ORIGINAL ARTICLE

# Visual Function Tests as a Cost Effective Screening Tool for Diabetic Retinopathy

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## ABSTRACT

**Purpose:** To find out the importance of visual function tests as cost effective screening tools for diabetic retinopathy.

**Study Design:** Descriptive, Cross sectional study.

**Place and Duration of Study:** Ophthalmology Unit of Holy Family Hospital, from September 2018 to November 2018.

**Material and Methods:** Two hundred and forty-two patients were selected by convenience sampling technique and were divided into three groups. Two groups of diabetics with and without retinopathy and one group of non-diabetics age-matched controls. After relevant history, patients were examined for Visual acuity, Color vision and Contrast sensitivity using Snellen's Chart, 24 Plates Ishihara Chart and Pelli Robson Chart respectively. Staging of retinopathy was done after mydriasis.

**Results:** Diabetic patients irrespective of type and stage, when compared with non-diabetic patients had a greater percentage of abnormal visual function tests. A 6/6 visual acuity was observed in 38.2% of non diabetics as compared to only 8.6% diabetics without retinopathy and 7.5% of diabetics with retinopathy. Color vision abnormalities were detected in only 8.6% of non diabetic patients. However, 11.1% of diabetics without retinopathy and 23.7% with retinopathy showed abnormalities of color vision. The percentage of abnormal Contrast sensitivity was 76.2% for diabetics with retinopathy and 60.4% for diabetics without retinopathy and 27.1% for non-diabetic patients.

**Conclusion:** Evaluation of Visual Acuity, Color Vision and Contrast Sensitivity are cheap and easy tests that can be used to screen for diabetic retinopathy thereby allowing early interventions to prevent development of serious ocular diabetic complications.

**Key Words:** Visual Acuity, Color Vision, Contrast Sensitivity, Diabetic Retinopathy.

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## INTRODUCTION

Diabetes mellitus is the leading cause of legal and irreversible blindness throughout the world[1]. Diabetic eye disease pertains diabetic retinopathy, cataract, glaucoma, macular edema with Diabetic Retinopathy (DR) being the most common ocular complication. Visual function changes appear in diabetics before any appreciable structural abnormalities can be detected by ophthalmoscopy and fluorescein angiography[2,3]. These changes include impaired Visual Acuity (VA), abnormal Contrast Sensitivity (CS) and defects in Color Vision (CV).

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Different tests have been devised to predict the development of DR[4,5]. Of which, Visual Function Tests are being recognized as sensitive screening tools before the development of clinically detectable DR and it may differentiate between various causes of visual loss.

The number of diabetics in Pakistan ranges from 6.2 million with one in every three diabetics suffering from diabetic eye disease. The purpose of this study is to find the determinative ability of Visual Function Tests as cost effective screening tools in patients with DR.

## MATERIAL AND METHODS

A hospital based, cross sectional study was carried out among three groups of patients; 2 groups of diabetics, of which one had diabetic retinopathy and the other had normal fundi. The third group was non-diabetic group. This study was conducted from September 2018 to November 2018 at Ophthalmology Unit of Holy Family Hospital, Rawalpindi.

The sample size was calculated by using the WHO sample size calculator. While keeping the level of confidence at 95%, absolute precision at 0.5% and prevalence at 19.5%, the minimum required sample size turned out to be 242.

All 242 patients, of age group 25 to 65 years were examined for their visual acuity, color vision, contrast sensitivity and stage of diabetic retinopathy. Patients with cataract, glaucoma, macular disorders, anterior segment pathologies and those having + 4/5 spherical DS or above were excluded from the study. Informed consent was taken from all the subjects after explaining to them the purpose of the study. The data was collected with the help of a structured questionnaire. The questionnaire was formulated to collect demographic details of all patients with their diabetic status, visual acuity, contrast sensitivity and color vision. The diabetics were asked about type of diabetes, duration of diabetes, control of diabetes and the kind of treatment they were taking.

The diabetic patients were classified on the basis of presence or absence of diabetic retinopathy. All diabetics were examined for stage of diabetic retinopathy using slit lamp Biomicroscopy, 90D lens and fundus photography following mydriasis. In this study, eyes were classified as no diabetic retinopathy (DR), non-proliferative diabetic retinopathy (NPDR), proliferative diabetic retinopathy (PDR) and macular edema. Visual acuity of all patients was measured using a Snellen Chart at a distance of 6 m. Color vision was tested using Ishihara 24 plates chart. The color vision was regarded as normal when greater than equal to 13 plates were read normally and abnormal when less than 9 plates were read normally. The plates were held at an arm's length (25 to 30 cm) from patient's eyes.

Contrast Sensitivity (CS) was assessed by using Pelli Robson Contrast Sensitivity Acuity Chart. Testing was carried out at a distance of 1 m (40 inches) with patients wearing their distance correction[6,7]. Pelli Robson Chart consists of horizontal lines of capital letters (6 per line), in which the contrast of letters decreases with each line. This chart tests patient's ability to detect letters that are gradually less contrasted against a white background. Each group has 3 letters of same contrast level, the score, a single number, is a measure of patient's log CS. Thus a score of 2 means, that the subject was able to read at least 2 of 3 letters with a contrast of 1%. CS = 100% or log 2. Normal score of contrast sensitivity was 2.0; that is 100%. Those who had a score below 1.5 were abnormal and this was recorded as decrease in CS[8].

SPSS version 22 was used to analyze all the data. For all the variables, frequencies and percentages were calculated and charts were made. For statistical analysis of the data one sample bimonial test was used. Using this test the colour vision and contrast sensitivity among three groups of non diabetics, diabetics without retinopathy and diabetics with retinopathy was analysed keeping CI of 95% and significance level of 0.05.

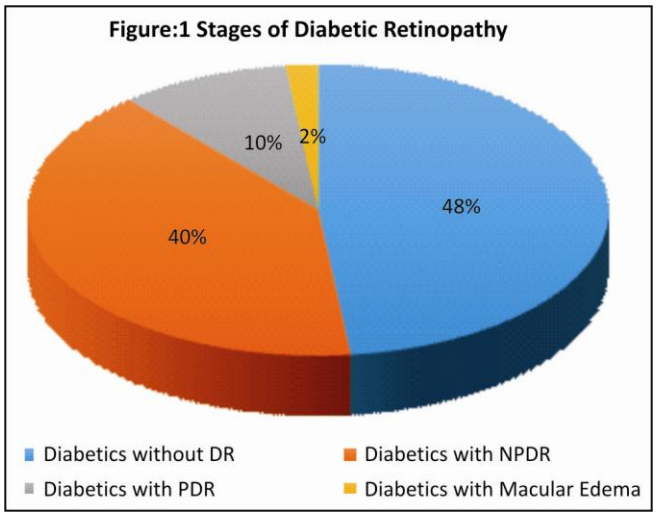
## RESULTS

A total of 242 patients were included in this study. Out of these patients, 161 patients were diabetic and 81 were non diabetic. Out of 161 diabetic patients, 27 (16.8%) were Type 1 and 134 (83.2%) were Type 2

**Table 1:** *General Characteristics of Patients (242).*

| Variable | | Frequency | Percentage |
|---|---|---|---|
| **Gender** | | | |
| | Males | 90 | 37.2% |
| | Females | 152 | 62.8% |
| | Total | 242 | 100% |
| **Diabetic Status** | | | |
| | Non Diabetics | 81 | 33.4% |
| | Diabetics with | 81 | 33.4% |

| Variable | | Frequency | Percentage |
|---|---|---|---|
| | no Retinopathy | | |
| | Diabetics with Retinopathy | 80 | 33.0% |
| | Total | 242 | 100% |
| **Type of Diabetes** | | | |
| | Type I | 27 | 16.8% |
| | Type II | 134 | 83.2% |
| **Control Status** | | | |
| | Good | 33 | 13.6% |
| | Average | 70 | 28.9% |
| | Poor | 58 | 24% |




diabetics. One hundred and fifty-two (62.8%) patients among this study were female and 90 (37.2%) were male. Patients from 25 to 65 years were included in this study with the age group 61-65 years was featured the most with 16.12%, followed by 46-50 and 56-60 years respectively.

This research shows that when diabetic patients, irrespective of type and stage are compared with non-diabetic patients, had a greater percentage of abnormal visual function tests. For details of distance visual acuity, color vision and contrast sensitivity among the three groups, refer to figure 2, table 2 and table 3. It was also evident from our results that of all the visual function tests, contrast sensitivity is affected the most in diabetic patients. Comparing all the three visual function tests, CS stands the most important in screening of the diabetic eye disease.

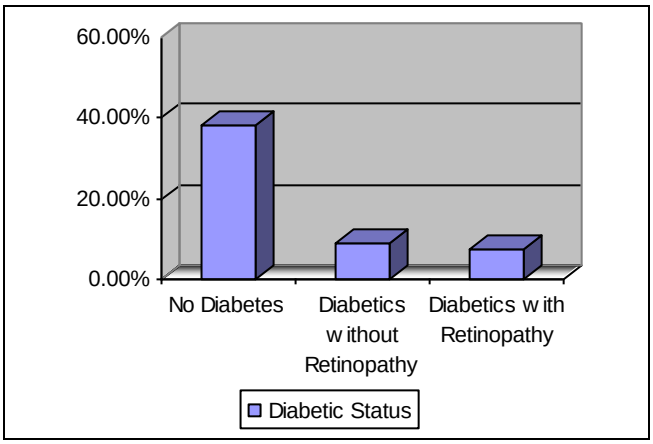



**Fig. 2:** Relationship between Diabetic Status and the Perfect Eye (6/6 VA) of the Patients.

**Table 2:** *Relationship between the Diabetic Status and Color Vision of the Patients.*

| Stage of Diabetes | CV Right (>/=13) n (%) | CV Right (<9) n (%) | CV Left (>/=13) n (%) | CV Left (<9) n (%) |
|---|---|---|---|---|
| No Diabetes | 74 (91.3%) | 7 (8.6%) | 74 (91.3%) | 7 (8.6%) |
| Diabetics without Retinopathy | 72 (88.8%) | 9 (11.1%) | 74 (91.3%) | 7 (8.6%) |
| Diabetics with NPDR | 55 (80.8%) | 13 (19.1%) | 52 (85.2%) | 9 (14.7%) |
| Diabetics with PDR | 9 (75%) | 3 (25%) | 3 (18.75%) | 3 (18.75%) |
| Diabetics with Macular Edema | 0 (0%) | 0 (0%) | 0 (0%) | 3 (100%) |

**Table 3:** *Relationship between the Diabetic Status and Contrast Sensitivity of the Patients.*

| Stage of Diabetes | CS Right (>/=1.5) n (%) | CS Right (<1.5) n (%) | CS Left (>/=1.5) n (%) | CS Left (<1.5) n (%) |
|---|---|---|---|---|
| No Diabetes | 65 (80.2%) | 16 (19.7%) | 59 (72.8%) | 22 (27%) |
| Diabetics without Retinopathy | 39 (48.1%) | 42 (51.8%) | 32 (39.5%) | 49 (60.4%) |
| Diabetics with NPDR | 25 (36.7%) | 43 (63.2%) | 16 (26%) | 45 (73.7%) |
| Diabetics with PDR | 3 (25%) | 9 (75%) | 3 (18.75%) | 13 (81%) |
| Diabetics with Macular Edema | 0 (0%) | 0 (0%) | 0 (0%) | 3 (100%) |

## DISCUSSION

The present study revealed an association between impaired visual function tests and the diabetic status of the patients. This study showed that visual acuity markedly decreased with the development of diabetes and that diabetics with increasing stage of diabetic retinopathy are less likely to have 6/6 visual acuity. Reduction in the visual acuity in diabetic patients can be ascribed to increasing stage of DR, hazy cornea and variation in refraction caused by unstable glucose levels in the blood[9]. Various studies have shown that visual acuity can be assessed by different tools and that visual acuity is sufficient to measure the visual impairment in diabetic patients[10,11].

According to the study published in 2015 there is a marked association between the acquired color vision deficiency and high blood glucose levels[12]. The findings in our study showed that deficiency in color vision is linked to the diabetic status of the patient and as the stage of diabetic retinopathy increases, the likelihood of abnormal color vision also increases. Patients with macular edema are unable to differentiate among short wavelengths of color and thus perform poor on color vision test.

It has been demonstrated in another research that diabetic maculopathy was more likely to cause abnormal color vision[13]. The most authentic justification of this impression is that macula is responsible for central vision and most of the cones are located at macula. Increased blood glucose levels impair macular function to transmit light which affect short wavelength cones giving impaired color vision.

Davies and Ong conducted studies and revealed a significant color vision deficiency in subjects with retinopathy especially in the yellow blue spectral region[14,15]. Similarly Wong et al discovered a positive correlation between color discrimination and extent of retinopathy[16]. Sixty-five percent of the patients who had diabetic retinopathy had abnormal 100-hue test and those with end stage DR especially macular edema were affected the most. In a separate study, Verrotti et al also found that subjects who had PDR were unable to perform on color vision test[17].

The present study established that non diabetics have better contrast sensitivity than the diabetic patients, diabetics with no retinopathy performs better on Pelli Robson Chart than the diabetics with NPDR, PDR and macular edema. Starvo and Wood used a high contrast Bailey Lovie chart and Pelli Robson chart in 20 type II diabetic patients and 24 age matched control subjects and established that the loss of CS is more in patients with retinopathy compared to the control subjects[2].

According to Abrishami et al study, the loss in CS is not only attributed to the retinal changes but also to lens changes[18]. In the present study we have excluded all the subjects with lens changes. A study by Macki and Walsh emphasized on the CS threshold. According to them CS threshold is seen to be increased in diabetic group who had PDR or background DR more than in patients with no retinopathy[19]. This finding is consistent with our results that loss in CS is attributed to the diabetic status and increasing stage of DR of the patients. Lobo et al and Lovestam Adrian et al both showed a relationship of loss of CS with degree of retinopathy[20,21].

The reason behind decrease in CS in diabetics is not clear. The possible mechanism, which can be accepted theoretically, is the abnormal accumulation of fluid in retina or impairment of neural functions in retina by overloading aldose reductase system. CS is a function of the retina and CS impairment is associated with degree of retinopathy. This makes CS a beneficial tool in finding early retinal changes. The findings of our study are concurrent with previous studies that the leading complication of diabetes is diabetic retinopathy in which all the visual function defects are observed[22,23].

The limitations of this study included limited time frame to evaluate the diabetes, visual acuity, color vision, contrast sensitivity. Furthermore, it was conducted in a single center and the subjects enrolled in this study were mostly illiterate which makes the results of charts reading less effective.

## CONCLUSION

Visual function tests are easy to perform and can be used to screen the patients with DR in Basic Health Units and Diabetic Clinics. By using these tests diabetic retinopathy can be treated at early stage.

### Ethical Approval

The study was approved by the Institutional review board/Ethical review board.

### Conflict of Interest

Authors declared no conflict of interest

## Authors' Designation and Contribution

Faryal Ahmed; House Officer: *Study design, data collection, manuscript writing, final review.*

Faraz Iftikhar Malik; House Officer: *Data analysis, manuscript writing.*

Chaudhary Ehtsham Azmat; House Officer: *Data analysis, manuscript writing.*

Ambreen Gul; Senior Registrar: *Study Concept, final review.*

Ali Raza; Professor: *Final review*.

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