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Original Research Paper

A Comparison between The Diagnostic Results of Short Wavelength Automated Perimetry And Standard Automated Perimetry In The Diagnosis of Early Diabetic Retinopathy: A Comparison Cross-sectional Study In Syria.

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ABSTRACT:
Aim: To compare the diagnostic results of Short Wavelength Automated Perimetry (SWAP) with Standard Automated Perimetry (SAP) in type 2 diabetes patients and to evaluate the role of SWAP in the early detection of diabetic retinopathy. **Methods**: In this comparative cross-sectional study, held in Ophthalmology Department. Participants undergo full ophthalmological and systematic examination. The participants are divided into three groups: Group (1) of healthy patients , Group(2) of diabetic patients without diabetic retinopathy, and Group (3) of diabetic patients with mild diabetic retinopathy. We conduct two tests on each subject; first SAP (G pattern) then SWAP using OCTOPUS 900 perimeter. The visual field global indices are compared between SAP and SWAP and between the groups on each perimetry technique separately. **Results**: There are statistically significant results regarding MS, MD and sLV in SAP and SWAP techniques. MD and sLV results are significantly higher in diabetic groups rather than healthy groups in both SAP, SWAP. Whereas MS values are lower in diabetic groups. Moreover, MD and sLV results are higher and MS results are lower in the NPDR group than not DR group in both SAP and SWAP. Lastly, MD, sLV and MS results are statistically significant in SWAP comparing with SAP, as MD, sLV results are higher and MS lower. **Conclusion**: This study show that SWAP is superior to SAP in identifying patients with early diabetic retinopathy, and may therefore be quite useful for determining early and progressive changes in diabetic retinopathy.

Keywords: Perimetry, ophthalmological, diabetic retinopathy

INTRODUCTION:

Diabetic retinopathy(DR) is considered a common complication of diabetes and remains the primary cause of blindness in the working age group.(1) The diagnosis and treatment of DR in clinical practice depend on the observation of vascular changes (blood vessels, hemorrhages, exudates, edema…) through fundoscopy , fluorescein angiography(FA), or Optical Coherence Tomography (OCT) . (2) However, these changes appear at later stages of the disease(3). The likelihood of vision loss increases in diabetic patients diagnosed with vascular diabetic retinopathy, which is why there is a need for concerted efforts to detect the condition at the earliest possible stages (4) .

It is currently believed that Retinal Diabetic Neuropathy (RDN) plays a significant and early role in diabetic retinopathy and causes functional changes in the retina before the appearance of vascular changes. (5)

According to numerous histological and diagnostic studies, it has been shown that diabetes causes proptosis to certain retinal ganglion cells .(6–8) It was also found that there is a selective loss of cones sensitive to short-wavelength waves (blue wave) in patients with diabetes and non-proliferative diabetic retinopathy .(8,9)

Early damage can be detected using mechanisms that have a scattered neural representation, as is this case with cones sensitive to short wavelengths (SWS), which constitute a very small percentage of the total number of receptors and ganglion cells .(10) These cones also have non-overlapping receptive fields compared to cones sensitive to longer wavelengths .(11) Moreover, the difference in the response field ,(10) and the different nature of the ganglion cells ,(12) which may be responsible for the earlier measurable functional loss.(13) Short Wave-length Automated Perimetry (SWAP) is a valuable tool using blue stimulus to selectively activate the blue cones, with a high luminance yellow background, Blue on Yellow Perimetry (B-Y) is designed to saturate the rod activity. Compared with White on White (W-W) perimetry, the clinical application of Short Wavelength Automated Perimetry (SWAP) is constrained due to: increased inconsistency in threshold estimation; absorption by the ocular media; prolonged test duration; and an enhanced learning effect.(14) Studies are still ongoing to improve and develop examinations to achieve the optimal test, balancing between early detection of irreversible damage, ease of procedure, and suitable duration for both the patient and the doctor. We did not find in the medical literature any study comparing the two tests using global indices in the Octopus 900 device; therefore, the idea of the research came to study the effectiveness of the short-wave method in Octopus perimetry in the context of diabetic retinopathy.

MATERIALS AND METHODS:

In this Comparative Cross-sectional study, held in Ophthalmology Department from February 2023 to February 2024, 300 Eyes of 150 subjects were enrolled. Informed consent was obtained from all subjects after the nature and possible consequences of the procedure had been fully explained to them. They underwent full systematic evaluation including Hba1c measurement and full diabetes consultation in the department of endocrinology to confirm the diagnosis of DM. In addition to that, ophthalmological Examination includes biomicroscopy, Intraocular Pressure (IOP) Measurement utilizing Goldmann’s applanation tonometry, and color Vision testing using Ishihara’s plates.

The participants were divided into Three groups:

Group(1): healthy patients group (100 eyes),

Group (2): diabetic patients without Diabetic retinopathy (100 eyes).

Group(3): diabetic patients with mild diabetic retinopathy(100 eyes).

The study performed on each subject two tests, First SAP using (OCTOPUS 900) perimetry, G pattern with Goldman III size,then SWAP using Golman V size, and the visual field global indices, HbA1C, and duration of diabetes were recorded.

Inclusion Criteria:

1-Age above 45 years old.2-Diagnosed with type 2 diabetes according to the glycosylated hemoglobin (HbA1C≥6.5%).3-BCVA≥0.6.4-Patients not diagnosed with glaucoma (IOP<21 mm Hg).5-Agreement to participate in the study and accepting informed consent.

Exclusion criteria:

1-Pregnancy and Breastfeeding. 2-BCVA < 0.6. 3-Refraction error 5 D sphere or 2.5D cylinder or more. 4-Patients with congenital color vision defects. 5-Any type of glaucoma. 6- Ocular media opacities (cataract diagnosed by slit-lamp exam), retinal and neurological condition. 7- Retinal diseases that cause visual field abnormalities such as retinitis pigmentosa, age-related macular degeneration. 8-Optic nerve disorder secondary to glaucoma or not. 9-Patients take drugs that cause color vision abnormalities such as anti-histamines/anti-depressants / oral contraceptive pills. 10- Inability to do visual field test (mentally retard, low IQ). 11-Not aiming to sign informed consent.

Statistical Analysis:

Descriptive Study (comparative cross-sectional study).

Description Statistical Quantitative variables were expressed in arithmetic mean, standard deviation, and qualitative variables in frequencies and percentages.

One Way Anova test to compare the differences of averages between more than two independent groups.

Chi-square test to study the relationships between qualitative variables.

Results are considered statically significant when P-value<5%.

All statistical analyses were performed using IBM SPSS Statistics (version 20.0, SPSS Inc., Chicago, Illinois, USA).

RESULTS:

According to Table(1), there are no statistically significant differences between the studied research groups with regard to demographic variables (age and sex). Also, There are statistically significant differences between the two groups of diabetics patients with respect to the mean values of HbA1C which was higher in the diabetic retinopathy group with p-value = 0.001

Table(1): age, sex and HbA1C values in the three groups

Variables	Group (1)	Group(2)	Group(3)	P-value
Sex **males** **females**	39(78%) 11(22%)	36(72%) 14(28%)	35(70%) 15(30%)	0.6
Age(years)	55.34±7.3	56.54±5.8	58.36±6.09	0.06
HbA1C(%)	-	8.45±1.2	9.52±1.8	0.001

According to Table (2) , we notice statistically significant differences between the studied research groups regarding the mean values of MD and sLV according to SWAP and SAP. The values were higher in diabetic patients compared to healthy individuals (controls) in both methods. Additionally, the MD and sLV values were higher in patients with mild diabetic retinopathy. Similarly, when comparing the two methods, SWAP values were significantly higher in diabetic patient groups, while there was no significant difference among healthy controls. Similarly, MS results were lower in diabetic patients groups and especially in the group with mild retinopathy in both techniques. Also, MS values were lower in SWAP rather than SAP in the diabetic groups.

Table(2) :MD,MS and sLV results in groups according to SAP/SWAP

	Group (1)	Group(2)	Group(3)	p-value (1&2)	p-value(1&3)	p-value (2&3)
MD						
SAP	1.08±0.8	1.66±0.5	2.33±1.9	0.0001	0.0001	0.03
SWAP	1.18±0.4	3.87±1.6	6.88±1.5	0.0001	0.0001	0.002
P-value	0.2	0.0001	0.0001			
sLV						
SAP	1.74±0.3	1.92±1.3	2.32±1.5	0.01	0.01	0.02
SWAP	1.36±0.6	3.99±1.3	4.19±1.3	0.0001	0.0001	0.04
P-value	0.2	0.0001	0.0001			
MS						
SAP						
SWAP	24.24±1.5	24.60±1.6	23.20±2.9	0.4	0.01	0.01
P-value	20.42±2.01	15.60±1.1	14.20±0.7	0.0001	0.0001	0.01
	0.0001	0.0001	0.0001			

DISCUSSION:

Regarding demographic variables, the age range in our study was consistent with many previous studies(15,16).In terms of gender, the male: female ratio was similar in the three groups and there were no statistically significant differences; this differs with [Maky et al](17)where they found that females prevalence was statistically significantly higher, this can be explained by Maky's finding that the majority of females show their affliction with proliferative diabetic retinopathy and this was excluded in our study.

Hemoglobin A1C (HbA1C) determined the regulation of blood glucose, was better in group 2 (diabetic without retinopathy) compared with group 3(diabetic with mild retinopathy). Controlling blood sugar decreases the prevalence of DR, as well as reduces the progression of retinopathy (17), In accordance to The United Kingdom Prospective Diabetes Study Stratton et al(18), The diabetes control and complications trial and diabetic retinopathy study (DRS) and (19). ETDRS. In our study, we found that the mean values of MD were significantly higher in diabetic patients compared to healthy individuals (controls) (p-value =0.0001), which is consistent with several reference studies: Ozates et al(20), Peprnikova et al. (21), Abrishami et al. (22), and Zico et al. (23). Additionally, when comparing between diabetic groups, we observed a statistically significant difference, where MD values were higher in patients with mild retinopathy in both tests ($p < 0.03$ in SAP and $p < 0.002$ in SWAP), which aligns with the findings of Zico et al. (23). Furthermore, comparing the two tests, our study revealed a significant statistical difference, with MD values in SWAP being higher than in SAP ($p < 0.0001$), consistent with Zico et al.'s study (23). As for the square root loss of variance variability (sLV), which investigates the nature of the field disturbance pattern (diffuse or localized), our study found that the mean sLV values were significantly higher in diabetic patients compared to healthy individuals in both tests: $p < 0.0001$ in SWAP and $p < 0.01$ in SAP. Comparing our results with several reference studies and relying on the fact that the PSD in Humphrey correlates with sLV in Octopus, we observed the following:

1. In the study by Ozates et al. (20), PSD values were higher only in diabetic patients compared to healthy controls in the SWAP test (3.15 ±1.24) dB (0.86 ± 0.41) dB, respectively) with $p < 0.001$. However, no significant differences were observed in SAP ($p = 0.139$). This discrepancy may be attributed to variations in the studied diabetic type, as participants in this study had type 1 diabetes, where the onset of the disease is more precisely known than in type 2 diabetes. Additionally, there was no effect of lens opacification as seen in type 2 diabetic patients (20).
2. In the study by Zico et al. (23), CPSD values increased in diabetic patients compared to healthy controls in both tests, consistent with our findings.

Moreover, sLV values were significantly increased in patients with mild retinopathy in both tests: $p < 0.001$ in SAP and $p < 0.0001$ in SWAP. This aligns with Zico et al.'s study (23), specifically in the SWAP test ($p < 0.005$), while no significant difference was observed in SAP ($p = 0.4$).
Comparing the two tests, our study revealed statistically significant differences in sLV values, with higher values in SWAP ($p < 0.0001$) compared to SAP. This differs from Zico et al.'s findings (23), where no significant differences were observed between the two tests.

The variation in results can be explained by potential overestimation of sLV values due to fluctuations caused by noise and patient fatigue. Therefore, corrected sLV (CsLV) ,simirarly CPSD in Humphrey device (equivalent to Corrected PSD) was introduced to reduce excessive fluctuations, resulting in lower values (24). This explains the discrepancy between our results and the study by (25)."

As for the mean sensitivity (MS), we found that sensitivity values decrease in diabetic patients compared to healthy individuals (controls). In the SAP test, the MS values for the control group ,diabetic without retinopathy and diabetic with mild retinopathy were (24.24±1.5), (24.60±1.6), and (23.20±2.9) decibels, respectively. In the SWAP test, the corresponding values were (20.42±2.01), (15.60±1.1), and (14.20±0.7) dB. Sensitivity decreases in mild diabetic retinopathy in both tests (p-value < 0.01). On the other hand, our study found that MS is lower in SWAP compared to SAP across all groups (statistically significant with p-value = 0.0001).

Similar studies by Abrishami et al. (22) and Remky et al. (13) align with our findings, showing decreased sensitivity in diabetic patients compared to controls. Their study also indicated that SWAP can be used to monitor functional changes in the retina of diabetic patients, with lower sensitivity values in SWAP compared to SAP

In our current study, sensitivity indices in both visual field tests showed clear differences in values between the control group and diabetic patients. Additionally, the sensitivity values in SWAP were different from those in SAP, particularly related to diabetic retinopathy. While SAP values remained within the normal range, SWAP values indicated disturbances in the visual field. This highlights the sensitivity of SWAP technology for early diagnosis

According to our knowledge, there is currently no study that has directly compared the overall sensitivities between the two types of visual field tests using global indices: SAP (standard achromatic perimetry) and SWAP (short-wavelength automated perimetry) using the Octopus 900 device. The available studies have primarily focused on using the Humphrey Field Analysis (HFA) device. Additionally, the dynamic range of the Octopus 900 is estimated to be 18 dB greater than that of the Humphrey Field Analyzer in the SWAP mode. This difference may explain the slight variations in sensitivity values between our study and the reference studies while remaining within the same clinical context

Traditional visual field testing examines two types of retinal ganglion cells (RGCs)—the large and parvocellular cells. However, there is overlap between their receptive fields, leading to the inability to specifically assess certain locations and RGC subtypes(26). Since diabetic damage has been established for the blue cones in the early stages of the disease, (8,9)which are primarily processed by small bistratified RGCs, these cells are not effectively tested using traditional methods. Instead, they are sensitive to blue light and are better assessed through SWAP (short-wavelength automated perimetry). (27)This is evident through the increased sensitivity values observed in SWAP, which reflect the severity of damage in the visual field.

Additionally, according to Davidson,(28) changes in sensitivity values specific to visual field testing are associated with the threshold visual index (TVI)(28,29). In cases where the retinal receptors are affected, such as in diabetic retinopathy,(8,9) TVI tends to shift upward and to the right(30).This phenomenon impacts the sensitivity values during visual field examination, as we observed in our study.

CONCLUSION:

The SWAP test is considered an effective diagnostic tool for detecting visual field disorders in patients with diabetes (pre-diabetic retinopathy stage), when the traditional SAP visual field test is normal.

Availability of data and materials:

The authors declare that the data supporting the findings of this study are available from the corresponding author on a reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

AA made the conception and design of the work, analyzed and interpreted the patient data, was a major contributor in writing the manuscript. AA analyzed the data and was a contributor in writing the manuscript. SY and RM analyzed the data and was a contributor in writing the manuscript and substantively revised the work.

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