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Evaluation of Macular retinal sensitivity and its role in foveal function among diabetic and non-diabetic patients with normal acuity

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Abstract:

Objective: To evaluate macular retinal sensitivity and its role in foveal function among diabetic and non-diabetic patients with normal acuity.

Material and Method: Participants in this cross-sectional, prospective, observational, descriptive research with and without type 2 diabetes mellitus did not exhibit any abnormalities in their eyes. The study, which was conducted at the University of Lahore Teaching Hospital from June 15, 2023, to June 30, 2024, had 33 diabetes participants and 30 non-diabetic subjects who were age-matched. The subjects, who might be of any gender and ages, exhibited stable fixation, corrected visual acuity of 20/20, and no ocular media opacities. Participants were chosen by non-randomized sequential sampling.

Results: The evaluation consisted of 80 eyes from 63 people, ranging in age from 45 to 75 years (mean, 54.2 ± S.E. 0.97); 55 eyes (68.75%) belonged to females. The tests were deemed credible since the mean fixation losses were 0.4 ± 0.09 and the test length ranged from 5.43 to 7.04 min (mean 6.05 ± 0.08). Group 1 (Table 1) consisted of forty eyes from 30 participants without diabetes; their ages ranged from 45 to 75 years old (mean 52.7 ± 2.4). Fifity five eyes (68.75%%) belonged to females, and their foveal sensitivity ranged from 28 to 40 dB (mean 35.78 ± 0.6). In the second group, 25 eyes (62.5%) belonged to females and 40 eyes (mean 55.8 ± 1.4) of 33 people with diabetes but no retinopathy were assessed. The participants ranged in age from 45 to 75 years. The foveal sensitivity measured was 33.88 ± 0.7dB. Foveal sensitivity and perimetry points for the two groups are shown in Tables 2-4. Table 3 shows that group 1 had greater mean sensitivity than group 2 at particular stages (6, 9, 12, and 15). Table 2 shows bivariate correlations. Due to group 2's lower sensitivity in decibels, this indicates that group 2 needs a higher brightness (Asb) in order to perceive stimuli. According to Table 4, there was a 41 percent difference in proportion between groups at point 15, although point 7 stayed the same. At point 15, focal sensitivity revealed a correlation of 35%.

Conclusion: Diabetics have reduced macular and foveal sensitivity than non-diabetics even eyesight is normal. This decline may indicate early functional retinal impairment that occurs prior to noticeable vision loss. Point 1 significantly enhanced foveal sensitivity in people with diabetes.The findings emphasize the need of assessing macular sensitivity in order to detect retinal damage in diabetic patients early on. These findings provide possible methods for monitoring and detecting diabetic retinopathy.

Keywords: Foveal sensitivity, Macular retinal sensitivity, Diabetic and non-diabetic

Introduction:

Retinal sensitivity (RS) testing is necessary to measure retinal acuity, which is the gold standard for evaluating visual function, their evaluation is not complete without them[1].Using a threshold perimetry test that assesses 20◦ and 30◦ central vision, the capacity to discriminate a stimulus light from background illumination is known as Retinal sensitivity (RS)[2], and it is a useful tool for identifying conditions that cause decreases in the visual field, including glaucoma and similar optic neuropathies[3,4].Threshold tests of 6◦ and 10◦ can be used to diagnose disorders of the macular center, or fovea, which is the most sensitive part of the retina. These diseases induce a localized drop of retinal sensitivity [5,6]. A measurement of the macula's overall function may be made using the central macular threshold of 6 dB, which assesses the fovea and 6^0 locations surrounding it[7]. Retinal sensitivity may diminish in systemic disorders such type 2 diabetes mellitus, even without clinical signs of diabetic retinopathy.[8]. Reactive oxygen species and angiotensin II may disrupt photoreceptor signal transmission to the central nervous system[9].

The average foveal sensitivity in diabetics with focal macular edema without involvement of the foveal center is 29.84 ± 4.48 dB[10]. To calculate the extent of dysfunction this indicates, it is required to know the foveal sensitivity values in patients without retinopathy and in subjects with diabetes without retinopathy, which have not been published in our study. Diabetes may impact any area of the macula and diminish foveal sensitivity, even in the absence of retinopathy or vision loss. Determining the relationship between sensitivity in the areas near to the fovea and foveal sensitivity is necessary to limit retinal damage in eyes without retinopathy that have normal visual acuity. A research was conducted to examine the macular threshold test results for retinal sensitivity in participants without diabetes who had normal visual acuity with those with diabetes who had no retinopathy. Furthermore, the analysis of macular perimetry refers to alterations in foveal sensitivity was performed on participants without diabetes and compared to those with diabetes.

Material and Method:

Participants in this cross-sectional, prospective, observational, descriptive research with and without type 2 diabetes mellitus did not exhibit any abnormalities in their eyes. The study, which was conducted at the University of Lahore Teaching Hospital from June 15, 2023, to June 30, 2024, had 33 diabetes participants and 30 non-diabetic subjects who were age-matched. The subjects, who might be of any gender and ages, exhibited stable fixation, corrected visual acuity of 20/20, and no ocular media opacities. Participants were chosen by non-randomized sequential sampling.The study excluded participants who were being evaluated for a possible diabetes diagnosis and those with a history of posterior segment ocular disease, cataract surgery, or refractive surgery. Individuals with diabetes were allocated to group 2, whereas those without the disease were placed to group 1. Subjects with low reliability macular perimetry were excluded. By using Humphrey's computerized perimetry equipment to measure the achromatic macular threshold test at a 6 degree angle, the outcome variable was retinal sensitivity, which is operationally defined as the capacity to discern a stimulus light from background illumination. The foveal sensitivity was automatically measured by the instrument at sixteen locations around the fovea and expressed in decibels (dB); one researcher conducted all of the macular threshold tests.

The test was reliable for descriptive purposes when fixation losses were less than 20% (2.4). The mean sensitivity at 18 locations and foveal sensitivity were evaluated in both groups. The Kolmogorov-Smirnov test was performed to determine if the variables were normal.

The Mann-Whitney U test was used to compare mean sensitivity at each point and foveal sensitivity between groups. A Spearman's test was utilized to determine the relationship between foveal sensitivity and each of the 18 points in each group. A multivariate regression analysis was conducted in each group to find perimetry points that influenced foveal sensitivity.A p-value < 0.05 indicated significance.

Results:

The evaluation consisted of 80 eyes from 63 people, ranging in age from 45 to 75 years (mean, 54.2 ± S.E. 0.97); 55 eyes (68.75%) belonged to females. The tests were deemed credible since the mean fixation losses were 0.4 ± 0.09 and the test length ranged from 5.43 to 7.04 min (mean 6.05 ± 0.08).

Group 1 (Table 1) consisted of forty eyes from 30 participants without diabetes; their ages ranged from 45 to 75 years old (mean 52.7 ± 2.4). Fifity five eyes (68.75%%) belonged to females, and their foveal sensitivity ranged from 28 to 40 dB (mean 35.78 ± 0.6). In the second group, 25 eyes (62.5%) belonged to females and 40 eyes (mean 55.8 ± 1.4) of 33 people with diabetes but no retinopathy were assessed. The participants ranged in age from 45 to 75 years. The foveal sensitivity measured was 33.88 ± 0.7dB. Foveal sensitivity and perimetry points for the two groups are shown in Tables 2-4. Table 3 shows that group 1 had greater mean sensitivity than group 2 at particular stages (6, 9, 12, and 15). Table 2 shows bivariate correlations. Due to group 2's lower sensitivity in decibels, this indicates that group 2 needs a higher brightness (Asb) in order to perceive stimuli. According to Table 4, there was a 41 percent difference in proportion between groups at point 15, although point 7 stayed the same. At point 15, foveal sensitivity revealed a correlation of 35%.The paracentral macular region, represented by points 9, 6, and 12, needed the largest % increases following foveal sensitivity; the temporal visual field, representing the nasal retina's function, was represented by points 13 and 10, which had the lowest percentage changes. Out of the five points, only point 1 contributed to the regression model in group 2, whereas the other four points (points 1, 4, 7, 8, and 15) showed a correlation of less than or equal to 0.4 with the foveal sensitivity in group 1. Point 7 in this group added to the model, and it showed an increase in correlation with foveal sensitivity from 0.40 to 0.48; point 15's correlation was among the lowest.

In terms of anatomy, the nasal visual field’s temporal portion of the retina contributed most to the foveal sensitivity in both groups. The point that increased foveal sensitivity in participants without diabetes had a central location; in patients with diabetes, however, the sensitivity of the central points was reduced; hence, paracentral points had the greatest impact on foveal sensitivity.

Table 1: Characteristics per group

Variables	**Group 1**	**Group 2**
No.of Patients	30	33
No.of eyes	40	40
Gender (M/F)	7/23	8/25
Foveal Sensitivity	35.78 ± 0.6	33.88 ± 0.7

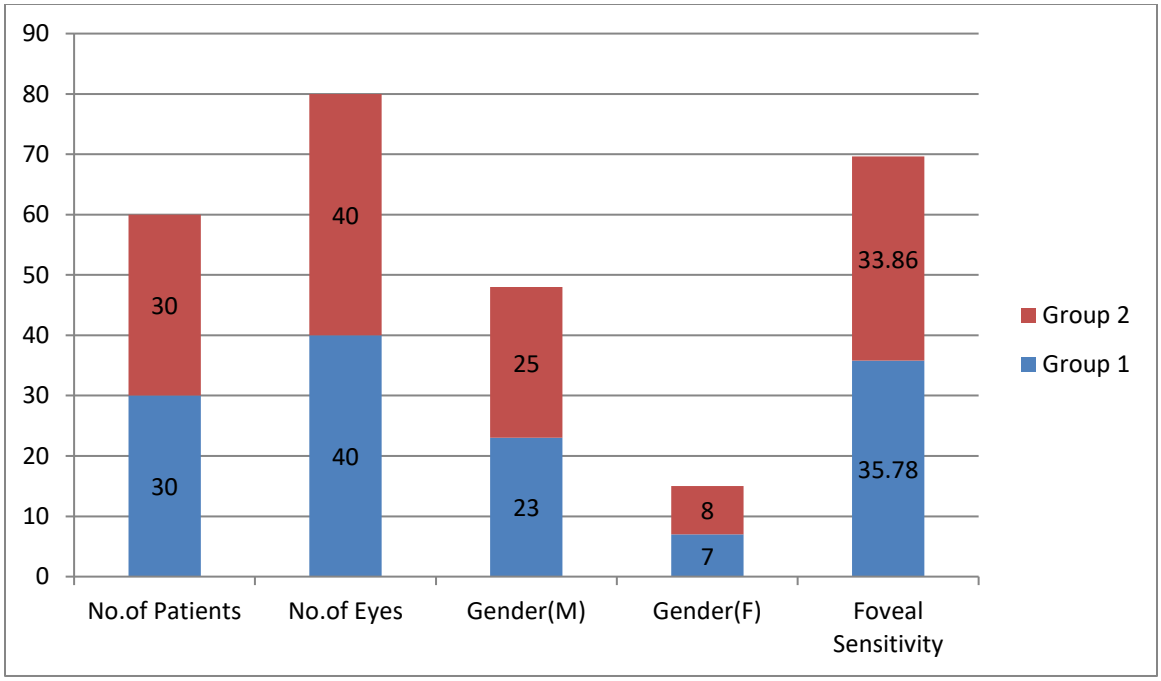


Table 2: Retinal sensitivity coefficient and Foveal sensitivity Coefficient with and without diabetes

Position Point	Foveal Sensitivity	
	Group1	Group 2
1	0.63	0.17
2	0.31	0.28
3	0.33	0.08
4	0.47	0.21
5	0.40	0.24
6	0.06	0.14
7	0.41	0.49
8	0.43	0.30
9	0.23	0.20
10	0.15	0.08
11	0.36	0.14
12	0.39	0.07
13	0.12	0.20
14	0.36	0.25
15	0.45	0.08
16	0.11	0.21
17	0.37	0.15
18	0.44	0.31
Spearman's rho test P value <0.05		

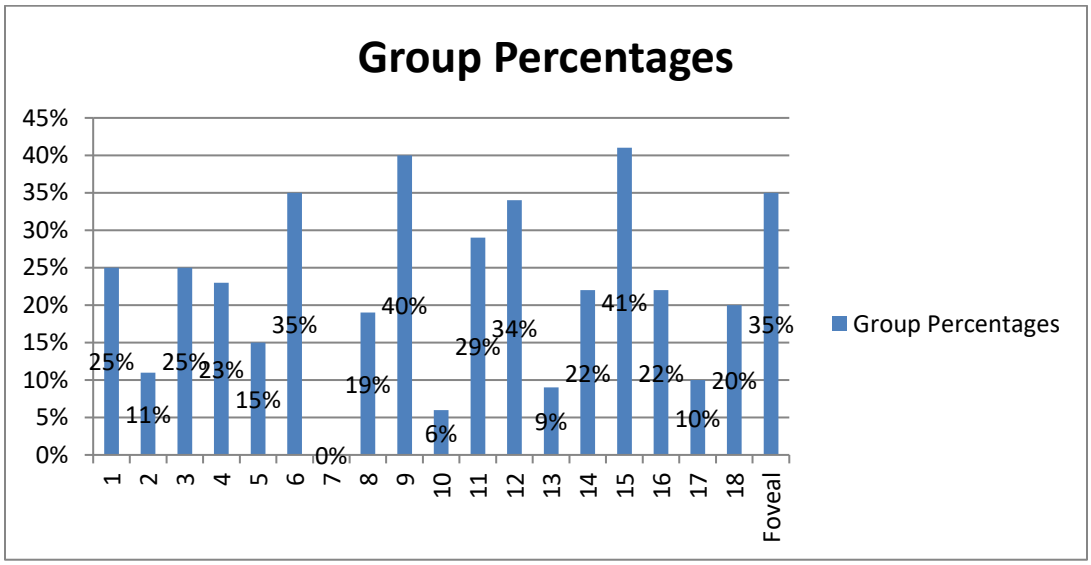
Table 3: Macular retinal sensitivity Groups Means

Position Point	Group 1	Group 2	P-value
1	34.11± 0.5	32.94 ± 0.7	0.18
2	32.98± 0.5	32.54 ± 0.6	0.66
3	33.91± 0.6	32.74 ± 0.8	0.20
4	34.04± 0.4	32.98 ± 0.8	0.71
5	32.94± 0.5	32.28 ± 0.6	0.47
6	33.61± 0.5	31.81 ± 0.7	0.06
7	33.01± 0.4	33.01 ± 0.5	0.85
8	33.48± 0.4	32.61 ± 0.5	0.18
9	33.34± 0.5	31.21 ± 0.7	<0.002
10	32.24± 0.5	32.01 ± 0.6	0.96
11	33.78± 0.4	32.38 ± 0.7	0.13
12	33.24± 0.6	31.51 ± 0.7	0.04
13	32.98± 0.5	32.61 ± 0.6	0.86
14	33.61± 0.6	32.61 ± 0.5	0.06
15	34.01± 0.6	31.81 ± 0.8	0.02
16	33.58± 0.4	32.54 ± 0.6	0.41
17	35.50± 0.6	33.63 ± 0.7	0.20
18	37.14± 0.8	35.97 ± 0.9	0.21
Foveal	35.78± 0.6	33.86 ± 0.7	0.20
Mann---Whitney’s U test			

Table 4: Percentages of change for each point in the brightness (in Asb)

Position Point	Group 1	Group 2	Percentage
1	2042.75	1560.56	25%
2	1574.99	1423.34	11%
3	1950.85	1490.37	25%
4	2010.10	1574.99	23%
5	1560.56	1340.69	15%
6	1820.71	1203.27	35%
7	1585.90	1585.90	0%
8	1767.05	1446.45	19%
9	1711.03	1048.14	40%
10	1328.40	1259.94	6%
11	1893.35	1371.89	29%
12	1672.10	1123.03	34%
13	1574.99	1446.45	9%
14	1820.71	1446.45	22%
15	1996.27	1203.27	41%
16	1808.18	1423.34	22%
17	1576.00	1447.46	10%

18	1768.06	1447.46	20%
Foveal	2998.17	1936.43	35%
Means(asb).			



Discussion:

The primary results of this study demonstrate that, in comparison to individuals without retinopathy of the same age and visual acuity (20/20), persons with diabetes without retinopathy had decreased retinal sensitivity in the nose region, which represents temporal retina.

Foveal sensitivity in non-diabetic adults in this study showed a substantial correlation with point 1 (central superior nasal hemi-field) sensitivity, but not at other locations. individuals with diabetes had a 35% greater luminance requirement at the fovea than non-diabetic individuals, and there was a weaker association between their point 1 and foveal sensitivities. Decibels (dB) representing brightness (Asb) were used to indicate retinal sensitivity in Group 2, which is diabetic. Higher dB values signify the ability of a more functioning retina to detect weaker stimuli[2]. Higher sensitivity points were correlated with a decrease in mean foveal sensitivity, which fell from 35.78 dB in persons without diabetes to 33.88 dB in diabetics without retinopathy[11].

The macular threshold test in this investigation showed that, in eyes with stable central fixation and normal visual acuity, mean retinal sensitivity was greater than previously reported, both at the fovea and at the 16 locations around it. These findings had not been described in our sample before. Research that have using perimetry to assess macular disorders have compared various methodologies based on global sensitivity measures, but they have not disclosed the outcomes of macular threshold tests at each stage[12-15]. The functional state of peripheral and central vision in various types of optic neuropathies has been assessed using perimetry threshold tests. In

addition to being used to assess retinal function in conditions such as diabetic retinopathy, the 24-2 achromatic (white-on-white) or dichromatic (blue-on-yellow) threshold tests are also used to diagnose glaucoma[12].According to Cabezos et al., conditions like diabetes and glaucoma are associated with a considerable reduction in global retinal sensitivity, as determined by multichannel perimetry using an achromatic stimulus[16]. Using a regression model, Bengtsson et al. (2017) found that achromatic perimetry was a more effective method than blue-on-yellow perimetry for detecting loss of visual function due to macular degeneration. The 10-2 and 24-2 threshold tests were employed in that investigation; however, the latter's assessment of central function is limited as it fails to quantify the spots around the fovea. Using a 28-point microperimetry with a size-III stimulus, Sepah et al. (18) examined the relationship between sensitivity and macular thickness in both healthy eyes and eyes with macular edema brought on by uveitis. They found that 100% of the eyes had stable central fixation and that the mean macular sensitivity in healthy eyes was 16.48 ± 2.06 dB. Using microperimetry, Sampson et al. (2012)19 found that in the eyes of diabetic participants without optic neuropathies, the mean global retinal sensitivity was 22.15 dB, and the mean sensitivity in a 10◦ circle was 24.27 dB. The dB scale is altered by the microperimeter's background light intensity, which is why the sensitivity means in this study differ from those previously published.

Macular threshold test sensitivity is measured in four central locations located at 1^0 from the fixation point and in 12 points around them, localized at 3^0}; in this investigation, the analysis found that points 1, 4, 15 and 3 had the greatest means of sensitivity in group 1. Point 2 of the central-temporal region was not among the four places with the highest sensitivity; instead, the inferior-nasal field had a higher sensitivity, indicating that the temporal retina was functioning better[20]. The distribution in our sample differed from the predicted enhanced sensitivity of the four-central spots; this discovery may suggest topographic variations in macular function, which will need more investigation. The temporal-central section of the macula is more sensitive in healthy eyes, hence diseases affecting the central-temporal macula, especially point 1, decrease retinal sensitivity more than damage to the nasal macula. Hyperglycemic toxicity and oxidative damage are the two main ways that diabetes damages synapses between photoreceptors and bipolar cells in the outer plexiform layer[21]. An further factor in retinal neuronal damage, particularly in ganglion cells, is the activation of the angiotensin II AT1 receptor[22,23]. Retinal sensitivity and visual acuity are commonly reduced as a result of microvascular problems such as microaneurysms that arise from early diabetic retinopathy, which frequently affects the temporal macula. As a compensating mechanism, the nasal side can be involved[24]. The macular threshold test's four central points assess an area outside of the foveal avascular zone and the maximum resolution area, which is located before 1 ◦ of the visual field. Sensitivity may drop at the fovea but not at the four central points in conditions like macular edema that impact the macula's central point. In addition to treating retinal thickening, treatment for these eyes should focus on enhancing the function of the center region. Retinal thickening reduction alone would enable the eye to attain its maximum residual function, which may not always coincide with its maximum visual acuity area. The comprehensive assessment of the 6◦ in the macular area, which

enables representing the macular function, was one of the study's strengths. On the other hand, a possible drawback was that we did not examine the entire macular area using the same distribution of points at 10◦, which would have been helpful to compare this function in the temporal perifoveal zone.The 10-2 threshold test, which contains a measurement at 2 ◦, may be used to examine sensitivity and assess foveal function prior to the center 3 ◦. This test would complete the study's findings since it would enable the estimation of a gradient of sensitivity change at the fovea.

Conclusion

Diabetics have reduced macular and foveal sensitivity than non-diabetics even eyesight is normal. This decline may indicate early functional retinal impairment that occurs prior to noticeable vision loss. Point 1 significantly enhanced foveal sensitivity in people with diabetes.The findings emphasize the need of assessing macular sensitivity in order to detect retinal damage in diabetic patients early on. These findings provide possible methods for monitoring and detecting diabetic retinopathy.

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