Original Article

Impaired Colour Vision and Contrast Sensitivity in Patients with Diabetes Mellitus

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Pak J Ophthalmol 2018, Vol. 34, No. 1

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Purpose: This study determines the major factors which lead to the complications in diabetic patients irrespective of diabetes status.

Study Design: Cross-sectional study.

Place and Duration of the Study: Department of Ophthalmology, Dow University Hospital from September 2015 to December 2016.

Material and Methods: A total of two hundred patients were included. Information regarding types of diabetes (Type 1 Diabetes Mellitus (T1DM) / Type II Diabetes Mellitus (T2DM)), diabetic status (controlled / uncontrolled), Snellen acuity, color vision and contrast sensitivity was collected from patients attending eye OPD along with demographic data of patients.

Result: There were 51% males and 49% females with mean age of 50.23 ± 7.89 years. There were 87% married patients, 60.5% had controlled diabetes while 39.5% had uncontrolled diabetes. Patients having T2DM were 76.5% and patients with T1DM were 23.5%. Snellen visual acuity of 6/9 was seen in 27% patients in the right eye and 28% in the left eye. There was a significant association of status of diabetes with colour vision deficiency (p-value 0.031). Diabetic patients, who were using glasses, were 2.2 folds more susceptible to have defects in contrast visual acuity than those who were not using glasses (OR_{adj}=2.2, 95% CI: 1.0 – 4.7).

Conclusion: Colour vision deficiency was significantly associated with status of diabetes (controlled/uncontrolled) while contrast sensitivity was significantly associated with patients having refractive errors.

Keywords: Diabetic retinopathy; colour vision; contrast sensitivity; diabetes mellitus.

Worldwide, Diabetes mellitus (DM) distresses the physiology of the retinal neurons and in its pathogenesis, vascular and metabolic aspects are dominantly involved. According to the World health organization there are 285 million people with visual impairment & contrast sensitivity is one of the leading cause of visual impairment[1]. Diabetic retinopathy with impaired vision, colour vision defect & contrast sensitivity is the common cause of legal irreversible blindness[2], especially between 20 to 74 years of age[3], even though it can be prevented by proper glycaemic control[4,5].

Colour vision deficiency secondary to ocular disease is recognized as acquired colour vision deficiency. In entire world, 8% of males and 0.5% of females are affected from acquired colour vision deficiency[6]. In diabetic patients, increase in lens density, retinal changes, and hyperglycaemia are involved in the changes in contrast sensitivity, with or without the presence of diabetic retinopathy.

Pakistan ranks eighth in the prevalence of diabetes among most populated countries in the world[7,8]. Approximately 6.2 million are suffering from diabetes in Pakistan[8] and one in every third diabetic patient has diabetic eye disease[9-11]. In our region, most of the studies have been done on colour vision and contrast sensitivity of diabetic patients which were mostly related to diabetic retinopathy but we planned to see the defects of colour vision & contrast sensitivity in relation to the diabetic status (controlled / uncontrolled).

METHODS AND MATERIALS

This cross-sectional study was conducted from September 2015 to December 2016 at eye department of tertiary care hospital. All diabetic patients in eye OPD irrespective of age and gender were included. People with non-diabetic status, known cognitive impairment that were unable to comprehend and answer the interview questions were excluded.

Data was collected from participants with the help of structured questionnaire. The questionnaire was designed to collect information about demographic, exposure and outcome variables of patients in which risk factors such as diabetic status (controlled/uncontrolled), duration of diabetes, type of diabetes, Snellen visual acuity with diabetic retinopathy and maculopathy, colour vision loss, reduced contrast sensitivity and blood glucose level were noted. A brief ocular history was also taken about the frequency of visits in eye hospital, status of glasses and history of eye surgery. Patient's random capillary blood glucose values were measured to determine their fasting and random blood glucose level. Visual acuity of both eyes was measured by Snellen visual acuity chart on six-meter notation. Colour Vision in each eye was assessed by using Ishihara 14-plates test in which plates 1 to 11 only assessed the normality of colour vision. The colour vision was regarded as normal when ≥ ten plates were read normal and it was abnormal (deficient) when ≤ seven plates were read normal.[12] Contrast sensitivity was measured by using Pelli-Robson Contrast Sensitivity Acuity Chart. Normal score of Contrast sensitivity was 2.0, i.e. 100%. Those who had score below 1.5 were abnormal, which was recorded as a decrease in the Contrast sensitivity. Testing was carried out at a distance of one meter (40 inches) with the patients wearing their distance correction[13,14].

A written informed consent was taken before collecting data. Patient's identity and their data were kept confidential and anonymous. Only researchers had access to their data. No monetary burden was put on patients. Participants had full right to withdraw at any time during the study.

SPSS version 20 was used for statistical analysis. Descriptive statistics was explored by using frequency and percentages for qualitative and median and interquartile range for quantitative variables. The correlation of diabetic status (controlled/ uncontrolled), colour vision and contrast visual acuity with other variables were explored by using Chi-square test. Mann-Whitney test was also applied to see the difference of fasting blood sugar, random blood sugar with diabetic status, colour vision acuity and contrast visual acuity. P-value < 0.05 was taken as significant. Further we used binary logistic regression analysis to check the association of contrast visual acuity with other variables. Variables with P-values less than 0.25 in univariate (crude) analysis were included in the multiple logistic regression (adjusted) analysis to assess the association of contrast visual acuity with other significant variables. Variables were added in the model one by one, starting with the most significant variable in the univariate analysis. Only those variables were considered to report from multiple logistic models which had p value less than 0.05. The contrast visual acuity was expressed with the effect size and 95% confidence interval.

RESULTS

A total of 200 patients were included in the study. Mean age of the patients was 50.23 ± 7.89 years and participants with > 50 years were 55.5% (n = 111) and < 50 years were 45.5% (n = 89). The frequency of males was slightly higher 51% (n = 102) as compared to females 49% (n = 98). Majority of the patients were married 87% (174). Defective Contrast sensitivity was observed in 20% (n = 40) of the patients. However, 30% (n = 60) patients had reduced scotopic vision. Colour vision deficiency was observed in three (1.5%) patients only. The median of fasting blood glucose was 130 with inter quartile range (IQR) (110 - 190) and random blood glucose was 220 with IQR (184 - 310). There were 66% (n = 132) diabetic patients with ≤ 15 years history of diabetes. T2DM was predominantly higher 76.5% (n = 153) as compared to T1DM 23.5% (n = 47). Most of the patients had controlled diabetes 60.5% (n = 121) while uncontrolled diabetes was observed in 39.5% (n = 79) patients. Refractive error was the most common complication noted in 66.5% (n = 133) patients, followed by cataract in 21.5% (n = 43),

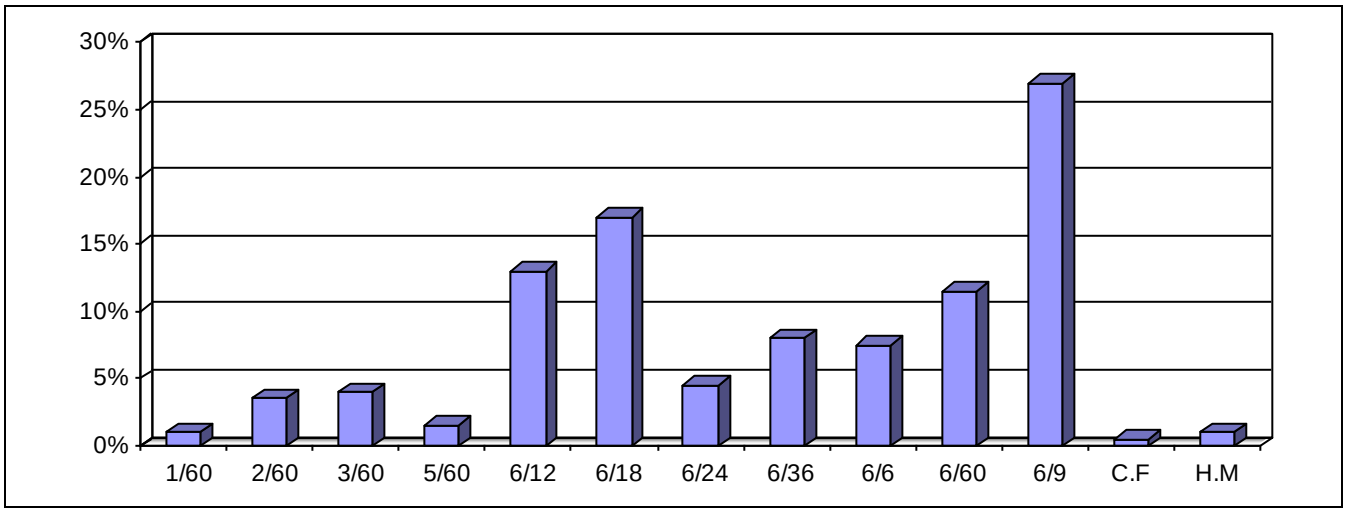

Figure 1: Snellen Visual Acuity of Right Eye.

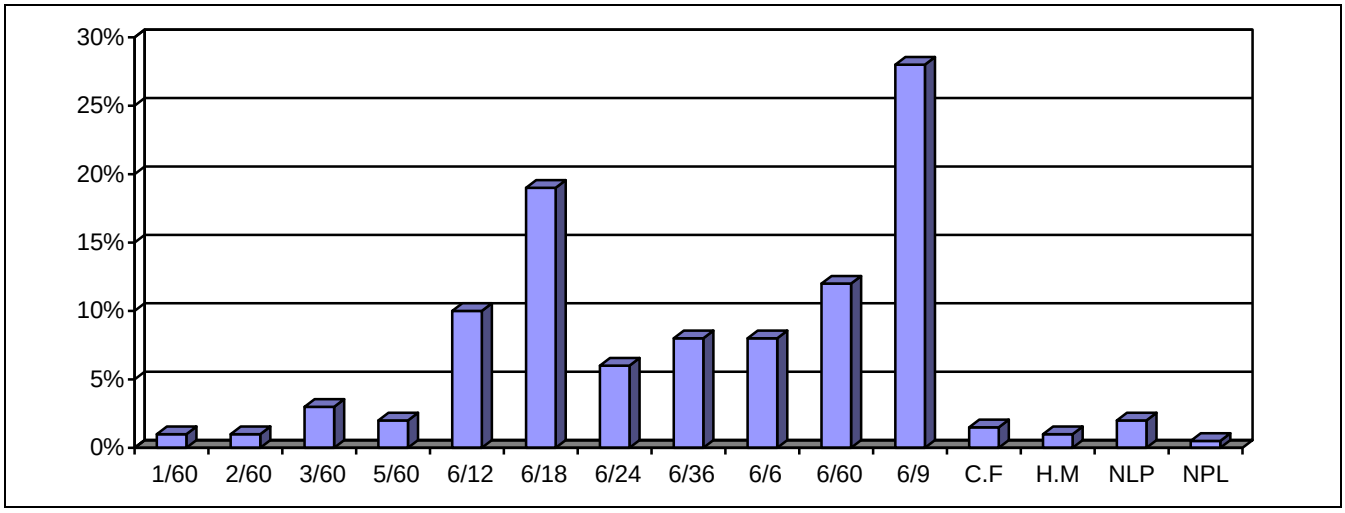

Fig. 2: Snellen Visual Acuity of Left Eye.

diabetic maculopathy/retinopathy in 1.5% (n = 3), history of eye surgery in 27% and use of glasses in 57% patients (Table 1).

By using univariate analysis, insignificant difference of controlled diabetes was observed with age (P_{chi}-value 0.737), gender (P_{chi}-value 0.098), marital status (P_{chi}-value 0.085), duration of diabetes (P_{chi}-value 0.513), types of diabetes (P_{chi}-value 0.882), history of eye surgery (P_{chi}-value 0.128), visual complications (P_{chi}-value 0.196) and using glasses (P_{chi}-value 0.195). Colour vision deficiency was only found significantly associated with diabetes status (controlled/uncontrolled) (P_{chi}-value 0.031) whereas contrast visual acuity (P_{chi}-value 0.560) and problem in scotopic vision (P_{chi}-value 0.298) was insignificantly associated with diabetic status. However, significant association of contrast visual acuity was observed with age (P_{chi}-value 0.05), problem in scotopic vision (<0.001), duration of diabetes (P_{chi}-value 0.03), type of diabetes (P_{chi}-value 0.04), use of glasses (P_{chi}-value 0.04) and complications (P_{chi}-value <0.001) (Table 2). By applying regression, participants with age group > 50 years had 2.0 folds more chances of having reduced contrast sensitivity than patients <50 years age (OR_{crude} = 2.0, 95% CI: 1.0 - 4.3). Patients having diabetes for more than 15 years, had 2.2 folds more chance of having reduced contrast visual acuity than those who had diabetes less than 15 years (OR_{crude} = 2.2 ,95% CI:1.0 - 4.4). Patients with T2DM were 60% less prone to have defective contrast visual acuity than those who

had T1DM (OR_{crude} = 0.4, 95% CI: 0.2 - 1.0). Diabetic patients who were using glasses had 2.2 folds more chance to have decreased contrast visual acuity than those who were not using glasses (OR_{crude} = 2.2, 95% CI: 1.0 - 4.0) (Table 3).

By using multivariate analysis, only uses of glasses (P_{adj} - value 0.05) remained significant after adjustment and types of diabetes was closed to significant (P_{adj} - value 0.09). Patients with T2DM were 50% less prone to have decreased contrast visual acuity than those who had T1DM (OR_{adj} = 0.5, 95% CI: 0.2 - 1.1) Diabetic patients who were using glasses, were 2.2 folds more susceptible to have contrast visual acuity defects than those who were not using glasses (OR_{adj} = 2.2 , 95% CI:1.0 – 4.7) (Table 3).

Table 1: Baseline Characteristics of the Patients (n = 200).

		n (%)
Age (years)		50.23 ± 7.89
	≤ 50	89 (44.5%)
	> 50	111 (55.5%)
Gender		
	Male	102 (51%)
	Female	98 (49%)
Marital Status		
	Single	11 (5.5%)
	Married	174 (87%)
	Widow	11 (5.5%)
	Divorced	4 (2%)
Reduced Contrast Sensitivity		40 (19.5%)
Reduced Colour visual acuity		3 (1.5%)
Reduced Scotopic vision		60 (30%)
RCBG		
	FBG	130 (110 - 190) *
	RBG	220 (184 - 310) *
Duration of Diabetes (years)		
	≤ 15	132 (66)
	> 15	68 (34)
Type of diabetes		
	Type 1	47 (23.5)
	Type 2	153 (76.5)
Status of diabetes		
	Controlled	121 (60.5)
	Uncontrolled	79 (39.5)
Visits in eye hospital		
	Every 3 months	29 (14.5)
	Every 6 months	44 (22)
Visual complications		
	Refractive Error	133 (66.5%)
	Diabetic MP/ RP	3 (1.5%)
	Cataract	43 (21.5%)
History of eye surgery		54 (27%)
Use glasses		115 (57.5%)

Note: Random capillary blood glucose (RCBG), fasting blood glucose (FBG), random blood glucose (RBG), Muculopathy (MP), Retinopathy (RP), *Median (IQR).

Table 2: Comparison of Contrast Visual Acuity with General Characteristics of the Patients (n = 200).

	Contrast Vision		p-value
	Normal	Abnormal	
Variables	**n (%)**	**n (%)**	
Age (years)			
≤ 50	77 (47.8)	12 (30.8)	0.054†
> 50	84 (52.2)	27 (69.2)	
Gender			
Male	81 (50.3)	21 (53.8)	0.692†
Female	80 (49.7)	18 (46.2)	
Marital Status			
Single	8 (5)	3 (7.7)	0.318†
Married	142 (88.2)	32 (82.1)	
Widow	7 (4.3)	4 (10.3)	
Divorced	4 (2.5)	0 (0)	
Reduced Scotopic vision			
Yes	23 (14.3%)	37 (94.9%)	< 0.001†*
No	138 (85.7%)	2 (5.1%)	
RBCB			
FBG	130 (110 - 180)	148 (111 - 233)	0.084‡
RBG	210 (180 - 285)	300 (200 - 330)	0.097‡
Duration of Diabetes (years)			
≤ 15	112 (69.6)	20 (51.3)	0.031†*
> 15	49 (30.4)	19 (48.7)	
Type of diabetes			
Type 1	33 (20.5)	14 (35.9)	0.042†*
Type 2	128 (79.5)	25 (64.1)	
Status of diabetes			
Controlled	99 (61.5)	22 (56.4)	0.56†
Uncontrolled	62 (38.5)	17 (43.6)	
History of eye surgery			
Yes	39 (24.2)	15 (38.5)	0.072†
No	122 (75.8)	24 (61.5)	
Use glasses			
Yes	87 (54)	28 (71.8)	0.044†*
No	74 (46)	11 (28.2)	
Visual Complications			
Refractive Error	131 (81.4)	2 (5.1)	< 0.001†*
Diabetic MP/RP	0 (0)	3 (7.7)	
Cataract	15 (9.3)	28 (71.8)	
Others	15 (9.3)	6 (15.4)	

Note: Random capillary blood glucose (RCBG), fasting blood glucose (FBG), random blood glucose (RBG), Muculopathy (MP), Retinopathy (RP).
†Chi-square test applied, ‡Mann-Whitney test applied, *p-value < 0.05.

Table 3: Regression Analysis for Variables Associated with Contrast Visual Acuity.

		Univariate Analysis		Multivariate Analysis	
		Crude OR (95% CI)	P-value	Adjusted OR (95%CI)	P-value
Gender	Female	1.0 (0.4 - 1.8)	**0.69**		NS
Age	> 50 years	2.0 (1.0 - 4.3)	0.05	2.0 (1.0 - 4.2)	0.12
Marital Status			**0.49**		NS
	Married	0.6 (0.1 - 2.4)	0.47		
	Widow	1.5 (0.3 - 9.3)	0.64		
	Divorced	0	0.99		
Duration of Diabetes	> 15 years	2.2 (1.0 - 4.4)	0.03	1.5 (1.0 - 3.2)	0.32
Types of Diabetes	Type 2	0.4 (0.2 - 1.0)	0.04	0.5 (0.2 - 1.1)	0.09
Status of Diabetes	Uncontrolled	1.2 (0.6 -3.0)	**0.56**		NS
History of eye surgery	Yes	2.0 (1.0 -4.0)	0.07	1.6 (0.7 - 3.5)	0.24
Uses of glasses	Yes	2.2 (1.0-4.0)	0.04	2.2 (1.0 - 4.7)	0.05

Note: OR = Odd ratio, CI = confidence interval, NS= not significant
Reference Categories: Male in Gender, < 50 years in Age, Single in Marital Status, < 15 years in Duration of Diabetes, Controlled in Status of Diabetes, No in History of Eye Surgery and No in Uses of Glasses.

DISCUSSION

The findings of our study showed increased rate of normal contrast sensitivity and short ratio of acquired colour vision deficiency in uncontrolled diabetic patients. Moreover, it was observed in our study that acquired colour vision deficiency was significantly correlated with the uncontrolled high blood glucose level[15]. It has also been reported in another study that there was an association of acquired colour vision deficiency with macular edema[16] and diabetic maculopathy was more likely to cause acquired colour vision deficiency. Therefore, the severity of diabetic retinopathy can cause diabetic maculopathy which was associated with colour vision[1,17,18]. Plausible reasons that macula was more affected in uncontrolled diabetic patients in which macula is responsible for central vision and it has large number of cones which support in colour vision. Meanwhile uncontrolled blood glucose level fails macula to transmit light, this affects the short cone wavelength cones. Furthermore, our study suggested that diabetic patients who were using glasses had two times more chances to have their contrast sensitivity reduced. Our findings were concurrent with previous study conducted by Alexandra Anton that patients who were using lenses than glasses had decreased contrast visual sensitivity[19]. Plausible reason of high prevalence of contrast sensitivity in diabetic patients with glasses that patients were using glasses only occasionally.

Our study found insignificant difference of controlled diabetes with age, gender, duration of diabetes and type of diabetes. The findings of our study were comparable with finding of previous study that controlled diabetic status was not dependend upon age, gender, and marital status, type of diabetes, duration of diabetes, history of eye surgery and use of glasses[17,20].

It was noted that age greater than 50 years, T2DM, greater than 15 years of diabetes, uses of glasses, vision problem in dim light and had some clinical signs of diabetic maculopathy predominantly showed contrast sensitivity defects. Reason behind it was, the dysfunction of contrast sensitivity occurred because of ocular disease like maculopathy, cataract, and severity of retinopathy. Our finding was concurrent with previous studies that diabetic retinopathy was the leading complication of diabetes in which colour vision defect, contrast sensitivity, absorptive loss of blue sensitivity vision and blindness were common[1,21].

Contrast sensitivity is a function of the retina. Even though, for early detection of maculopathy in the patients with diabetes mellitus, the measuring contrast sensitivity could be a beneficial tool and It could also

be beneficial in investigating the relationship between metabolic control and retinal function[19]. Moreover, other studies suggested that diabetic patients were at higher risk of getting contrast sensitivity problems because patients who have diabetes for more than 15 years had usually high blood glucose level with greater than 50 years of age and they do not know the cautionary measures that reduces their eye complications. These findings are consistent with past studies[7,8].

Although it has been revealed by different studies that central vision loss is caused by visual acuity and assessment of visual acuity with different tools is sufficient to measure visual impairment in Diabetic Retinopathy[22,23].

This study included both types of diabetes, i.e. type 1 and type 2 and we found predominately higher ratio of T2DM in patients. Our result showed no statistical association of types of diabetes with colour vision acuity; but an association of types of diabetes was found with contrast sensitivity impairment. In contrary, in another study, significant association of colour vision impairment was found in type 2 diabetic patients.[24]Nevertheless, in our study, T2DM had 60% less chance to have contrast visual acuity.

The limitations are that controlled and uncontrolled diabetic patients were enrolled with small sample size that is why short result of colour vision acuity was found. Moreover, we could not find significant results in association of colour vision and diabetes (controlled/uncontrolled) with other variables. It was a cross section and single centre study. Moreover, in this study, we have short time to evaluate the diabetes, colour vision acuity and contrast sensitivity, and we used quick and easy procedures. Therefore, we found diabetes by random capillary blood glucose, colour vision acuity by Ishihara test and contrast sensitivity by Pelli Robbson[20] and we did not use time consuming procedures which were more accurate. Furthermore, certain important information regarding diabetes risk factor was also noted like diabetic cataract, retinopathy, and variation in refractive state of eye during refraction in uncontrolled diabetes. Collection of this information along with above mentioned risk factors could help in better understanding the diabetic complications. However, the sub divisions of complications were found problematic in Regression analysis and variable of complications has been excluded from multivariate analysis to stabilize the result.

CONCLUSION

In this study, colour vision deficiency was found significantly associated with diabetes status (controlled/uncontrolled) while contrast vision was significantly associated with those who were using glasses.

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