Sriwijaya Journal of Ophthalmology
Journal Homepage: https://sriwijayaopthalmology.com/index.php/sjo

The Color Vision Disorder in Diabetic Patients

Wisam Chasib Alhamadani[1], Ali Taha Yasin Al-Ziayyir[1*], Khalid Tawfeeq Najm[1]

[1]Alfayhaa Teaching Hospital, Basrah Health Directorate, Ministry of Health, Basrah, Iraq

ARTICLE INFO

Keywords:
Color vision disorder
Diabetes mellitus
Trichromate
Tritanomaly

***Corresponding author:**
Ali Taha Yasin Al-Ziayyir

E-mail address:
Medicalresearch22@yahoo.com

All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/sjo.v6i2.106

A B S T R A C T

Introduction: The visible spectrum (about 400 to 700 nm) with a mosaic of three classes of photoreceptors compose the human visual system. They are sensitive to different wavelength ranges with overlapping. The receivers have high sensitivities at short wavelengths (~440 nm), medium (~535 nm), or longer (~565 nm), which are S, M, and L cones, respectively. The study aimed to determine blue color vision defects in diabetes mellitus. **Methods:** A cross-sectional study was done at an ophthalmology clinic on 200 eyes (right and left) of patients with DM for a period of 5 one years (2021). Ishihara plates were used initially for screening. The D-15 test was performed for the evaluation of color vision. **Results:** The mean age of the sample was 45.66±15.65 years. The most frequent disorder visualized was tritanomaly in 63%, followed by trichromate in 27%, and the least disorder was deuteranomaly in 2%. In addition, mixed disorder is seen in 8% of cases. In relation to laterality, right eye tritanomaly was found in 34%, while the left eye was recorded in 29%. The right eye trichromate was observed in 12%, whereas the left eye was reported in 15%. The left eye deuteranomaly was reported more than the right (1.5% vs. 0.5%). **Conclusion:** Color vision evaluation with good screening color vision test can be detected even before clinically visible diabetic retinopathy. Early detection was helpful in the prevention of vascular changes in the retina. All diabetic patients should be given proper awareness and health education regarding color vision deficiency. Timely assessment of color vision may detect tritanomaly earlier in diabetics.

1. Introduction

Definitely, the spectral sensitivities are evaluated by the specific photopigment molecules.[1] The single receiver type cannot show the difference between wavelength changes and intensities changes. The probability that a given photon is absorbed by a photopigment depends on the wavelength. All subsequent events in the receiver are wavelength independent. Thus, the wavelength data can be extracted by comparing the responses among different receiver classes.[2] Macular degeneration cause damage to the retina, which is a complication of diabetic retinopathy and causes tritanopia.[3] The diffuse color vision impairment in DM along both the blue/yellow and red/ green axis is affected, and this is strongly associated with the degrees of diabetic retinopathy or macular edema.[4]

Diabetic retinopathy (DR) is a primary cause of visual impairment worldwide.[5] DM may be associated with ophthalmoscopically non-visible neurovascular damage that progresses before the first clinical signs of DR appear. The inner neuro-retinal layer thickness reduced at macular optical coherence tomography with declined contrast sensitivity at low spatial frequencies, abnormal findings in color vision and micro-perimetry tests, and a prolonged implicit time recorded by multifocal electro-retinography have been used for detection of early functional and non-visible structural neuro-retinal changes.[6] Previous studies reported that DM leads to a lack of vision of tritan

colors (loss of discrimination along the blue/yellow axis). Tritan defect is explained by a higher susceptibility of short wavelength cones in the retina and early yellowing of the lens in the diabetic eye. Other studies reported discrimination along the blue/yellow and red/green axes.[7]

Koenig, von Kries, Koellner, and other German scientists using spectral devices had already studied the different forms of color vision impairment.[8] The first approach is greatly facilitated by the D-15 Panel in the meantime 100-Farnsworth Street. Almost all ocular disorders give rise to absorption systems, whereas retinal layers lesions cause a predominant reduction in the blue-yellow direction, and lesions in the ganglion layer and the optic nerve mainly cause red-green. The tritan anomaly is an acquired color defect known in DM, with or without clinical signs of DR.[9] The study aimed to determine blue color vision defects in diabetes mellitus.

2. Methods

A cross-sectional study was carried out on 200 eyes of DM. Diabetic retinopathy, congenital color vision defects, retinal disorder, optic nerve defects or neuropathy, or choroidal lesions were excluded. All participants were willing to include in this study. The ethical approval was done according to the modified Declaration of Helsinki policies. Slit lamp examination was done for anterior and posterior segment examination to exclude corneal opacities, lenticular opacities, or any other ocular pathologies. Fundus was examined for the exclusion of diabetic retinopathy. Ishihara plates were used initially to screen out any congenital defect. D-15 test was performed for evaluation of color vision. The test was performed thrice, and an average result was considered. Data were entered using the latest version 20 of SPSS, and chi-square was used to assess the association. P value <0.05 was considered statistically significant.

3. Results

The mean age of the sample was 45.66±15.65 years. 22% of patients belonged to the group (30-40 years), 45% belonged to the group (41-50 years), and above 50 years documented 33% of cases. Males were 57%, and females were 43%. 44% lived in urban areas, and 56% of cases lived in rural regions. 40% of patients were working. 61% of cases were educated. 58% of cases were smoking tobacco. 12% were alcoholic. 28% of patients wear glasses (Table 1). The most frequent disorder visualized was tritanomaly in 63%, followed by trichromate in 27%, and the least disorder was deuteranomaly in 2%. In addition, mixed disorder is seen in 8% of cases (Table 2). In relation to laterality, right eye tritanomaly was found in 34%, while the left eye was recorded in 29%. The right eye trichromate was observed in 12%, whereas the left eye was reported in 15%. The left eye deuteranomaly was reported more than the right (1.5% vs. 0.5%) (Table 3).

4. Discussion

In this study, the most frequent disorder visualized was tritanomaly in 63%, followed by trichromate in 27%, and the least disorder was deuteranomaly in 2%. In addition, mixed disorder is seen in 8% of cases. Gella et al. [4] and Zghal-Mokni et al.[10] found that risk factors for impaired color vision were OR 1.79 in women. They concluded that impaired color vision is an early indicator of neurodegenerative changes in the retina before clinically visible retinopathy. Radwan, in 2015 assessed acquired color vision defects in DM at different stages of retinopathy. Only 10% of control eyes failed the D15 test, while 34% of diabetic eyes failed the test. Results showed that tritan defect was the most encountered defect among all groups.[11] Zghal-Mokni et al.[10] conducted a multi-centric prospective study in 2008 of a representative population of 285 subjects. They concluded that regular ophthalmological examination is necessary to prevent ocular complications of diabetes.

Table 1. Variables of the study.

Variable		No.	%
Age (years)	**30-40**	22	22
	41-50	45	45
	>50	33	33
Gender	**Male**	57	57
	Female	43	43
Address	**Urban**	44	44
	Rural	56	56
Job	**Yes**	40	40
	No	60	60
Education	**Yes**	61	61
	No	39	39
Smoking	**Yes**	58	58
	No	42	42
Alcohol	**Yes**	12	12
	No	88	88
Use glasses	**Yes**	28	28
	No	72	72

Table 2. Color vision disorders.

*Disorder	No.	%
Tritanomaly	63	63
Trichromate	27	27
Deuteranomaly	2	2
Mixed	8	8
****P <0.01**		

*Deuteranomaly is the most common type of red-green color blindness. Trichromacy or trichromatism is the possessing of three independent channels for conveying color information, derived from the three different types of cone cells in the eye, tritan color blindness confuse blue with green and yellow with violet (blue-green color blindness), Tritanomaly: This is an alleviated form of blue-yellow color blindness, where the S-cones are present but do have some kind of mutation, Tritanopia: People affected by tritanopia are dichromats. This means the S-cones are completely missing, and only long- and medium-wavelength cones are present; **Fisher exact test.

Table 3. Color vision disorders according to eye involvement.

Disorder	Right eye		Left eye	
	No.	%	No.	%
Tritanomly	68	34	58	29
Trichromate	24	12	30	15
Deuteranomaly	1	0.5	3	1.5
Mixed	7	3.5	9	4.5
***P value**	**P<0.01**		**P<0.05**	

*Fisher exact test.

Shoji conducted a study to understand the reference values and discrimination values of color vision function. Male army officials were selected and underwent Ishihara pseudoisochromatic test, D15 panel, and standard pseudoisochromatic plates part 2. They proved that the color confusion index is in good agreement with acquired color vision impairment, and the D15 test is helpful for screening purposes.[12]

In 2013, Sun and Zhang conducted a study for the assessment of color vision in DM with a sample size of 78 individuals (126 eyes), and 64 healthy individuals were selected as healthy controls.[13] color defects appear in the early stages of diabetes, and color discrimination plays an important role in color perception and visual function damage in diabetics.[4,13] Vashist et al. suggested that the appropriate choice of test can be very helpful in screening methods for DM cases with retinopathy before clinical appearance.[14]

Khairoalsindi et al. concluded that most tritan defect is noted and it is associated with the age and education level of the subject. Early screening can prevent permanent visual disturbance.[15] Feitosa-Santana et al. concluded a prior assessment of retinopathy is possible with color perception and discrimination ability.[16]

Cone dystrophy, maculopathy, age-related lenticular changes, DM, glaucoma, optic neuritis, and traumatic head and brain injuries can cause impaired color vision.[17] For acquired color vision defects, it is not easy to classify type or color vision defects. Predominantly it is tritanopia, and the type and severity of the defect fluctuate during the disease.[18,19] This study found tritan color defects in DM before clinically visible retinopathy for the prevention of irreversible damage to the retina and thereby support treatment strategies. This can help cases in making professional choices easy whom color vision is affected and help them to overcome further emotional trauma.

5. Conclusion

Color vision evaluation with good screening color vision test can be detected even before clinically visible diabetic retinopathy. Early detection was helpful in the prevention of vascular changes in the retina. All diabetic patients should be given proper awareness and health education regarding color vision deficiency. Timely assessment of color vision may detect tritanomaly earlier in diabetics.

6. References

1. Raman R, Srinivasan S, Nagarajan R. Structural and functional retinal abnormalities in type 2 diabetes with obstructive sleep apnea. Sleep Breath. 2016; 20(3): 1005-7.
2. Souza CF, Gross JL, Gerchman F, Leitão CB. Pré-diabetes: diagnóstico, avaliação de complicações crônicas e tratamento [Prediabetes: diagnosis, evaluation of chronic complications, and treatment]. Arq Bras Endocrinol Metabol. Portuguese. 2012; 56(5): 275-84.
3. Gella L, Raman R, Kulothungan V, Pal SS, Ganesan S, Srinivasan S, et al. Color vision abnormalities in type II diabetes: Sankara Nethralaya Diabetic Retinopathy Epidemiology and Molecular Genetics Study II report no 2. Indian J Ophthalmol. 2017; 65(10): 989-94.
4. Gella L, Raman R, Kulothungan V, Pal SS, Ganesan S, Sharma T. Impairment of colour vision in diabetes with no retinopathy: Sankara Nethralaya diabetic retinopathy epidemiology and molecular genetics study (SNDREAMS- II, Report 3). PLoS One. 2015; 10(6): e0129391.
5. Alrasheed S, EL Awad M, Abdulbagi A. Congenital and acquired colour vision deficiency among population in North Kordofan State of Sudan. Sudanese Journal of Ophthalmology. 2017; 9: 22.
6. Gualtieri M, Feitosa-Santana C, Lago M. Early visual changes in diabetic patients with no retinopathy measured by color discrimination and electroretinography. Psychology & Neuroscience. 2013; 6: 227-34.
7. Safi H, Safi S, Hafezi-Moghadam A, Ahmadieh H. Early detection of diabetic retinopathy. Surv Ophthalmol. 2018; 63(5): 601-608.
8. Jończyk-Skórka K, Kowalski J. Ocena widzenia barw i jej wartość diagnostyczna w przewidywaniu ryzyka wystąpienia retinopatii cukrzycowej u chorych z zaburzeniami gospodarki węglowodanowej [The evaluation of color vision and its diagnostic value in predicting the risk of diabetic retinopathy in patients with glucose metabolism disorders]. Pol Merkur Lekarski. Polish. 2017; 43(253): 15-21.
9. O'Neill-Biba M, Sivaprasad S, Rodriguez-Carmona M, Wolf JE, Barbur JL. Loss of chromatic sensitivity in AMD and diabetes: a comparative study. Ophthalmic Physiol Opt. 2010; 30(5): 705-16.
10. Zghal-Mokni I, Nacef L, Letaief I, Mahjoub S, Bouguila H, Blouza S, et al. Atteintes oculaires dans le diabète: à propos de 285 cas [Ocular

manifestations of diabetes: 285 cases]. Tunis Med. French. 2008; 86(11): 1004-7.

11. Radwan TM, Ghoneim EM, Ghobashy AW. Assessment of color vision in diabetic patients. International Journal of Ophthalmic Research. 2015; 1: 19-23.
12. Shoji T, Sakurai Y, Sato H, Chihara E, Takeuchi M. Do type 2 diabetes patients without diabetic retinopathy or subjects with impaired fasting glucose have impaired colour vision? The Okubo Color Study Report. Diabet Med. 2011; 28(7): 865-71.
13. Sun TS, Zhang MN. [Characteristics of color discrimination changes in diabetic patients without diabetic retinopathy]. Zhonghua Yan Ke Za Zhi. Chinese. 2013; 49(1): 41-6.
14. Vashist P, Singh S, Gupta N, Saxena R. Role of early screening for diabetic retinopathy in patients with diabetes mellitus: an overview. Indian J Community Med. 2011; 36(4): 247-52.
15. Khairoalsindi OA, Almasoudi BM, Bamahfouz AY, Alghamdi AA, Siddiqui MI. Prevalence and determinants of color vision defects among preparatory University students at Makkah, Saudi Arabia. Middle East Afr J Ophthalmol. 2019; 26(3): 133-7.
16. Feitosa-Santana C, Oiwa NN, Paramei GV, Bimler D, Costa MF, Lago M, et al. Color space distortions in patients with type 2 diabetes mellitus. Vis Neurosci. 2006; 23(3-4): 663-8.
17. Sayin N, Kara N, Pekel G. Ocular complications of diabetes mellitus. World J Diabetes. 2015; 6(1): 92-108.
18. National Research Council (US) Committee on vision. Procedures for testing color vision: Report of working group 41. Washington (DC): National Academies Press (US); 1981. Chapter 2, Classification of Color Vision Defects.
19. Andrade LC, Souza GS, Lacerda EM, Nazima MT, Rodrigues AR, Otero LM, et al. Influence of retinopathy on the achromatic and chromatic vision of patients with type 2 diabetes. BMC Ophthalmol. 2014; 14: 104.