Correlation of visual acuity and contrast sensitivity in visually disabled patients of moderate to severe diabetic retinopathy

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Abstract

Purpose: Aims of this study is to characterise the visual disability of patients of moderate to severe diabetic retinopathy in terms of logarithm of minimum angle of resolution (LogMAR) visual acuity and contrast sensitivity.

Methods: A total of 30 eyes with moderate to severe diabetic retinopathy having low vision (WHO Criteria) with predefined inclusion and exclusion criteria were included as cases and 40 eyes with normal or near normal visual status correctable by refraction were included as control in the study. The visual acuity and contrast sensitivity were noted and analysed.

Results: The best corrected visual acuity (BCVA) of all eyes in control group is less than 0.5 LogMAR units. Among cases, 29(96.7%) eyes have BCVA in the range of 0.5 to 1.0 LogMAR units and 1(3.3%) eye has BCVA in the range of 1.0 to 1.3 LogMAR units, satisfying the inclusion criteria significantly (p value < 0.001). In case group, direct correlation of association is observed between uncorrected visual acuity and best corrected visual acuity (r = 0.69), near visual acuity (r = 0.49), best corrected near visual acuity (r = 0.64) and inverse correlation of association with contrast sensitivity (r = -0.65) which are statistically significant (p value <0.05).

Conclusions: In patients of diabetic retinopathy with visual impairment, irrespective of varying pathology of visual impairment, there is a negative correlation between contrast sensitivity and visual acuity in logMAR units. The logMAR visual acuity and contrast sensitivity is a better tool than vision assessment by snellen chart for evaluation, monitoring and prescription of low vision devices in subjects with visual impairment.

Keywords: Contrast sensitivity, Diabetic retinopathy, LogMAR visual acuity, Visual impairement.

Introduction

Around 300 million diabetic patients are estimated worldwide by 2025 and India will have the highest numbers reaching around 57 millions.[1] With increase in life expectancy, the incidence of diabetic retinopathy (DR) has also increased. DR accounts for almost 12% of all blindness in United States.[2]

The visual function to be affected first by DR is contrast sensitivity. Most of the daily visual tasks require the detection of objects with low contrast; therefore a more sensitive method than Snellen letter acuity for assessing visual function would aid the detection of diabetic eye disease as explained by impaired contrast sensitivity. Therefore, contrast sensitivity correlates better than visual acuity to the real visual function.[3, 4]

The complex nature and varying pathology leading to visual impairement and associated multisystem involvement in diabetic retinopathy patients not only make visual rehabilitation difficult and challenging,[5, 6] but also substantially decreases patients' utility value and quality of life.[7]

Several studies have correlated visual acuity, mostly distant visual acuity and contrast sensitivity with various parameters related to disease processes and etiopathogenesis. Very few studies have correlated logMAR visual acuity for distant and near contrast sensitivity for the purpose of evaluation and prescription of low vision devices.

Methods

The study has been approved by the institutional review board and informed consent has been obtained from each individual. The study followed the tenets of the declaration of Helsinki. A total of 30 eyes with the diagnosis of moderate to severe diabetic retinopathy having low vision by World health organisation (WHO) Criteria[8] with predefined inclusion criteria of patient giving consent and having moderate and severe diabetic retinopathy (severe non-proliferative and/or proliferative diabetic retinopathy, early treatment diabetic retinopathy study classification; ETDRS) with visual acuity less than 6/18 to hand movement were included as cases. Whereas, unwilling patients and patients with any other associated ocular disease e.g. Uveitis, corneal disorders etc. or systemic disease e.g. Thyroid disorders etc. were excluded from the case group in this study. Among control group, 40 eyes with normal or near normal visual status correctable by refraction were included in this study.

Patients underwent detailed ophthalmological examinations including visual acuity (LogMAR), contrast sensitivity (Pelli-Robson chart), slit lamp examination and slit lamp biomicroscopy with 78 Diopter lens (78D), indirect ophthalmoscopy for quantifying and diagnosing as moderate to severe diabetic retinopathy.

The visual acuity of the patients was measured using the Bailey–Lovie logMAR visual acuity chart for distance and Bailey–Lovie word reading charts for near.

The contrast sensitivity was measured using the standardized illuminated Pelli-Robson chart.

The statistical analysis software SPSS (Statistical Package for the Social Sciences) version 17 (IBM SPSS Statistics for windows, SPSSInc., USA) was used to compare the logMAR visual acuity scores with the Pelli-Robson contrast sensitivity scores for all the patients. The non-parametric Kruskal-Wallis Test was used to find the significant difference among the mean values because of lack of normalcy of the data among groups. Mann-Whitney U Test was used for paired comparison of various parameters between control and cases individually and also between the two groups of cases. Pearson correlation coefficient test was used to study the correlation of association of various parameters within the group p value <0.05 was considered statistically significant.

Results

The youngest individual was 17 years and the oldest was 68 years old. Among cases, 4(13.3%) eyes belong to 36 to 45 years of age group, 10 (33.3%) eyes belong to age group 46 to 55, 12(40%) eyes belong to age group 56 to 65 and 4 (13.3%) eyes belong to age group 66 to 75, whereas no eyes belong to less than 35 years of age group. Among cases, 6(20%) eyes belong to female individuals and 24(80%) eyes belong to male individuals; whereas in control group, 12(30%) eyes were of female individuals and 28(70%) eyes were of male individuals.

All eyes in control group are having visual acuity less than 0.5 LogMAR units. In case group, 29(96.7%) eyes have visual acuity in the range of 0.5 to 1.0 LogMAR units (WHO category I, moderate visual impairement) and 1(3.3%) eyes have visual acuity in the range of 1.0 to 1.3 LogMAR units (WHO category II, severe visual impairment). Both the case and the control groups are satisfying the inclusion criteria significantly with p value < 0.001 (chi square test).

The values of uncorrected visual acuity, best corrected visual acuity and contrast sensitivity are shown in table1.

Table 1: Baseline characteristics of visual acuity and contrast sensitivity assessment for case and control groups

	UCVA			BCVA			CS		
	Min.	**Max.**	**Mean (SD)**	**Min.**	**Max.**	**Mean (SD)**	**Min.**	**Max.**	**Mean (SD)**
Case	0.8	1.38	1.15(0.20)	0.60	1.06	0.70(0.16)	0.35	1.35	0.94(0.26)
Control	0.02	0.54	0.34(0.14)	0.00	0.24	0.09(0.08)	1.55	2.23	1.82(0.20)
Test of Significance of Mean Among the Groups (Kruskal- Wallis Test)	p value < 0.05			p value < 0.05			p value < 0.05		

Min.- minimum, Max.- Maximum, SD – Standard deviation, UCVA – Uncorrected visual acuity, BCVA – Best corrected visual acuity, CS – Contrast sensitivity.

The values of minimum and maximum uncorrected visual acuity (UCVA) in LogMAR units range from 0.8 to 1.38 in case group and 0.02 to 0.54 in control group. The mean of uncorrected visual acuity among case and control groups are 1.15(SD 0.20) and 0.34(SD 0.14) showing significant difference of UCVA among the groups with p value < 0.05 (Kruskal- Wallis Test).

The value of minimum and maximum best corrected visual acuity (BCVA) in LogMAR units is 0.60 to 1.06 in case group and 0.00 to 0.24 in control group. The mean of BCVA among case and control groups are 0.70 (SD 0.16) and 0.09 (SD 0.08) showing significant difference of BCVA among the groups (p value < 0.05) with cases having poorer visual acuity in spite of best refractive correction to the eyes.

The value of minimum and maximum contrast sensitivity (CS) in Logarithmic units is 0.35 to 1.35 in case group and 1.55 to 2.23 in control group. The mean of CS among case and control groups are 0.94 (SD 0.26) and 1.82 (SD 0.20) with cases having poorer CS (p value < 0.05).

The minimum and maximum near visual acuity are 1.10 to 1.60 logMAR units in case group and 0.70 to 1.20 logMAR units in control group and the minimum and maximum best corrected near visual acuity are 0.90 to 1.40 logMAR units in case group and 0.50 to 0.80 logMAR units in control group with significant difference for both near visual acuity and best corrected near visual acuity (p value < 0.05) showing cases are having poorer near and best corrected near visual acuity.

The paired comparison of the parameters i.e. UCVA, BCVA, CS, near visual acuity and best corrected near visual acuity of the cases with the same parameters of the control group is done using Mann-Whitney U Test. A significant difference with p value <

0.05 is found for all the parameters between the case and control group. (Table 2).

Table 2: Paired comparison of various parameters between cases and control group individually (Mann-Whitney U Test)

Paired comparison of parameters among case and control group	Uncorrected visual acuity	Best corrected visual acuity	Contrast sensitivity	Near visual acuity	Best corrected near visual acuity
Mann-Whitney U Test	P value <0.001	P value <0.001	P value <0.001	P value <0.001	P value <0.001

The study of correlation of association using Pearson correlation coefficient test was done among the parameters i.e. uncorrected visual acuity, best corrected visual acuity, contrast sensitivity near visual acuity and best corrected near visual acuity within the individual group separately. (Table 3)

Table 3: Correlation study of association of various parameters within the group using pearson correlation coefficient test

Parameters Groups	Best corrected visual acuity	Contrast sensitivity	Near visual acuity	Best corrected near visual acuity
Uncorrected visual acuity (case)	r = 0.69 p value < 0.001	r = -0.65 p value <0.001	r = 0.49 p value 0.006	r = 0.64 p value <0.001
Uncorrected visual acuity (Control)	r = 0.75 p value <0.001	r = -0.44 p value <0.001	r = 0.77 p value <0.001	r = 0.74 p value <0.001

Among cases, direct correlation of association is observed between uncorrected visual acuity and best corrected visual acuity (r = 0.69, p value < 0.001), near visual acuity (r = 0.49, p value <0.001), best corrected near visual acuity (r = 0.64, p value < 0.001) and inverse correlation of association with contrast sensitivity (r = -0.65, p value < 0.001) which are statistically significant (p value <0.05). Similarly among control group, the statistically significant association with p value < 0.05 is observed between uncorrected visual acuity and best corrected visual acuity (r = 0.75, p value <0.001), near visual acuity (r = 0.77, p value <0.001), best corrected near visual acuity (r = 0.74, p value <0.001) and inverse relationship with contrast sensitivity (r = -0.44, p value <0.001).

Discussion

In our study, all eyes in control group are having visual acuity less than 0.5 LogMAR units. In case group, 29(96.7%) eyes have visual acuity in the range of 0.5 to 1.0 LogMAR units (moderate visual impairement) and 1(3.3%) eyes have visual acuity in the range of 1.0 to 1.3 LogMAR units (severe visual impairement). Both the case and the control groups are satisfying the inclusion criteria significantly with p value < 0.001 (chi square test).

We observed that the value of minimum and maximum best corrected visual acuity (BCVA) in LogMAR units is 0.60 to 1.06 in case group and 0.00 to 0.24 in control group. The mean of BCVA among case and control groups are 0.70 (SD 0.11) and 0.09 (SD 0.08) showing significant difference of BCVA among the groups (p value < 0.05) with cases having poorer visual acuity in spite of best refractive correction to the eyes similar to that of the studies by Misra, Shaili, et al.[4] In their study in 2010 mean LogMAR visual acuity (VA) was 0.353±0.231in non-proliferative diabetic retinopathy, 0.300±0.020 in early proliferative diabetic retinopathy cases and 0.187±0.232 in the control group. Statistically significant difference for LogMAR VA was observed between controls and cases with non-proliferative diabetic retinopathy (t test, p<0.001) respectively.[4]

In our study, the value of minimum and maximum contrast sensitivity (CS) in logarithmic units is 0.35 to 1.35 in case group and 1.55 to 2.23 in control group. The mean of CS among case and control groups are 0.94 (SD 0.26) and 1.82 (SD 0.20) with cases having poorer CS (p value < 0.05) similar to that of the studies by Howes Sc et al.[9, 10] They found a systematic decrease in contrast sensitivity (from normal control group) with increase in retinopathy grading.[9, 10] Similarly, Misra, Shaili et al. found that mean contrast sensitivity was 1.161±0.233 in non-proliferative diabetic retinopathy, 0.920± 0.027 in early proliferative diabetic retinopathy cases and 1.428±0.271 in the control group. Statistically significant difference for contrast sensitivity was observed between control and cases with non-proliferative diabetic retinopathy (t test, p<0.001) respectively.[4]

The significant findings of our study are compared with the relevant findings of previous study in table 4.

Table 4: Comparison of our study with previous study

Parameters	Our study		Mishra Shaili et al.'s study
	Case group	Control group	
Uncorrected visual acuity	Mean 1.15, SD 0.20	Mean 0.34, SD 0.14	Non-proliferative diabetic retinopathy group - Mean 0.353±0.231, Early proliferative Diabetic retinopathy group - Mean 0.300±0.020, Control group – Mean 0.187±0.232
Best corrected visual acuity	Mean 0.70, SD 0.11	Mean 0.09, SD 0.08	
Contrast sensitivity	Mean 0.94, SD 0.26	Mean 1.82, SD 0.20	Non-proliferative diabetic retinopathy group - Mean 1.161±0.233, Early proliferative Diabetic retinopathy group - Mean 0.920± 0.027, Control group - Mean 1.428±0.271

SD – Standard deviation

There is a positive correlation between decreases in contrast sensitivity and visual impairement in patients of diabetic retinopathy with poor visual acuity irrespective of varying pathology of visual impairment in diabetic retinopathy. LogMAR visual acuity chart and its near vision equivalent greatly simplify the process of calculating the estimated magnification required by the patient, therefore its clinical importance for testing and monitoring the visual status of our patients can now be realised and implemented for prescription of low vision devices with ease.

References

1. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. Diabetes care. 1998 Sep 1;21(9):1414-31.
2. Miki E, Lu M, Lee ET, Keen H, Bennett PH, Russell D, WHO Multinational Study Group. The incidence of visual impairment and its determinants in the WHO Multinational Study of Vascular Disease in Diabetes. Diabetologia. 2001 Sep 1;44(2):S31.
3. Sokol S, Moskowitz A, Skarf B, Evans R, Molitch M, Senior B. Contrast sensitivity in diabetics with and without background retinopathy. Archives of ophthalmology. 1985 Jan 1;103(1):51-4.
4. Misra S, Saxena S, Kishore P, Bhasker SK, Misra A, Meyer CH. Association of contrast sensitivity with LogMAR visual acuity and glycosylated hemoglobin in non-insulin dependent diabetes mellitus. Journal of ocular biology, diseases, and informatics. 2010 Jun 1;3(2):60-3.
5. Ahmadian L, Massof R. Does functional vision behave differently in low-vision patients with diabetic retinopathy?—a case-matched study. Investigative ophthalmology & visual science. 2008 Sep 1;49(9):4051-7.
6. Demers-Turco P. Providing timely and ongoing vision rehabilitation services for the diabetic patient with irreversible vision loss from diabetic retinopathy. Journal of the American Optometric Association. 1999 Jan;70(1):49-62.
7. Brown MM, Brown GC, Sharma S, Shah G. Utility values and diabetic retinopathy. American journal of ophthalmology. 1999 Sep 1;128(3):324-30.
8. World Health Organization International Statistical Classification of Diseases and Related Health Problems 10th revision, Version 2016, chapter VII, H54 Visual impairment including blindness (binocular or monocular); classification of severity of visual impairment recommended by the Resolution of the International Council of Ophthalmology (2002) and the Recommendations of the WHO Consultation on "Development of Standards for Characterization of Vision Loss and Visual Functioning" (September 2003).
9. Howes, Sharon C, Caelli T, Mitchell P. Contrast sensitivity in diabetics with retinopathy and cataract. Clinical & Experimental Ophthalmology. 1982 Aug 1;10(3):173-8.
10. Verriest G. Further studies on acquired deficiency of colour discrimination. J. Ophthal Soc Am 1963;53(1):185-195.