Evaluation of the Results of 24-2C Visual Field Test in Glaucoma Patients

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ABSTRACT

Objective: This study aimed to compare the results of the 24-2C test strategy of the Humphrey Automated Perimetry device with the 24-2 test strategy in terms of its ability to detect central visual field defect (CVFD), test duration, and visual field global indices in glaucoma patients.

Materials and Methods: Visual field tests of a randomly selected eye of 105 glaucoma patients were included in this prospective study. Swedish Interactive Thresholding Algorithm (SITA)-Faster 24-2 and SITA-Faster 24-2C tests were performed on all patients. Test duration, global visual field indices and pattern deviation map results were analyzed.

Results: The SITA-Faster 24-2C test is statistically longer than the SITA-Faster 24-2 test (p=0.014). There was no significant difference in Mean Deviation (MD), Pattern Standard Deviation (PSD), or Visual Field Index (VFI) between the two visual field strategies. There was a statistically significant difference in terms of Glaucoma Hemifield Test (GHT) between the 24-2 grid and 24-2C grid visual field tests (p = 0.0001). Comparing the number of scotomas detected by both test strategies in the 10° central visual field, the 24-2C algorithm detected a significantly higher rate of central scotomas (p=0.017).

Conclusion: Although the 24-2C test was slightly more time-consuming than the 24-2 test, it provided comparable results in terms of global visual field indices and was superior at detecting CVFD.

Keywords: central visual field defect, glaucoma, glaucoma hemifield test, pattern deviation map, visual field.

INTRODUCTION

Glaucoma is a progressive, chronic disease that is the leading cause of permanent vision loss in the world.[1] Intraocular pressure (IOP) is the most significant modifiable risk factor associated with the development and progression of glaucoma.[2] The disease causes a progressive degeneration of retinal ganglion cells, which affects visual function. The goal of the treatment of the disease is to prevent these losses or to delay them as much as possible.

The static automated perimetry (SAP) visual field test is still the most essential assessment for monitoring glaucomatous damage.[3] For many years, the gold standard method in perimetry was the full-threshold automated visual field test, however the long testing period caused eye fatigue and made it difficult to repeat the test at short intervals.[4] Modern techniques have been developed to shorten testing time while maintaining reliability, such as the Swedish Interactive Threshold Algorithm (SITA).[5] Compared to the first model, SITA-Standard, the SITA-Faster algorithm significantly reduces the average test time.[6] The disadvantage of SITA-Faster is that it has a much higher rate of unreliable test results compared to the SITA-Standard algorithm. However, both strategies give

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similar results for many visual field parameters such as visual field index (VFI), glaucoma hemifield test (GHT), foveal threshold.[7]

Currently, 24-2 and 30-2 grids are commonly used to detect glaucomatous visual field defects.[8] However, central visual field defects (CVFD) have been recognized in glaucoma for decades, and the 10-2 visual field is more effective in detecting central scotomas.[9] Evaluation of CVFD is important for several types of glaucoma severity classification methods and, consequently, has implications for treatment adjustments.[10]

Therefore, novel testing strategies have been developed to detect both peripheral and early central scotomas.[11] Recently, the 24-2C has been developed for clinical use on the Humphrey field analyzer (Carl Zeiss Meditec, Dublin, CA), which features 10 additional test locations within the central 10 degrees from fixation, five for each hemifield. The additional points, are not distributed symmetrically across the vertical and horizontal midlines.[5] Another advantage of the 24-2C grid is that it significantly shortens the test time compared to the SITA -Standard method.[12]

In this study, we compared the 24-2 and 24-2C test strategies of the Humphrey Automated Perimetry device in glaucoma patients in terms of testing time, the ability to detect CVFD, and the similarity of the parameters (mean deviation (MD), pattern standard deviation (PSD), GHT, VFI) that we use in glaucoma follow-up.

MATERIALS and METHODS

Written informed consent was obtained from all patients participating in this prospective, cross-sectional study. The investigation adhered to the principles of the Helsinki Declaration and was approved by the ethics committee of Haydarpaşa Numune Training and Research Hospital (HNEAH-KAEK 2023/KK67). 105 glaucoma patients who applied to the glaucoma subspecialty clinic of Sultan Abdülhamid Han Training and Research Hospital Training and Research Hospital for routine control were included in the study. Patients were recruited from May to August of 2023.

The patients were diagnosed with glaucoma by at least two specialists in our clinic with characteristic optic disc examination findings (glaucomatous C/D ratio increased, notched optic disc), retinal nerve fiber layer analysis (RNFL) compatible with optic neuropathy, and visual field defect. The patients' glaucoma types and the topical antiglaucomatous drops were recorded. Patients over 18 years of age, who had at least two previous successful visual field tests, refractive errors in the range of +8/-8 D, open angles with gonioscopy, no history of ocular surgery other than routine cataract surgery and/or uncomplicated selective laser trabeculoplasty or laser peripheral iridotomy, whose best-corrected visual acuity (BCVA) was greater than 6/10 according to the Snellen chart were included in the study. Patients with additional neurological, systemic,

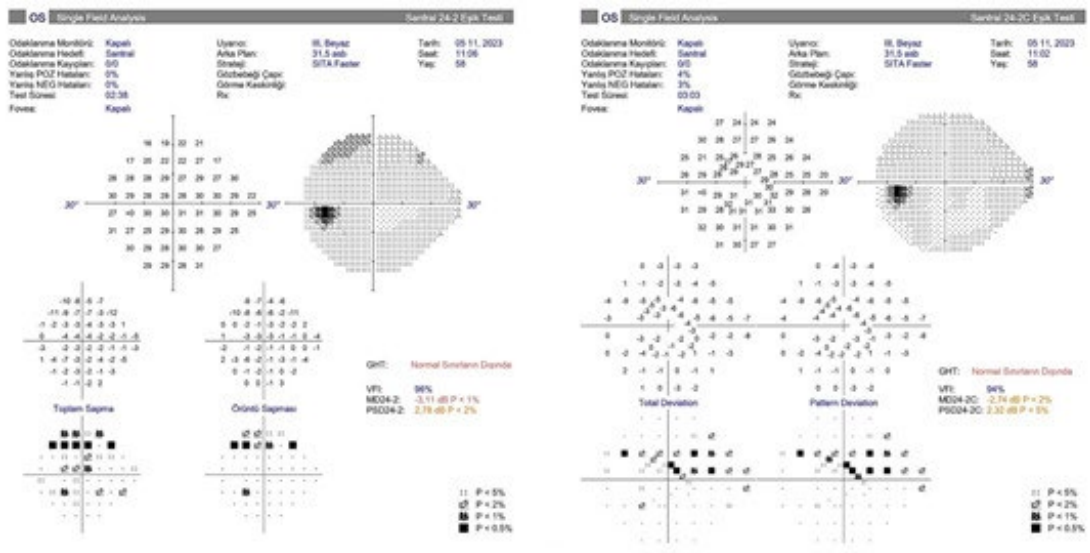

Figure 1: *Printout of 24-2 and 24-2C test strategies on Humphrey Automated Perimetry Device*

or ocular diseases that could cause visual field defects, those with a history of ocular trauma, and those who used medications like hydroxychloroquine that might cause visual field defects were excluded from the study. Visual field tests with a false negative or false positive rate of over 20% and tests with a fixation loss rate of over 30% were not included in the study. One eye of each patient was randomly selected for the visual field tests.

Visual Field Tests

All patients were tested with 24-2 and 24-2C grids (HFA II with 24-2 testing using the Swedish Interactive Thresholding Algorithm, Carl Zeiss Meditec Inc., Dublin, CA). Both 24-2 and 24-2C tests were implemented in the SITA-Faster algorithm. The tests were performed on the same day, and the experienced visual field nurse who performed the tests gave patients adequate time to rest between the two tests. The 24-2 test using the SITA-Faster algorithm was used first, followed by the SITA-Faster 24-2C test. MD, PSD, GHT, VFI outcomes and test duration were recorded for both strategies.

Statistical Analysis

IBM SPSS 26.0 package program was used for the statistical analysis of the study, and descriptive statistics of the demographic characteristics of the participants were calculated. The Shapiro Wilk test was used to check whether all variables were distributed normally and it was seen that they were not normally distributed. In comparing the measured variables of the participants according to the visual field test methods, Wilcoxon signed ranks test was used for continuous variables. The Chi-square test was used for categorical variables. All statistical analyses were evaluated at the 95% confidence interval and significance was determined at the $p<0.05$ level.

RESULTS

Of the 105 glaucoma patients who participated in our study, 39 were male (37.1%) and 66 were female (62.9%), with a mean age of 61.66±12.8 years. The average IOP of the participants was 17.26±3.1 mm Hg, and the average central RNFL was 88.07±15 µm. Those with MD results up to -6 decibel (dB) were classified as early-stage, those with MD values between -6 and -12 dB were classified as moderate-stage, and those with MD values more than -12 dB were classified as advanced-stage glaucoma.

According to the MD score, 91.4% (n=96) of the patients had early-stage glaucoma, 3.8% (n=4) had moderate-stage glaucoma, and 4.8% (n=5) had advanced-stage glaucoma. (Table 1).

The mean time for the SITA-Faster 24-2C test was 154.11±39.3 seconds, while the mean time for the SITA-Faster 24-2 test was 168.51±58.9 seconds. This result indicates that the average duration of the SITA-Faster 24-2C test is statistically significantly longer than the SITA-Faster 24-2 test (**p=0.014).** Comparing the number of scotomas detected by both test strategies in the 10° central visual field (statistically significant depressed points on the pattern deviation map are counted), the 24-2 algorithm detected 2.88±2.8 scotomas, while the 24-2C algorithm detected 4.17±4.7 scotomas. The 24-2C algorithm detected a significantly higher rate of central scotomas (**p=0.017**). In the comparison regarding the depth of the scotoma areas, a

Table 1: *Demographic characteristics of participants*

	Glaucoma Patients (n=105)
Gender Female Male	 62.9% (n=66) 37.1% (n=39)
Age (year, mean±SD), (min-max)	61.66±12.8, (21-78)
Mean IOP (mm Hg, mean±SD),(min-max)	17.26±3.1, (10-24)
Mean RNFL Thickness (µm, mean±SD), (min-max)	88.07±15, (42-123)
Glaucoma Stage Early-stage (up to -6 dB MD*) Moderate-stage (between -6, -12 dB MD) Advanced-stage (>-12 dB MD)	 91.4% (n=96) 3.8% (n=4) 4.8% (n=5)
IOP:Intraocular Pressure, RNFL:Retinal Nerve Fiber Layer, MD: Mean Deviation, dB: decibel	

statistically significant difference was seen only as a result of p value of less than 2%. While the average number of p<2% scotomas of the 24-2C test strategy was 0.83±1, this value was 0.55±0.9 in the 24-2 algorithm (**p=0.025**). There was no statistically significant difference between the two test strategies in terms of fixation loss rate, false negative rate, and false positive rate (p>0.05 for each). Additionally, there was no significant difference in MD, PSD, or VFI between the two visual field strategies (p>0.05 for each) (Table 2).

There was a statistically significant difference in terms of GHT between the 24-2 grid and 24-2C grid visual field tests. In the 24-2 test, according to the GHT result, 43.8% of patients had an outside the normal limits result, 17.1% had a borderline result, and 2.9% had an abnormally high sensitivity result. In the 24-2C test, the percentage of patients with an outside the normal limits result was 38.1%, borderline was 21.9%, and the percentage of patients with an abnormally high sensitivity was 3.8% (**p=0.0001**) (Table 3).

Table 2: *Comparison of 24-2 and 24-2C testing strategies of the Humphrey Automated Perimetry device*

Parameters	**24-2 Test Strategy (n=105)**		**24-2C Test Strategy (n=105)**		**P value**
	Mean±SD	**Min-Max**	**Mean±SD**	**Min-Max**	
Fixation Loss (%)	0.02±0.1	(0-0.3)	0.01±0	(0-0.2)	0.078
False Positive (%)	4.76±7.3	(0-43)	3.56±5.1	(0-25)	0.24
False Negative (%)	3.6±5.3	(0-26)	3.35±4.4	(0-19)	0.942
Test Duration(seconds)	154.11±58.9	(99-368)	169.34±39.3	(3-291)	**0.014***
Visual Field Index (%)	94.34±12.7	(10-100)	93.83±13.9	(12-100)	0.647
Mean Deviation(dB)	-2.05±4.9	(-3.47- -29.55)	-2.19±5.1	(-5.43- -28.9)	0.485
Pattern Standard Deviation (dB)	2.78±2.2	(0.91-11.87)	2.74±2.2	(1.06-11.4)	0.253
10° Central Scotoma Total p<0.5 p<1 p<2 p<5	 2.88±2.8 0.78±1.7 0.58±0.9 0.55±0.9 1.02±1.2		 4.17±4.7 1.29±3.3 0.8±1.1 0.83±1 1.33±1.5		 **0.017*** 0.142 0.136 **0.025*** 0.119

*= p<0.05
(Wilcoxon signed ranks test)

Table 3: *Comparison of 24-2 and 24-2C testing strategies in terms of Glaucoma Hemifield Test*

GHT 24-2C							
GHT 24-2	**% (n)**	**Inside Normal Limits**	**Outside Normal Limits**	**Borderline**	**Sensitivity is abnormally high**	**Total**	**P value**
	Inside Normal Limits	20% (n=21)	4.8% (n=5)	10.5% (n=11)	1% (n=1)	36.2% (n=38)	**0.0001****
	Outside Normal Limits	7.6% (n=8)	30.5% (n=32)	5.7% (n=6)	0% (n=0)	43.8% (n=46)	
	Borderline	7.6% (n=8)	2.9% (n=3)	5.7% (n=6)	1% (n=1)	17.1% (n=18)	
	Sensitivity is abnormally high	1% (n=1)	0% (n=0)	0% (n=0)	1.9% (n=2)	2.9% (n=3)	
	Total	36.2% (n=38)	38.1% (n=40)	21.9% (n=23)	3.8% (n=4)	100% (n=105)	

GHT: Glaucoma Hemifield Test, chi-square test, X^2=67.52, p=0.0001<0.01

DISCUSSION

In this study, we intended to compare the SITA-Faster 24-2 and SITA-Faster 24-2C visual field testing strategies in terms of reliability, effectiveness, and test time in glaucoma patients. We searched for to determine whether the 24-2C SITA-Faster visual field test could be used safely in routine glaucoma patient follow-up. There was no statistically significant difference between the two strategies in the rates of fixation loss, false positives, and false negatives, which are the reliability indices of the visual field test. Furthermore, there was no significant difference between the mean values of the glaucoma monitoring parameters MD, PSD, and VFI. The success of the 24-2C algorithm in detecting scotomas in the central 10° visual field was found to be statistically significantly higher than the 24-2 algorithm. The 24-2C SITA-Faster test had a substantially longer average test duration than the 24-2 SITA-Faster test. This variance is a result of the addition of 10 test points to the central 10 degrees in the 24-2C test. According to these findings, patients can effectively complete the SITA-Faster 24-2C test, and this testing strategy allows us to detect macular changes as early as the 10-2 visual field test.

In a recent study comparing 24-2 and 24-2C testing strategies, no difference in MD, PSD and GHT results was seen for either testing strategy in the SITA-Faster algorithm.[13] In the same study, when the results of the 24-2 SITA Standard test and the 24-2C SITA Faster test were compared, it was found that the MD results were statistically significantly worse with 24-2C; no change was seen in the PSD and GHT results. In our study, the SITA-Faster algorithm was used to perform both the 24-2 and 24-2C tests. There was no significant difference between the false positive, false negative, and fixation loss rates, which determine reliability of the test, and the MD, PSD, and VFI results. Comparing the GHT results, the rates of patients within normal limits were similar for both tests; however, the rate of patients outside normal limits was higher for the 24-2 test than the 24-2C test, and the patient group with borderline and abnormally high sensitivity results was higher for the 24-2C test. GHT is an algorithm that detects symmetrical changes in the horizontal meridian.[14] However, in the 24-2C test strategy, the additional 10 points added to detect central defects are not symmetrically distributed in the vertical and horizontal midlines, unlike the 24-2 and 10-2 grids.[5] We believe that this explanation could be the cause of the disparity in GHT results.

When we evaluated the detection rate of CVFD between the 24-2 and 24-2C algorithms, we noticed that there were very few studies conducted by individuals other than the manufacturer.[13,15] Hong et al. reported that the 24-2C grid was superior to the 24-2 grid in detecting macular defects in patients with open-angle glaucoma.[15] In the study by Phu et al., although the number of central scotomas was higher in the 24-2C algorithm, there was no statistically significant difference in the number of consecutive scotomas that were clustered, which could be interpreted as supporting glaucoma and encouraging a change in treatment.[13]

Reviewing the studies comparing 10-2 and 24-2C test grids for detection of CVFD, the 10-2 test detected more defects than the 24-2C test in the study performed by Phu et al. While the 10-2 visual field test detected more scotoma clusters, both tests gave similar results in terms of global the visual field indices.[16] In the study conducted by Chakravarti et al., more CVFD were detected in 10-2 visual field compared to 24-2C. However, the main reason for this difference in the number of defects is related to the fact that there are 64 points scanning the central 10° in the 10-2 visual field, while there are 22 points in the 24-2C test. When they evaluated the total deviation plot and pattern deviation plot based on results from the superior, inferior, and both hemifields, they found that 10-2 and 24-2C grids had moderate agreement.[17] In another study comparing 10-2 and 24-2C results in patients with neuro-ophthalmological disorders, no statistically significant difference was found between the two tests in terms of the defects detected in total deviation and pattern deviation plots. As a result of the study, it was concluded that the 24-2C grid can detect CVFD similarly to the 10-2 grid.[18]

In our study, when 24-2 and 24-2C grids were compared in terms of detecting CVFD in the central 10°; in the pattern deviation plot, 24-2C detected a significantly higher rate of defects than 24-2. While the average of these defects with a p value less than 2% was found to be higher at 24-2C; there was no significant difference in the average of those with a p value less than 5%, 1% or 0.5%. These findings are consistent with previous studies.

The current study has some limitations. The first limitation of our research is that not all patients included in the analysis

had a preexisting CVFD. This circumstance reduces the accuracy of the study's estimation of the detection rate of central visual field loss. Secondly, on the same day, the patients underwent a visual field test with a 24-2 grid and then a 24-2C grid. Even though the patient was given an adequate period of rest between the two tests, this may have contributed to fatigue during the 24-2C test. Finally, we could not correlate the data we obtained in our study with ganglion cell layer analyses. The fact that we were not able to verify whether the existing scotoma areas had OCT counterparts also limits our study.

As a conclusion, although the SITA-Faster 24-2C test grid caused a minimum increase in test time compared to SITA-Faster 24-2, it was found to be superior in detecting CVFD. In addition, based on the global metrics of visual field measurements, it seems unlikely to affect reliability. Current findings should be confirmed by further studies.

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