Precis: Using standard glaucoma structural and functional tests, clinicians accurately predicted the presence/absence of 10-2 glaucomatous visual field (VF) loss in 90% of the eyes in this study.

Purpose: To investigate how well clinicians with variable experience can predict the presence and location of 10-2 VF loss using structural and functional data that are routinely obtained for glaucoma assessment.

Methods: Within a test set of 416 eyes (210 subjects) who were diagnosed glaucoma suspect or primary open-angle glaucoma (with most eyes having mild disease), 6 clinicians were asked to predict the presence and hemispheric location of 10-2 VF loss using 24-2 VF and spectral-domain optical coherence tomography structural data. Prediction accuracies were calculated for each clinician and compared using the weighted k-statistic. Receiver operating characteristic analyses were used to evaluate models for predicting 10-2 VF loss.

Results: Among the 6 clinicians, mean (range) accuracy, false negatives, and false positives for predicting presence/absence of 10-2 VF loss were 90% (87% to 92%), 4.7% (2.4% to 7.0%), and 5.4% (1.7% to 7.5%) respectively. The mean (range) weighted k-statistic was 0.75 (0.64 to 0.83), suggesting good or very good inter-rater agreement between examiners. Mean accuracy for correctly predicting hemispheric location was 73% (range, 65% to 82%) with the most common error occurring in eyes with both superior and inferior 10-2 VF defects in which one hemisphere was correctly identified but the other missed.

Conclusions: In this study, the presence/absence of 10-2 glaucomatous VF loss was highly predictable using standard functional and structural clinical metrics. These findings suggest that 10-2 VF testing is not needed to reliably recognize and confirm central VF involvement in most eyes with glaucoma. Whether error related to identifying second hemisphere involvement in 10-2 VF loss is important requires further study.

Key Words: glaucoma, visual field, 10-2

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Automated achromatic threshold perimetry has served as a durable cornerstone of glaucoma-related patient care for over 4 decades and remains the standard of care for visual field (VF) measurement in glaucoma. The most commonly used VF testing methodology uses a grid of test points, spaced ~6 degrees apart, which is centered on fixation and extends 24 to 30 degrees in each direction (24-2 test pattern). By using various thresholding algorithms to determine relative visual sensitivity for each of the grid’s test locations, this testing approach has been shown to provide valid measurements of glaucomatous VF loss, thereby offering critical data for aiding diagnosis, monitoring progression, informing disease staging, and guiding treatment decisions.

Despite the crucial role of the 24-2 test in glaucoma care, however, research shows that the 24-2 test can underestimate glaucomatous VF compromise, particularly within the central VF region. Some studies have shown that measurement of the central VF using a dense grid of test points concentrated in the central 10 degrees (10-2 pattern) may provide advantages for characterizing the presence, size, depth, and shape of central glaucomatous VF defects when compared with the 24-2 VF test pattern.

Glaucomatous VF loss involving the central field has been found to adversely impact vision-related quality of life and has long been used for glaucoma staging and treatment intensity decisions. Moreover, central visual field loss has been associated with faster rates of VF progression, thereby providing insight into degree of ongoing risk. Accordingly, identification of central VF loss is clinically important and because the 10-2 test may offer advantages for characterizing central VF loss, it is hypothesized that this test may provide unique value for exposing central VF loss. However, adding 10-2 VF testing to the standard testing protocol also has disadvantages, particularly regarding the substantial time and cost burdens that are placed on patients, practices, providers, and payers. For example, integrating an extra VF test into an already substantial glaucoma baseline workup protocol necessitates strategic scheduling, time dedicated to the testing and its interpretation, and processes geared to appropriate medical record documentation and claim processing by payers. In addition, interpretation of the 10-2 VF test can be more challenging for providers because statistical analysis tools are not as readily available for the 10-2 versus the 24-2 VF test strategy. And because questions persist about how much added value the 10-2 VF test offers compared with the 24-2 test, the determination about whether 10-2 VF testing should be included in the standard baseline glaucoma testing protocol remains unclear.

These conditions have led to interest about whether 10-2 VF test results might be clinically predictable as such capability would simultaneously offer the benefits of 10-2 VF testing and possibly reduce some of its drawbacks.
testing while avoiding its associated burdens. In prior studies on this general topic, investigators have evaluated relationships between central glaucomatous VF loss and various prognostic factors including sensitivity of central 10-degree test points on the 24-2 VF test, the addition of new central VF points to the 24-2 VF test, and spectral-domain optical coherence tomography (SD-OCT) measurements of inner-retinal macular thickness and peripapillary retinal nerve fiber layer (RNFL) thickness.

Although all of these studies describe important inter-relationships between central VF loss and the studied parameters, only modest accuracy for predicting 10-2 VF loss was achieved in any of the studies. Moreover, none of the studies used protocols specifically requiring clinicians to analyze and predict central 10-2 VF loss using standard clinical data, thereby simulating what might occur in clinical practice. Specifically, none of these studies simultaneously evaluated the combination of 24-2 VF testing, SD-OCT RNFL thickness, and SD-OCT inner-retinal macular thickness, which are commonly used together for glaucoma evaluation in the current era.

This study was therefore designed to explore how well a group of clinicians (both experienced and inexperienced) could accurately predict the presence and location of 10-2 VF loss using structural (SD-OCT) and functional (24-2 VF) data that are already obtained as part of baseline glaucoma assessment. The primary study hypothesis was that clinicians would be capable of accurately predicting the presence/absence of 10-2 VF loss in most eyes using the combination of 24-2 VF, RNFL, and inner-macular thickness data, thereby providing aid to glaucoma decision making without the burden of additional 10-2 VF testing.

**MATERIALS AND METHODS**

This study adhered to the tenets of the Declaration of Helsinki, conformed to health insurance portability and accountability act regulations, and was approved by the Albuquerque Veterans Administration Medical Center Institutional Review Board. All case subjects for this observational investigation were participating in a prospective, longitudinal glaucoma research study, and each provided informed consent before study participation. For the case analysis and 10-2 VF loss prediction components, 2 attending staff and 4 residents who were also coinvestigators in our longitudinal study agreed before study participation. For the case analysis and 10-2 VF test points on the pattern deviation (PD) plot at P<0.05 and at least 1 at P<0.01, not including points on the edge of the field. For the 10-2 test, VF loss was defined as a cluster of at least 3 contiguous abnormal points in the superior or inferior hemifield flagged at either the 5%, 5%, and 1% level or the 5%, 2%, and 2% level on the total and/or PD plots. All 24-2 and 10-2 VF defects were required to be reproducible on at least 3 consecutive tests and demonstrate congruent structural irregularity.

**Structural Testing**

SD-OCT was used to acquire standard 3.4-mm circum-papillary RNFL scans in both eyes of each subject, and images with poor centration, segmentation errors, and scan quality <15 were excluded. Sectors thinner than the 95% confidence interval limit were considered abnormal. We also obtained SD-OCT macular scans for each eye using the posterior pole asymmetry analysis (PPAA) protocol. Post image acquisition, each of the 61 raster scans was reviewed by one of the authors for centration and segmentation errors that were manually repaired when needed. PPAA abnormality for each eye was ascertained using intraeye hemispheric asymmetry ≥10 µm in conjunction with a subjective review of its heatmap output. PPAA scans were also used to create ganglion cell layer (GCL) maps using the SD-OCT instrument’s proprietary segmentation software. Each map was constructed from circle diameters of 1.3 and 6 mm resulting in 1 central, 4 inner, and 4 outer GCL thickness sectors. Although these instrument-defined sectors are not designed to specifically correspond with glaucoma-related compromise, this approach enabled the generation of inner-retina heat maps that are analogous to commercially available output on other SD-OCT instruments that are commonly used in clinical care. To further enhance the utility of this GCL information for 10-2 VF loss prediction, we also developed cut-point values for all 9 GCL sectors using data from 52 age-matched normal controls (normal visual fields, IOP, optic nerves, and SD-OCT scans) with a thin sector conjunction with concomitant SD-OCT findings and corresponding glaucomatous VF loss on 24-2 and/or 10-2 VF tests in at least one eye. IOP was not used as a diagnostic criterion for POAG. Diagnostic criteria for GS required IOP ≥22 mm Hg on at least one occasion and/or an optic nerve appearance that was suspicious for glaucoma in at least one eye in conjunction with the lack of repeatable 24-2 or 10-2 VF loss in either eye.

We excluded eyes with best-corrected distance visual acuity <20/30 (Snellen) and eyes with significant cataract, defined by cataract exceeding grade 2 nuclear sclerosis or cortical cataract as defined by the LOCS III criteria or any amount of posterior subcapsular cataract. In addition, eyes were excluded if there was clinical evidence of macular disease (eg, drusen, pigment disruption, edema, partial or full-thickness hole, epiretinal membrane, vitreo-macular traction) whether detected with dilated fundoscopy or with SD-OCT imaging.

**VF Testing**

The Humphrey Visual Field Analyzer II (Carl Zeiss Meditec, Dublin, CA) was used to obtain threshold achromatic 24-2 and 10-2 VF tests on alternating visits. We used optimal near-point correction during testing, adding +3.00 or +3.25 diopter sphere (depending on trial lens availability) over the patient’s distance subjective refractive error. All VF tests were required to meet reliability criteria (false positives <15%; false negatives <33%; fixation losses <33% unless gaze-tracking demonstrated steady fixation). Minimum criteria for 24-2 glaucomatous VF loss included glaucoma hemifield test result outside normal limits and/or the presence of at least 3 contiguous test points on the pattern deviation (PD) plot at P<0.01 and at least 1 at P<0.05, not including points on the edge of the field. For the 10-2 test, VF loss was defined as a cluster of at least 3 contiguous abnormal points in the superior or inferior hemifield flagged at either the 5%, 5%, and 1% level or the 5%, 2%, and 2% level on the total and/or PD plots. All 24-2 and 10-2 VF defects were required to be reproducible on at least 3 consecutive tests and demonstrate congruent structural irregularity.
defined as a value lower than the 95% confidence interval limit defined for that sector (see Fig. 3). Determination of GCL abnormality was at the discretion of each clinician examiner.

Procedure for Predicting the Presence and Location of 10-2 VF Loss

Six clinicians [1 with 26 y (D.P.), 1 with 9 y (S.K.), and 4 (N.C., M.H., H.K., B.K.) with 9 mo of clinical experience] were first provided a training set consisting of 20 cases that demonstrated structure/function relationships between the following 5 data items: 24-2 VF test, 10-2 VF test, RNFL output report, PPAA output map, and GCL output map for each eye. See Figures 1–7 for a training case example. Clinicians were directed to focus on structure/function relationships between global 24-2 VF sensitivity, central 10-degree sensitivity on 24-2 VF tests, regions of thin RNFL, regions of thin GCL, and regions of relative thinning on PPAA maps. After each clinician was satisfied with their evaluation of the training set, the de-identified test set was provided and each clinician was asked to predict the presence and location (superior vs. inferior vs. both hemispheres) of 10-2 VF loss for all eyes using 24-2 VF, RNFL, PPAA, and GCL data. No time limit was prescribed, and all answers were independently recorded by each clinician examiner on separate spreadsheets.

Diagnostic accuracy, false positives, and false negatives were calculated for each clinician and compared using receiver operating characteristic (ROC) analyses. Diagnostic agreement between clinicians was computed by weighted κ-statistic (κ). Within this system, a k-value <0.20 suggests poor agreement, 0.21 to 0.40 suggests fair agreement, 0.41 to 0.60 suggests moderate agreement, 0.61 to 0.80 suggests good agreement, and 0.81 to 1.00 suggests very good agreement. To investigate the associations between 10-2 VF loss and corresponding structural and functional data, ROC analyses were used to investigate various models for predicting the presence/absence of 10-2 VF loss. Statistical significance was defined as $P<0.05$, and all statistical analyses were performed using MedCalc (MedCalc, Ostend, Belgium, V.12.4.0.0).

RESULTS

The test set included 416 eyes from 210 subjects (128 POAG, 82 GS). Repeatable 24-2 VF loss was present in 181 of 416 (43%) eyes with median (IQR) mean deviation (MD) equal to $-0.69$ ($-2.63$ to $0.34$) dB. Overall, 380 (91%) eyes had 24-2 MD better than $-6.00$ dB, whereas 21 of 416 (5%) eyes had MD between $-6.00$ and $-12.00$ dB, and 15 of 416 (4%) eyes had MD worse than $-12.00$ dB. Concurrently, repeatable 10-2 VF loss was present in 145 of 416 (35%) eyes and median (IQR) MD for the 10-2 VF test was $-0.68$ ($-2.65$ to $0.32$) dB. Most eyes ($n=379$) had 10-2 MD better than $-6.00$ dB, whereas 21 eyes had MD between $-6.00$ and $-12.00$ dB and 16 eyes had MD worse than $-12.00$ dB. There were 10 eyes with 10-2 VF loss but no 24-2 VF loss, 46 eyes with 24-2 VF loss but no 10-2 VF loss, and 135 eyes with both 24-2 and 10-2 VF loss. Additional descriptive characteristics for the test subjects are shown in Table 1.
Among the 6 clinician examiners, the mean number of correct answers for predicting the presence/absence of 10-2 VF loss was 373 of 416 (90% accuracy; range, 87% to 92%). False-negative rates (under-call error) ranged from 2.4% to 7.0%, with an average of 4.9%, and false-positive rates (over-call error) ranged from 1.7% to 7.5%, with an average of 5.4% (see Table 2). At least 4 of the 6 clinician examiners correctly identified 375 of 416 (90%) eyes, with all 6 agreeing on the presence/absence of 10-2 VF loss in 303/416 (73%) eyes. There were 13 of 416 (3%) eyes in which none or only one of the clinician examiners correctly identified whether 10-2 VF loss was present or absent. When the sample was stratified by 24-2 MD, clinician examiners more accurately predicted 10-2 VF loss in eyes with 24-2 MD worse than −6.00 dB (96% correct) versus eyes with 24-2 MD better than −6.00 dB (88% correct, Kruskal-Wallis test, \( P = 0.007 \)).

Weighted \( \kappa \)-statistic (k) for the group of raters was 0.75 on average with a range of 0.64 to 0.83, suggesting good or very good inter-rater agreement between all examiners (see Table 3). We also compared inter-rater diagnostic performance using ROC analyses and area under the curve (AUROC) showed only minor diagnostic performance differences between examiners with AUROC ranging from 0.854 to 0.916 (mean AUROC = 0.887).

Of the 145 eyes with reproducible 10-2 VF defects, 39 had superior, 45 had inferior, and 61 had both superior and inferior defects for a total of 206 hemispheric 10-2 VF defects. The mean number of correct hemispheric VF loss predictions across all 6 raters was 73% (range, 65% to 82%). There were 12% false-positive errors (identifying a 10-2 VF location when there was no 10-2 VF defect), 10% false-negative errors (failure to identify the presence and therefore the location of a 10-2 VF defect), and 16% partial false-negative errors in which...
one hemisphere was correctly identified but the other missed in eyes with both superior and inferior 10-2 VF defects. There were only 8 total instances (<1% error rate) in which a 10-2 VF defect was correctly predicted but assigned an erroneous location (eg, a superior VF defect was present but predicted as being an inferior VF defect).

In ROC analyses focused on factors associated with 10-2 VF loss, results for all 5 individual data items (24-2 VF, central points on 24-2 VF, RNFL thickness, GCL thickness, and PPAA) were significantly related to the presence/absence of 10-2 VF loss, with AUROC ranging from 0.675 to 0.887 (all \( P < 0.001 \)). When parameters were combined, predictive capability improved with the highest predictive capability found for eyes with 3 or more abnormal test elements (AUC = 0.910; sensitivity = 98%; specificity = 84%) and for eyes demonstrating 24-2 VF loss with concurrent abnormal repeated central 10-degree points (AUC = 0.908; sensitivity = 88%; specificity = 94%). See Table 2. Only 3 of 238 eyes with 2 or fewer abnormal test elements and only 1 of 187 eyes with normal RNFL thickness demonstrated 10-2 VF loss in this study.

**DISCUSSION**

Clinicians in this study accurately predicted the presence/absence of 10-2 VF loss in 9 of every 10 eyes using structural and functional data that are routinely obtained for glaucoma assessment. This high rate of precision is particularly notable because it was achieved in a sample characterized by the overall mild severity of glaucomatous disease. In addition, our results showed similar diagnostic prediction capabilities between the more- and less-experienced clinician examiners in the study. Although the clinical training of each of these clinicians included instruction on standard structure/function relationships in glaucoma, there was no study-specific coaching given to the clinician examiners and thus the high level of realized accuracy should be broadly achievable across clinicians of varying experience levels. Accordingly, these results imply that the presence of central visual field loss as manifest on the 10-2 VF test is largely predictable and that this information can be clinically used to reliably inform risk assessment and disease management.

In studies directly comparing 24-2 and 10-2 PD parameters for identification of central VF loss, results suggest that both tests detect central VF loss at similar rates when controlling for specificity.\(^{21,22,23}\) This study’s results align with these prior reports, as we found that glaucomatous 24-2 VF loss that included abnormalities in the central 12 points (central 10 degrees) had good sensitivity (88%) with high specificity (only 6% false positives) for detecting 10-2 VF loss. We also found that any combination of 3 or more abnormal parameters was very sensitive (98%) for predicting 10-2 VF loss, though with a false-positive rate of 16%. Because 3 of the 5 study parameters directly correspond to central function or structure (abnormal central points on the 24-2 VF test, PPAA, and macular GCL thickness), most combinations of 3 items will include both structural and functional central abnormalities that may help explain the strength of this indicator.\(^{39}\) This result may also correspond with a recent report by Hood et al\(^ {40} \) in which a combined structure/function parameter was found to have improved sensitivity for detecting central damage versus using a functional parameter in isolation.

Although this study’s findings indicate that 10-2 VF testing is not generally required to confirm central damage, we did find that clinicians were less accurate (73% precision) when asked to predict the location of 10-2 VF loss. False-negative predictions were the predominant type of error, occurring primarily when clinicians failed to predict the existence of 10-2 VF loss (and therefore also failed to identify VF loss location) and most often occurred when clinicians failed to identify second hemisphere involvement in eyes harboring both superior and inferior 10-2 VF defects. Notably, this underestimation of second hemisphere involvement occurred in over half of all eyes that had both superior and inferior 10-2 hemispheric defects (32 of 62 eyes) and implies that severity of 10-2 VF loss was underestimated in this group. This false-negative error rate may have important clinical implications as prior studies have shown that eyes with visual field loss in one hemisphere were significantly related to the presence/absence of 10-2 VF loss, with high specificity (94%).

### TABLE 1. Demographic Characteristics of Test-set Participants Stratified by Diagnosis (N = 210)

|          | POAG (N = 128) | GS (N = 82) | \( P^* \) |
|----------|----------------|-------------|----------|
| Age (y)  | 74.8 (69.5-82.0) | 71.0 (68.2-73.2) | <0.001†  |
| Race, n (%) | 0.18           | 0.18        |
| White    | 66 (52)        | 36 (44)     |
| Hispanic | 45 (35)        | 38 (47)     |
| Black    | 13 (10)        | 6 (7)       |
| Native American | 4 (3) | 2 (2)     |
| Sex, n (%) | 0.55           |             |
| Male     | 123 (96)       | 79 (96)     |
| Female   | 5 (4)          | 3 (4)       |

Age values represent median (interquartile range).

| Test type | \( P^* \) |
|-----------|----------|
| GS > POAG | 1.00     |

GS indicates glaucoma suspect; OH, ocular hypertension; POAG, primary open-angle glaucoma.
field loss involving both superior and inferior hemispheres exhibit greater rates of progression when compared with eyes with VF defects in only one hemisphere.\(^4\) Moreover, diffuse 10-2 VF loss involving both hemispheres has been associated with worsened vision-related quality of life scores when compared with eyes with only one hemisphere of VF loss.\(^5\) Accordingly, the use of vision-related quality of life scores when compared with eyes involving both hemispheres has been associated with worsened clinical implications of this finding. To better understand this study’s prediction errors, we also identified a subset of 21 of 416 (5%) eyes that were correctly predicted by less than half of the raters (no correct predictions in 5 eyes, one correct prediction in 8 eyes, and 2 correct predictions in 8 eyes). Among these 21 eyes, 10-2 VF loss was present in 13 eyes and absent in 8 eyes. Interestingly, the SD-OCT findings in the 13 eyes with 10-2 VF loss were characterized by mild structural damage, which likely contributes to the under-call of 10-2 VF loss in this group of eyes. Furthermore, 7 of these 13 eyes had no 24-2 VF loss.

As only 10 eyes in the entire study sample had 10-2 VF loss without 24-2 VF loss and only 3 of 10 were accurately predicted by the clinician examiners, the implication is that lack of 24-2 VF loss represents a significant barrier for predicting 10-2 VF loss. Conversely, structural damage shown on SD-OCT imaging was rather advanced in the 8 eyes without 10-2 VF loss, which likely explains why these eyes were falsely predicted to harbor 10-2 VF loss. Interestingly, the severity of 24-2 VF loss did not seem to contribute to this error as the mean 24-2 and 10-2 MD (\(-1.72 \text{ dB}, -1.34 \text{ dB}\)) in these 8 eyes was similar to the 395 eyes that were correctly predicted by a majority of the clinician examiners (\(-1.95 \text{ dB} \) and \(-2.03 \text{ dB}\)). Taken together, these analyses suggest that structural findings may be misleading in a small subset of cases and that predicting 10-2 VF loss in eyes demonstrating no 24-2 VF loss with only modest structural damage is challenging.

Our findings contribute to understanding the role of 10-2 VF testing in glaucoma management. Although central 10-2 VF testing has a well-recognized role in aiding clinical management of advanced glaucoma, the evidence demonstrating how it improves management and outcomes in early and moderate glaucoma is less clear. Hood and DeMoraes propose that 10-2 VF testing should be considered for all glaucoma or GS patients in which 24-2 VF testing is ordered, particularly in those with abnormal SD-OCT structural findings (macular and/or RNFL thinning consistent with glaucoma) or those with abnormal central points on 24-2 VF testing.\(^4\) The underlying foundations for this broad recommendation include that central VF loss is common across all stages of glaucoma,\(^8\) that the strong structure/function relationship between 10-2 VF sensitivity and OCT macular structural data can provide diagnostic confirmation of glaucoma,\(^10,28,32-36,40\) that some eyes with glaucoma demonstrate 10-2 but not 24-2 VF loss,\(^8\) that central VF loss is an important consideration in determining treatment intensity,\(^5,17,18\) that central VF loss impacts quality of life,\(^13\) and that the denser testing grid of the 10-2 may improve detection of central VF progression. Despite the potential of 10-2 VF testing, however, it has not yet been shown that 10-2 VF testing is more successful than 24-2 VF testing for detecting the presence of central VF loss.\(^8\) And although studies have shown that vision-related quality of life is correlated with 10-2 VF loss, further study is needed to better understand the relative impact and best methods to measure the relationship between central VF loss and quality of life. Regarding the assessment of disease severity, studies show that mean defect values for 24-2 and 10-2 VF tests are well correlated,\(^10,22-25\) and this study’s findings suggest 10-2 VF loss can be accurately predicted without the employment of 10-2 VF testing. In terms of diagnostic confirmation, it has not been shown that 10-2 VF testing significantly improves the ability to diagnose glaucoma, and only small percentages of patients seem to demonstrate 10-2 VF loss in the absence of 24-2 VF loss.\(^8\) And although studies have shown that vision-related quality of life is correlated with 10-2 VF loss, further study is needed to better understand the relative impact and best methods to measure the relationship between central VF loss and quality of life. Regarding the assessment of disease severity, studies show that mean defect values for 24-2 and 10-2 VF tests are well correlated,\(^10,22-25\) and this study’s findings suggest 10-2 mean defect can generally be forecast by 24-2 mean defect. Further, a recent study showed that severity of 10-2 VF loss may be anticipated by the depth of defect within the central 4 24-2 VF points, thereby aiding prediction of which eyes might demonstrate worse 10-2 than 24-2 mean defect.\(^21\) In contrast, this study found that central VF loss severity can be underestimated for some eyes. Finally, although 10-2 VF testing would seem to have significant potential for aiding detection of central VF progression, few studies have yet demonstrated this capability.\(^10,20\) Together, it is apparent that additional study is needed to determine how to best utilize 10-2 VF testing for optimizing glaucoma care.

Strengths of this study include its relatively large test data set, characterized primarily by eyes with early glaucoma and glaucoma suspicion for which prediction of central VF loss is more challenging. To fully validate VF loss status, we also required that VF defects were repeatable on at least 3 consecutive tests for both the 24-2 and 10-2 tests.\(^43\) In addition, the study simulated clinical practice by employing clinicians to predict the presence and location of 10-2 VF loss using standard functional (24-2 VF) and structural (high-quality RNFL and macular thickness) test results. Finally, the study evaluated predictive capability

### TABLE 2. Inter-rater Agreement Comparison Between All 6 Clinician Examiners for Predicting Presence of 10-2 VF Loss

| Examiner 1 | Examiner 2 | Examiner 3 | Examiner 4 | Examiner 5 | Examiner 6 | Average |
|------------|------------|------------|------------|------------|------------|---------|
| Examiner 1 | 73         | 75         | 67         | 82         | 75         | 74      |
| Examiner 2 | 73         | 72         | 71         | 76         | 81         | 75      |
| Examiner 3 | 75         | 72         | 64         | 77         | 74         | 72      |
| Examiner 4 | 67         | 71         | 64         | 72         | 76         | 71      |
| Examiner 5 | 82         | 76         | 77         | 72         | 83         | 77      |
| Examiner 6 | 75         | 81         | 74         | 76         | 83         | 79      |

All values expressed in weighted k (κ) values.

Scoring system to assess strength of agreement:
\[ \kappa = 0.00-0.20: \text{poor}; \kappa = 0.21-0.40: \text{fair}; \kappa = 0.41-0.60: \text{moderate}; \kappa = 0.61-0.80: \text{good}; \kappa = 0.81-1.00: \text{very good}. \]

VF indicates visual field.
between clinicians at various career stages, thereby providing comparative data for clinicians of variable clinical experience.

Limitations of this study include our convenience sample, which was enrolled from our institution’s outpatient clinic. Our sample also did not include eyes with refractive error > 6 diopters, a group that might be more likely to benefit from 10-2 VF testing because of axial myopia effects on imaging characteristics in these eyes. All clinician examiners were also based at our center that may have impacted results because of a common clinical approach to glaucoma assessments. This study also relied on machine-generated SD-OCT output reports, and thus clinicians did not have access to raw anatomic images that were used to develop the output reports. Also, ganglion cell thickness maps were laid out in an early treatment diabetic retinopathy study grid and because we did not have access to normative ranges for this data, we developed our own cut-points using age-matched normal eyes from our longitudinal research study. These inner-macular thickness data were meant to simulate inner-macular thickness output parameters available on currently available commercial instruments, but the data approach we used is nonetheless unique to our study and may not be optimal for predictive purposes. Finally, the study did not investigate the newer VF test grids (eg, 24-2C strategy that adds additional central VF points to the 24-2 test pattern.) Although previous studies suggest the 24-2C may enhance structure/function correlation analyses that might improve diagnostic certainty for some patients, there is no current evidence that shows that the 24-2C test pattern is superior to the 24-2 test pattern for identifying central VF loss. Further focused study is needed to better identify the specific advantages and disadvantages of adding central test points to the standard glaucoma test grid.

CONCLUSION

In summary, this study shows that the presence/absence of 10-2 glaucomatous VF loss is predictable in most eyes with glaucoma, including eyes with early stages of the disease. Specifically, 6 clinicians of varying experience achieved a mean 90% accuracy rate for identifying the presence/absence of 10-2 VF loss using standard functional (24-2 VF) and structural (RNFL and macular thickness) metrics. These findings suggest that 10-2 VF testing is not required to confirm central visual field compromise in most eyes with glaucoma. Despite this overall high level of accuracy, however, we did find a systematic underestimation of second hemifields worse in both superior and inferior 10-2 VF defects. This finding, which implies that underappreciation of central visual field loss can occur in some eyes harboring 10-2 VF loss, requires further study to better understand its clinical implications. Additional research is also needed to better understand how best to accomplish testing of the central VF and what added clinical value 10-2 VF testing may offer with regard to diagnostic accuracy, detection of progression, quality of life, and long-term prognosis in glaucoma.

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