analysis, we used the number of test locations showing statistically significant ($P < 0.05$) deterioration of TD with statistically significant slopes with cutoff values ranging from 0 dB/year through −2.0 dB/year (in steps of −0.25 dB/year).

To determine the overlap among patients with glaucoma identified as progressing with global and sectoral analyses, we used the cutoff value for MD_{12} and $MD_{10\text{-}2}$ that yielded 90% specificity. Because it was not possible to attain the same level of granularity in the pointwise analysis, that is, the number of test locations required to show significant deterioration at the various slope values, we used matched specificities as close as possible to 90%.

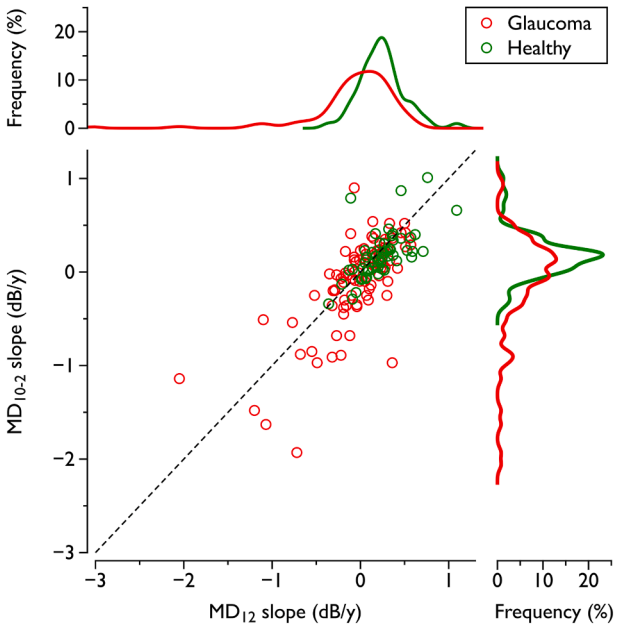


Figure 1. Scatterplot showing the relationship between the mean deviation slope of the central 12 test locations of the 24-2 test (MD_{12}) compared with the mean deviation slope of the 10-2 test ($MD_{10\text{-}2}$) in patients with glaucoma and healthy control participants. Split plots show histograms of the MD_{12} and $MD_{10\text{-}2}$ slopes for each participant group.

Descriptive data were reported as mean (standard deviation) or median (interquartile range [IQR]), with group variables compared with either the group *t* test or median test. Areas under the ROC curves (AUCs) were compared with DeLong's test. The chi-square test was used to compare hemifield differences in pointwise slopes. All analyses were performed with IBM SPSS statistics version 28. Conventional multivariable regression models were used to determine which baseline parameters were predictive of subsequent visual field progression. Statistical significance was assumed for $P < 0.05$.

Results

The study contained 96 patients with glaucoma with early visual field loss and 56 healthy control participants with a median age of 69.5 years (IQR, 62.3–73.7 years) and 62.8 years (IQR, 56.4–67.7 years), respectively (Table 1). Patients with glaucoma showed a marginally longer follow-up (median, 4.69 years vs. 4.49 years in healthy participants) with a median of 13 pairs (IQR, 12–14 pairs) of 24-2 and 10-2 tests compared with 11 pairs (IQR, 7–13 pairs) in healthy participants (Table 1).

The mean (standard deviation) and median MD_{12} slopes in patients with glaucoma were −0.01 (0.64) dB/year and 0.04 dB/year (IQR, −0.19 to 0.24 dB/year), whereas in healthy participants they were 0.24 (0.25) dB/year and 0.23 dB/year (IQR, 0.07–0.36 dB/year). The corresponding values for $MD_{10\text{-}2}$ slopes were −0.10 (0.53) dB/year and 0.00 dB/year (IQR, −0.25 to 0.23 dB/year) and 0.18 (0.25) dB/year and 0.17 dB/year (IQR, 0.03–0.28 dB/year). In patients with glaucoma, neither baseline $MD_{24\text{-}2}$ ($P = 0.36$), baseline $MD_{10\text{-}2}$ ($P = 0.83$), baseline age ($P = 0.53$), nor sex ($P = 0.39$) were predictive of subsequent $MD_{10\text{-}2}$ slope. Although both MD_{12} and $MD_{10\text{-}2}$ slopes in patients with glaucoma and healthy participants were statistically different ($P < 0.01$), a notable overlap was found in the distributions (Fig 1). Results from the same analysis conducted with the $MD_{24\text{-}2}$ yielded similar results (Fig S1, available at www.aaojournal.org). A Bland-Altman plot showing the differences in MD_{12} and $MD_{10\text{-}2}$ slopes is shown in Figure S2 (available at www.aaojournal.org).

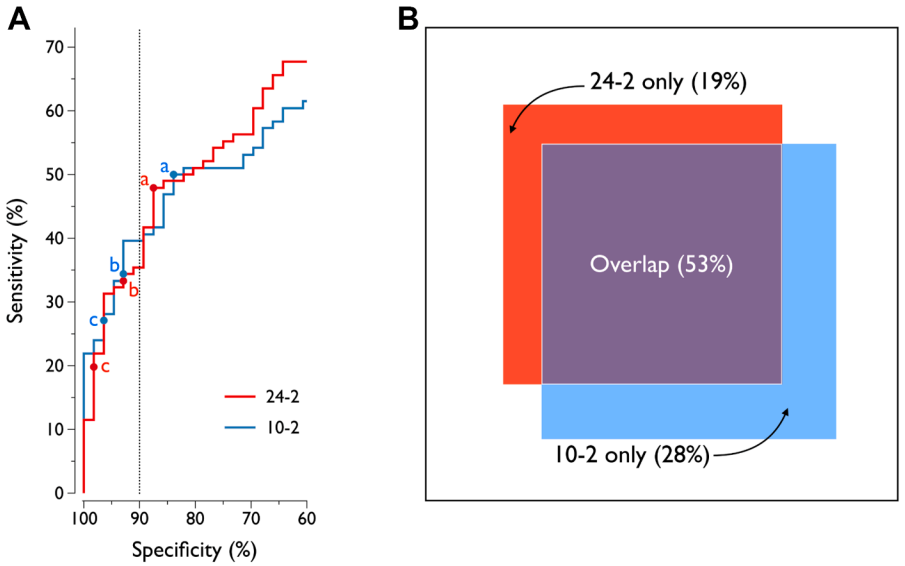


Figure 2. **A**, Graph showing the receiver operating characteristic curves of the mean deviation slope of the central 12 test locations of the 24-2 test (MD_{12}) and the mean deviation slope of the 10-2 test ($MD_{10\text{-}2}$). Points along the curve (a, b, and c) indicate cutoff MD_{12} and $MD_{10\text{-}2}$ slope values of 0 dB/year, −0.1 dB/year, and −0.25 dB/year, respectively, for the visual field to be classified as progressing. Dashed line indicates 90% specificity. **B**, Area-proportional Venn diagrams showing overlap in the number of patients with glaucoma classified as progressing with the 24-2 and 10-2 tests at 90% specificity in addition to those classified as progressing with only 1 of the tests. Outside box shows the total glaucoma population.

The AUCs of the MD_{12} and $MD_{10\text{-}2}$ slopes were not significantly different (paired difference in AUC, 0.040; 95% confidence interval, −0.027 to 0.107; $P = 0.25$; Fig 2). Using cutoff values for MD_{12} and $MD_{10\text{-}2}$ slopes that yielded 90% specificity, 25 of the 47 patients (53%) classified as having progression with either test were identified by both tests. Nine patients (19%) showed progression with only the 24-2 test, whereas 13 patients (28%) showed progression with only the 10-2 test (Fig 2). Quadrant analysis of MD_{12} and $MD_{10\text{-}2}$ slopes showed similar results with paired differences in AUC ranging from −0.040 to 0.067 with widely overlapping confidence intervals ($P > 0.11$; Fig S3, available at www.aaojournal.org). At 90% specificity, between 34% and 49% of patients classified as showing progression with either test were identified by both (Fig S3).

The mean pointwise TD slopes in patients with glaucoma and healthy participants are shown in Figure 3. Paired comparison of TD slopes in mirror image test locations split along the horizontal midline showed that in patients, 25 of 34 paired locations (74%) showed more negative slopes superiorly, indicating faster progression rates in the superior hemifield compared with the inferior hemifield (Fig 3). In healthy participants, 14 of the paired locations (41%) showed more negative slopes superiorly, indicating a more random spatial distribution of pointwise TD slope values (Fig 3). This difference between patients and healthy participants was statistically significant ($P = 0.01$).

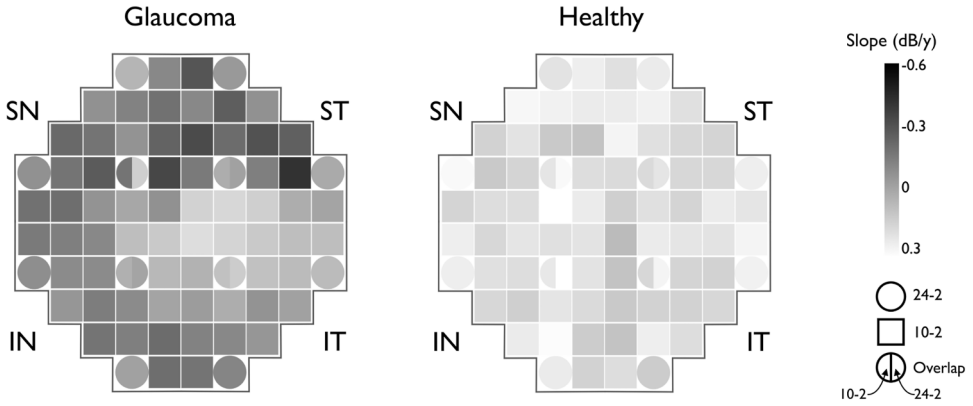


Figure 3. Pointwise total deviation slopes in patients with glaucoma and healthy control participants in the central visual field. Test locations depicted as circles and squares are unique to the 24-2 and 10-2 tests, respectively, whereas overlapping test locations are shown as bisected circles. IN = inferior nasal; IT = inferior temporal; SN = superior nasal; ST = superior temporal.

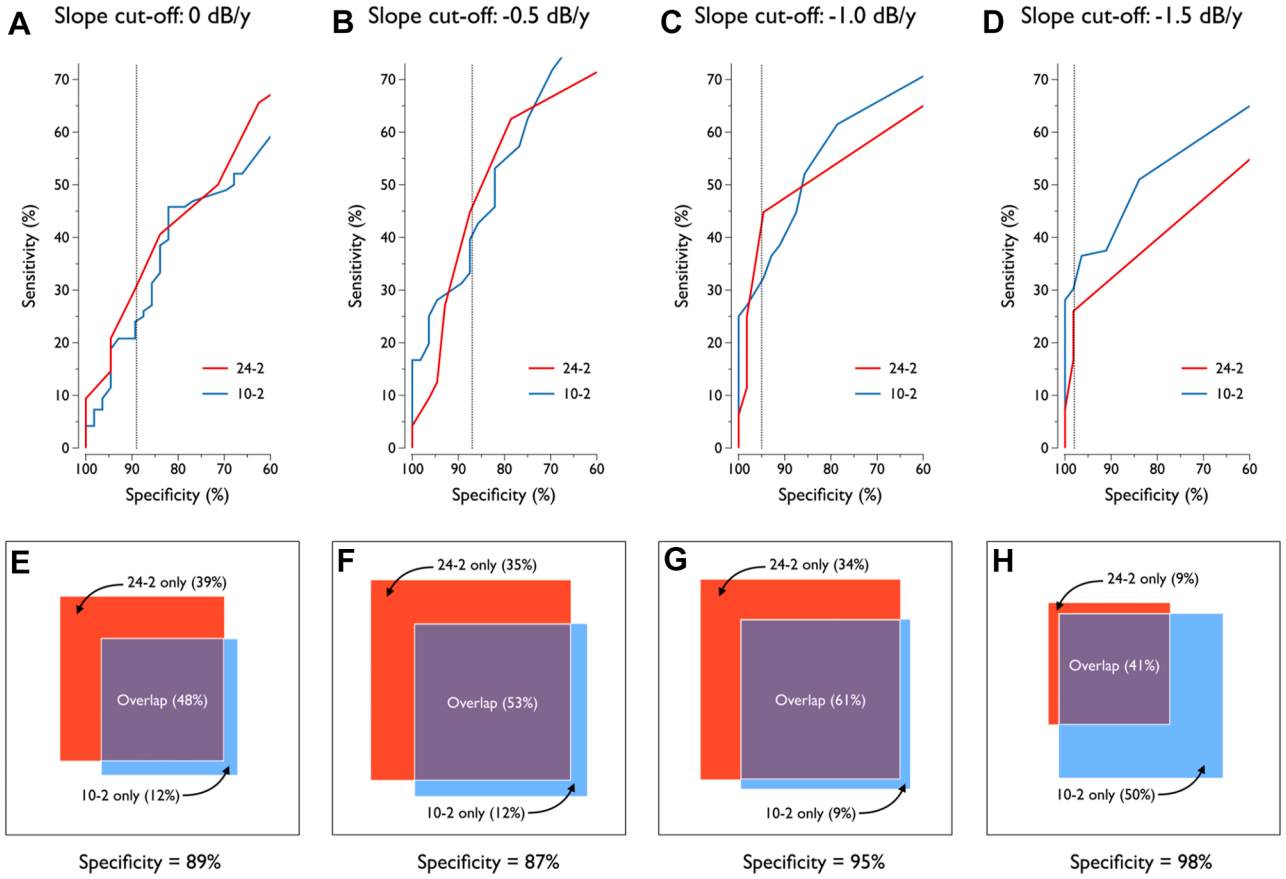


Figure 4. **A**–**D**, Graphs showing receiver operating characteristics curves of the 24-2 and 10-2 tests for the number of test locations with pointwise total deviation shown for cutoff slopes of 0 dB/year (**A**), −0.5 dB/year (**B**), −1.0 dB/year (**C**), and −1.5 dB/year (**D**) required for the visual field to be classified as progressing. Dashed lines indicate specificity values as close as possible to 90% that were identical for each test to compute the overlap in patients with glaucoma classified as progressing with both tests. **E**–**H**, Corresponding area-proportional Venn diagrams showing the overlap at the corresponding specificities in addition to those classified as progressing with only 1 of the tests. Outside boxes show the total glaucoma population.

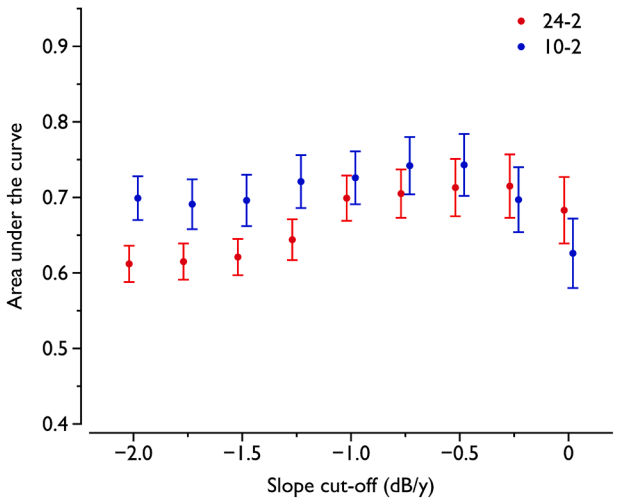


Figure 5. Graph showing the area under the receiver operating characteristic curve for the 24-2 and 10-2 tests for the number of test locations with the full range of pointwise total deviation cutoff slopes.

The ROC curves for TD slope cutoff values of 0 dB/year, −0.5 dB/year, −1.0 dB/year, and −1.5 dB/year are shown in Figure 4. Unlike analyses of MD_{12} and $MD_{10\text{-}2}$ slopes, no cutoff values (expressed as the number of locations showing significant change with the various slope cutoff values) yielded the same specificity for the 2 tests for all slope values. Matched specificity ranged from 82% to 98% (Fig 4), and between 41% and 61% of patients classified as showing progression with either test were identified by both (Fig 4).

The AUC values for all pointwise TD slope values are shown in Figure 5 and indicate that for both tests, criteria based on a cutoff of −0.5 dB/year yielded the highest AUC. The AUC values for cutoffs of −1.0 dB/year or more (less steep) were not different between the 2 tests ($P > 0.12$); however, the differences were statistically significant for slopes of −1.25 dB/year or less (steeper), with the 10-2 test showing significantly higher AUC values ($P < 0.02$; Fig 5). At matched specificity and when the TD slope cutoff was −0.5 dB/year, the mean (standard deviation) baseline $MD_{24\text{-}2}$ and $MD_{10\text{-}2}$ values of patients showing progression with only the 10-2 test were −2.38 (1.49) dB and −2.72 (1.76) dB. At matched

specificity and when the slope cutoff was −1.5 dB/year, the respective values were −3.50 (1.98) dB and −5.92 (3.91) dB. No significant difference was found in the baseline MD_{24-2} ($P = 0.23$) for these 2 progression criteria; however, it was significant for baseline MD_{10-2} ($P = 0.02$), indicating that patients with faster pointwise progression in the central visual field showed relatively worse baseline central visual field loss.

Discussion

Ample evidence exists indicating that visual field testing is conducted less frequently than by standards recommended for reliably detecting visual field progression.[14,15] The lack of adequate visual field data to assess progression means a possibility exists that clinicians may not make optimal decisions, such as escalating treatment to reduce the rate of disease progression. Performing tests, such as the 10-2 test, in addition to the most commonly used 24-2 test, requires additional time and financial resources. Given that there is already a paucity of 24-2 test results available to the clinician, convincing evidence of the value and benefit of other visual field tests must exist, even in a selected population of patients with glaucoma.

We conducted this study to determine whether the 10-2 test showed a clear advantage for detecting central visual field progression compared with the 24-2 test. We performed global, sectoral, and pointwise analyses. For the most part, the 2 tests showed comparable performance; however, we showed benefit of the 10-2 test in pointwise analysis of those patients with fast progression. Furthermore, these patients who benefited from follow-up with the 10-2 test showed relatively worse central visual field loss.

Previous studies comparing visual field progression with the 24-2 and 10-2 tests usually did not follow up healthy control participants; therefore, false-positive rates of progression could not be estimated to contrast with progression rates in patients with glaucoma.[10,12] Although OCT test results were not part of the inclusion criteria, we performed post hoc analyses to ensure that healthy participants showed normal structural findings at baseline. At baseline, 2 healthy participants (3.6%) and 1 healthy participant (1.8%) had a borderline and outside normal limits RNFL thickness classification, respectively, whereas the remainder had a within normal limits classification. By the definition of normative limits cutoffs, 5% and 1% of the healthy population would be expected to have a borderline and outside normal limits classification, respectively. Furthermore, 1 participant with a borderline RNFL thickness classification at baseline showed GHT findings outside normal limits in the third test of the series, but the findings were within normal limits for all remaining 11 follow-up tests. The other participant with a borderline RNFL thickness classification at baseline showed within normal limits GHT findings for all 14 follow-up tests, and the participant with an outside normal limits RNFL thickness classification at baseline showed within normal limits GHT findings for all 6 follow-up tests.

In their study, Hood et al,[13] who followed up healthy participants, reported that the 24-2 test yielded a relatively high rate of false-positive progression findings. In the present study, we followed up a parallel cohort of healthy participants to compare the rates of global and pointwise change with patients with glaucoma as well as to compare the 24-2 and 10-2 tests at fixed specificities for a range of cutoff values in global, sectoral, and pointwise analyses.

Choosing a suitable external reference standard for progression against which the relative value of the 24-2 and 10-2 tests can be estimated is problematic. One option is to use a structural marker of progression such as changes in the optic nerve head, retinal nerve fiber layer, or macular ganglion cell layer; however, established evidence is available now showing that structural and functional changes are asynchronous, in both temporal and topographical correspondence,[16–19] making this option less than optimal. Another approach is using simulated data to generate a template for test–retest variability on which empiric changes can be determined.[20,21] This option assumes modelling of real variability based on general response characteristics (e.g., increasing standard deviation of threshold values as visual field damage increases), applied to all participants. Such an approach may not be accurate given the complex factors that govern variability in individuals. We elected to use separation of patients with glaucoma and healthy control participants as the metric for diagnostic performance. The advantage of this approach is that it did not rely on an external reference standard, but instead assumed that a better separation between the 2 groups equated to superior diagnostic performance.

Although the distribution of MD_{12} and MD_{10-2} slopes in patients with glaucoma was shifted significantly toward more negative values compared with those of healthy participants, significant overlap was present. These findings suggest that in many treated patients with glaucoma, MD rates are comparable with those of healthy participants and are in accordance with previous findings from our own research and that of others.[1,22,23] The overlap in the MD_{12} and MD_{10-2} slopes between the 2 groups resulted in ROC curves with relatively low AUCs (Fig 2A). The relatively low AUC values also could have occurred if progression occurred more rapidly or more frequently outside the central 10°. The overall diagnostic performance would have been higher for both 24-2 and 10-2 tests had the MD distributions been more separated; however, our objective was to compare the AUCs of the 24-2 and 10-2 tests and not determine overall diagnostic performance.

In global and sectoral analysis of MD_{12} and MD_{10-2} slopes, no statistically significant differences in the AUC of the 24-2 and 10-2 tests were found. At fixed (90%) specificity, 53% of patients classified as progressing with global analysis were identified by both tests, with 19% identified with the 24-2 test and 28% with the 10-2. The number of patients identified with both tests in quadrant analysis was

less compared with the global analysis, but because only 3 test locations with the 24-2 test were available for analysis in each quadrant, these results are unsurprising.

In pointwise analysis, the 24-2 and 10-2 tests performed similarly when the cutoff criterion set for test locations showing progression was more positive (shallower) than −1.25 dB/year. In sharp contrast, when the cutoff was more negative (−1.25 dB/year or steeper), a significant difference in the AUC of the 24-2 and 10-2 tests was found, showing benefit of the 10-2 test. Patients showing pointwise progression with only the 10-2 test when the progression criteria were more conservative (i.e., requiring steeper slopes to be classified as progressing) also showed significantly worse baseline $MD_{10\text{-}2}$ compared with those who did not show progression. These findings indicate that the 10-2 test is beneficial for detecting progression in those patients with faster progression and with more severe central visual field loss. Although clinically intuitive, this study provides empirical evidence to support this notion, especially because deterioration of the central visual field is associated frequently with visual disability[24] and may require more forceful clinical intervention.

This study has some limitations. It excluded participants with a refractive error exceeding 6 D. Because patients with glaucoma with high myopia can demonstrate additional paracentral visual field defects,[25] the findings may not be applicable to the progression patterns in patients with high myopia and glaucoma, or indeed participants with high myopia but without glaucoma who show central visual field progression.[26,27] For inclusion in the study, patients with glaucoma had to have an abnormal 24-2 test result, but no criteria for the 10-2 test were applied. Because 10-2 tests are not performed routinely, there is possibility of a selection bias that excluded patients with abnormal 10-2 test results, but with normal 24-2 test results, limiting the generalizability of our findings. For the same reasons, it is plausible, although unlikely, that participants may have been recruited incorrectly as healthy control participants. Patients with glaucoma showed early visual field damage, with a median $MD_{24\text{-}2}$ and $MD_{10\text{-}2}$ of −2.18 dB and −1.78 dB, respectively. Stronger evidence for the value of the 10-2 test may have been possible if patients with more advanced visual field damage or more patients with preferential central visual field loss were included. More patients with glaucoma were included compared with healthy participants. Furthermore, patients with glaucoma underwent a median of 2 more pairs of tests and had a slightly longer follow-up (4.69 years compared with 4.49 years) compared with healthy control participants. The study was impacted significantly by the coronavirus disease 2019 pandemic when visits to the hospital were restricted on several occasions, especially for healthy participants, resulting in a skew in the distribution toward lower values of both the follow-up and number of tests compared with patients with glaucoma (Table 1). The varying number of tests could have affected the precision of slope estimates among study participants; however, because paired comparisons within participants were always made, the findings are unlikely to be impacted. Although we included only the central 12 locations of the 24-2 test to make a fair comparison with the 10-2 test, the visual field information of the 2 areas may not have been fully comparable because of the manner in which thresholds are derived. Because the Swedish Interactive Threshold Algorithm uses information from neighboring locations,[28] it is possible that test locations outside the central 10° of the 24-2 test may have influenced the final sensitivity of the peripheral test locations of the 24-2 test used in the analysis. Finally, recent studies show that the 24-2C test, which adds 10 additional test locations in the central 10°, improves the detection of central visual field defects compared with the 24-2 test.[29] Whether the 24-2C test can provide a suitable combination for the 24-2 and 10-2 test patterns remains to be seen in longitudinal studies. The 24-2C test was not available when the current study commenced.

In conclusion, in this longitudinal prospective study, which controlled for specificity with a parallel cohort of healthy control participants, we showed a comparable ability of the 24-2 and 10-2 tests to show glaucomatous visual field progression in global and quadrant analyses. In pointwise analysis, similar performance was noted when progression was defined by slope cutoffs that were −1 dB/year or shallower; however, for steeper slope cutoffs (−1.25 dB/year or steeper), a clear separation between the 2 tests was noted. Patients showing progression only with the 10-2 test demonstrated worse baseline $MD_{10\text{-}2}$. Although our findings do not support the widespread use of the 10-2 test to follow up patients with glaucoma, they provide evidence that the 10-2 test could be valuable for following up patients with more preferential central visual field loss and who are at a higher risk of faster central visual field progression.

Footnotes and Disclosures

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Author contributions

Conception and design: Tomita, Chauhan

Analysis and interpretation: Tomita, Salh, Chauhan

Data collection: Dyachok, West, Sharpe, Rafuse, Shuba, Nicolela

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Abbreviations and Acronyms:
AUC = area under the receiver operating characteristic curve; **D** = diopter; **IQR** = interquartile range; **MD** = mean deviation; $\mathbf{MD_{10\text{-}2}}$ = mean deviation of the 10-2 test; $\mathbf{MD_{12}}$ = mean deviation of the central 12 test locations of the 24-2 test; $\mathbf{MD_{24\text{-}2}}$ = mean deviation of the 24-2 test; **RNFL** = retinal nerve fiber layer; **ROC** = receiver operating characteristic; **TD** = total deviation.

Keywords:
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References

1. Giammaria S, Hutchison DM, Rafuse PE, et al. Rates of visual field change in patients with glaucoma and healthy individuals: findings from a median 25-year follow-up. *JAMA Ophthalmol*. 2022;140(5):504–511.
2. Medeiros FA, Jammal AA. Validation of rates of mean deviation change as clinically relevant end points for glaucoma progression. *Ophthalmology*. 2023;130(5):469–477.
3. Yu M, Lin C, Weinreb RN, et al. Risk of visual field progression in glaucoma patients with progressive retinal nerve fiber layer thinning: a 5-year prospective study. *Ophthalmology*. 2016;123(6):1201–1210.
4. Curcio CA, Allen KA. Topography of ganglion cells in human retina. *J Comp Neurol*. 1990;300(1):5–25.
5. West ME, Sharpe GP, Hutchison DM, et al. Value of 10-2 visual field testing in glaucoma patients with early 24-2 visual field loss. *Ophthalmology*. 2021;128(4):545–553.
6. De Moraes CG, Hood DC, Thenappan A, et al. 24-2 visual fields miss central defects shown on 10-2 tests in glaucoma suspects, ocular hypertensives, and early glaucoma. *Ophthalmology*. 2017;124(10):1449–1456.
7. WuDunn D, Takusagawa HL, Rosdahl JA, et al. Central visual field testing in early glaucoma: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2024;131(2):240–248.
8. Traynis I, De Moraes CG, Raza AS, et al. Prevalence and nature of early glaucomatous defects in the central 10° of the visual field. *JAMA Ophthalmol*. 2014;132(3):291–297.
9. Orbach A, Ang GS, Camp AS, et al. Qualitative evaluation of the 10-2 and 24-2 visual field tests for detecting central visual field abnormalities in glaucoma. *Am J Ophthalmol*. 2021;229:26–33.
10. Rao HL, Begum VU, Khadka D, et al. Comparing glaucoma progression on 24-2 and 10-2 visual field examinations. *PLoS One*. 2015;10(5):e0127233.
11. Park SC, Kung Y, Su D, et al. Parafoveal scotoma progression in glaucoma: Humphrey 10-2 versus 24-2 visual field analysis. *Ophthalmology*. 2013;120(8):1546–1550.
12. Wu Z, Medeiros FA, Weinreb RN, et al. Comparing 10-2 and 24-2 visual fields for detecting progressive central visual loss in glaucoma eyes with early central abnormalities. *Ophthalmol Glaucoma*. 2019;2(2):95–102.
13. Hood DC, La Bruna S, Tsamis E, et al. The 24-2 visual field guided progression analysis can miss the progression of glaucomatous damage of the macula seen using OCT. *Ophthalmol Glaucoma*. 2022;5(6):614–627.
14. Fung SS, Lemer C, Russell RA, et al. Are practical recommendations practiced? A national multi-centre cross-sectional study on frequency of visual field testing in glaucoma. *Br J Ophthalmol*. 2013;97(7):843–847.
15. Stagg BC, Stein JD, Medeiros FA, et al. The frequency of visual field testing in a US nationwide cohort of individuals with open-angle glaucoma. *Ophthalmol Glaucoma*. 2022;5(6):587–593.
16. Abe RY, Diniz-Filho A, Zangwill LM, et al. The relative odds of progressing by structural and functional tests in glaucoma. *Invest Ophthalmol Vis Sci*. 2016;57(9):Oct421–OCT428.
17. Alencar LM, Zangwill LM, Weinreb RN, et al. Agreement for detecting glaucoma progression with the GDx guided progression analysis, automated perimetry, and optic disc photography. *Ophthalmology*. 2010;117(3):462–470.
18. Artes PH, Chauhan BC. Longitudinal changes in the visual field and optic disc in glaucoma. *Prog Retin Eye Res*. 2005;24(3):333–354.
19. Mohammadzadeh V, Rabiolo A, Fu Q, et al. Longitudinal macular structure-function relationships in glaucoma. *Ophthalmology*. 2020;127(7):888–900.
20. Spry PG, Johnson CA, Bates AB, et al. Spatial and temporal processing of threshold data for detection of progressive glaucomatous visual field loss. *Arch Ophthalmol*. 2002;120(2):173–180.
21. Asaoka R, Nakamura M, Tanito M, et al. Short-term assessment of glaucoma progression in clinical trials using trend-based visual field progression analysis. *Ophthalmol Sci*. 2025;5(2):100656.
22. Jammal AA, Thompson AC, Mariottoni EB, et al. Rates of glaucomatous structural and functional change from a large clinical population: the Duke Glaucoma Registry Study. *Am J Ophthalmol*. 2021;222:238–247.
23. Chauhan BC, Malik R, Shuba LM, et al. Rates of glaucomatous visual field change in a large clinical population. *Invest Ophthalmol Vis Sci*. 2014;55(7):4135–4143.
24. Sumi I, Shirato S, Matsumoto S, Araie M. The relationship between visual disability and visual field in patients with glaucoma. *Ophthalmology*. 2003;110(2):332–339.
25. Kimura Y, Hangai M, Morooka S, et al. Retinal nerve fiber layer defects in highly myopic eyes with early glaucoma. *Invest Ophthalmol Vis Sci*. 2012;53(10):6472–6478.

26. Ohno-Matsui K, Shimada N, Yasuzumi K, et al. Long-term development of significant visual field defects in highly myopic eyes. *Am J Ophthalmol*. 2011;152(2):256–265.e1.
27. Lin F, Chen S, Song Y, et al. Classification of visual field abnormalities in highly myopic eyes without pathologic change. *Ophthalmology*. 2022;129(7):803–812.
28. Bengtsson B, Olsson J, Heijl A, Rootzén H. A new generation of algorithms for computerized threshold perimetry, SITA. *Acta Ophthalmol Scand*. 1997;75(4):368–375.
29. Nishijima E, Fukai K, Sano K, et al. Comparative analysis of 24-2C, 24-2, and 10-2 visual field tests for detecting mild-stage glaucoma with central visual field defects. *Am J Ophthalmol*. 2024;268:275–284.