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OPTICAL COHERENCE TOMOGRAPHY (OCT);

Findings and visual acuity (V/A) in diabetic macular edema (DME) patients

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ABSTRACT… Objectives: To see the consequences of diabetic macular edema as assessed by optical coherence tomography (OCT) and visual acuity (V/A). **Design:** A prospective observational study. Patients were selected by simple random technique. **Duration:** Jan 2012 - Dec 2013. **Material and Methods:** A total of one hundred patients (200 eyes) of ages forty two to sixty three years with an average age of 51.04 ± 6.26 years of either sex were included. All these patients were examined in the outpatient department and were diagnosed as diabetic with macular edema and no opacity in refractive media. Their V/A was checked. OCT was performed in the Diagnostic & Research Centre, Department of Ophthalmology, Allied Hospital, Faisalabad. **Results:** Out of 200 eyes on OCT our findings were Diffuse Retinal Thickening in 199 eyes (99.5%), Cystoid Macular Edema in 119 eyes (59.5%), Subretinal Fluid in 48 eyes (24%), Epiretinal Membrane in 15 eyes(7.5%), Vitreomacular Traction in 11 eyes (5.5%) and Taut Posterior Hyaloid Membrane in 4 eyes(2%). The visual acuity on the right side was 0.29±0.19 and on left side it was 0.38±0.11. The macular thickness was 437.10±82.57 microns on the right side and 414.01±69.35 microns on the left side. The best-corrected visual acuity was significantly correlated with central foveal thickness. Our results showed, on the right side, a significant negative correlation (correlation coefficient: -0.355, $p<0.01$) between them. On the left side, a significant negative correlation (correlation coefficient: -0.362, $p<0.01$) was recorded.

Key words: Diabetic macular edema, optical coherence tomography, visual acuity.

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INTRODUCTION

Diabetes Mellitus is one of the most common diseases not only in Pakistan but also worldwide. “Diabetes Mellitus” (DM) literally means “Sweet Urine”. It is a disease with impaired carbohydrate, fat and protein metabolism in which either lack of insulin secretions or decreased sensitivity of the tissues to insulin occurs[1]. On the basis of its causes, Diabetes can be divided into 2 types in general; Type-I and Type-II. Type-I diabetics include those patients who have insulin deficiency and Type-II diabetics are patients having decreased sensitivity of the specific tissues to the metabolic effects of insulin. Their cells develop insulin resistance.

Signs and symptoms of this disease vary widely from not only patient to patient but also individually over time, age of onset, duration and type of disease, controlled or uncontrolled and family history. Making some changes to lifestyles, most of the patients continue a normal and perfect life but they should stick to prescribed treatment, monitor the condition, follow a generally healthy diet and take part in the activities they have ever enjoyed[2].

The complications may be divided into acute and chronic. Acute complications include Diabetic ketoacidosis, hyper or hypoglycemic states, Diabetic coma, Respiratory infections and different dental problems. Diabetes mellitus and heart failure are chronic complex medical disorders that are closely related and usually develop together[3]. Several studies have reported a cognitive decline in Type 2 DM[4].

It is now well proved that the major microvascular complications of diabetes are linked to the patients with diabetes to understand that a healthy lifestyle and compliance with medical care can greatly decrease the development and progression of complications of their disease not only in the eyes but also in other body organs[5]. DM causes unbalancing of metabolites such as

lipids, carbohydrates, and blood coagulation factors[6] and subsequently brings about many microvascular and cardiovascular complications[7] such as diabetic cardiomyopathy, nephro-pathy, neuropathy and retinopathy in chronic cases.

DM is a disease which affects the whole of the body. If uncontrolled, complications develop which affect mainly the eyes, kidneys, heart and the nervous system. It was reported that during the first two decades of disease, almost all patients with type 1 diabetes and >60% of patients with type 2 diabetes have retinopathy. During their research work, Delcourt[8] proved that the prevalence of patients with DR in Western countries ranges from 21.9 to 36.8%. According to Population-based studies, it is suggested that about 1/3rd of the total diabetics have DR and 1/10th have DME and PDR[9,10].

According to the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR), 3.6% of type1 diabetics and 1.6% of type II diabetics were legally blind. In the younger-onset group (type1 diabetics), 86% of blindness was because of diabetic retinopathy. In the older-onset group (type II diabetics), in which other eye diseases were common, one-third of the cases were blind due to diabetic retinopathy[11].

An important event that occurs in diabetic retinopathy, Diabetic macular edema (DME), is more common in type II than type 1 diabetics[12]. DME is the primary cause of poor visual acuity in type II diabetes and Proliferative Diabetic Retinopathy (PDR) is the most common sight damaging lesion in type 1diabetes. Progression of retinopathy is effected by the severity and the length of time that hyperglycemia exists[13]. The potential visual loss in patients with diabetic retinopathy can be related to the conditions such as macular edema induced by capillary leakage, macular ischemia caused by capillary occlusion and neovascularization induced by ischemia[14].

Blurring of the vision can also be a leading symptom of more serious eye problem. The major eye problems can be cataract, glaucoma, and retinopathy. In this eye problem, hyperglycemia causes not only increase in retinal blood flow but metabolism also which affects retinal endothelial cells and pericytes directly so that vascular autoregulation is disturbed. It also causes increased vascular permeability, causing exudative damage. The development of diabetic macular edema is not known completely. It may be initiated from intracytoplasmic swelling of Mu¨ller cells due to ischemia, causing cytotoxic edema[15]. The cytotoxic edema can proceed to vasogenic edema and at later stages may release permeability substances like prostaglandins and vascular endothelial growth factor from ischemic areas of retina[16]. Due to persisting edema, the liquefaction necrosis of the Mu¨ller cells and adjacent neural cells can occur or ischemia may lead to cystoid cavity formation, especially in the outer retinal layer[17].

For development and progression of retinopathy, the duration of diabetes is perhaps the strongest predictor among younger-onset diabetics. In the WESDR, at 3 years, the prevalence of any retinopathy was 8%, 25% at 5 years, 60% at 10 years, and at 15 years, it was 80%. The prevalence of PDR was 0% at 3 years and at 15 years, it increased to 25%)[18].

OCT is a non-invasive technique used to take the optical sections of macula for evaluation of Diabetic Macular Edema (DME) cases. It is the best and latest technique for high resolution, cross sectional imaging[19]. For the past two decades, the ability to perform OCT imaging of the neural retina has afforded researchers and clinicians a great reproducible technique used for following and diagnosing DME that is favorably comparable with other methods of DME assessment like fundus photography and clinical examination[20]. It can give important additional information about the retina. It produces objective, reproducible and reliable retinal images in many ocular diseases especially in diabetic macular edema. Because of OCT, identification of structural changes and quantitative assessment of macular edema have become easier as determined by retinal thickness and volume. Lang G[21] proved that for small

changes in retinal thickness determined by OCT is more sensitive than slit-lamp biomicroscopy. It can be helpful for diagnosing traction at the macula and to quantify the macular edema[22]. In future it will become an essential tool for managing anti angiogenic therapy, an expanding therapeutic option, for patients with macular edema due to DR[23].

Visual Acuity (VA) is the clearness or acuteness of vision, which depends on the sensitivity of the interpretative faculty of the brain and the sharpness of the retinal focus within the eye[24]. It is tested separately for distant and near vision. To check distant visual acuity Snellen's chart is used. It has letters of different sizes and the chart is kept 6 meters away from the person being tested. Normal distant V/A is6/6 for both eyes.

MATERIALS AND METHODS

A total number of 100 known diabetic selective patients with macular edema were studied. This was an observational study. The patients were selected by simple random technique.It was completed in collaboration with Ophthalmology Department, Allied Hospital Faisalabad, Pakistan. Only known diabetics having vision on both sides and complaining of decreased vision with diabetic macular edema were included in the study.

Exclusion Criteria

The patients with dense opacities in refracting media; cataract, corneal opacity or vitreous hemorrhage, any macular disease like age related macular degeneration which can alter retinal architecture or have normal 6/6 visual acuity were excluded. The average age of patients was 51.04 ± 6.26 years. The minimum and maximum ages were noted as 42 & 63 years respectively. Both male and female patients were studied. Sixty seven were male and thirty three were female patients. A written consent was taken from every patient. The study was conducted for a period of one year (Jan 2012 - Dec 2013). The best corrected visual acuity of each eye was estimated with the help of Snellen's chart. The patients wearing glasses were examined with their spectacles. The data were collected and arranged. Visual acuity and macular thickness were compared and correlated statistically. An OCT was done of each eye to see morphologic type of DME of every case. Spectral domain RTVue type IV machine having resolving power of 5 microns was used in this study. The results were arranged. Macular thickness was statistically compared and correlated with visual acuity.

Statistical Analysis

The data of comparison of visual acuity and macular thickness was collected and analyzed statistically using SPSS 17 version. Pearson correlation coefficient was used to find out the relationship between visual acuity and macular thickness. It was shown that the relationship between the variables was inverse. Correlation was significant at 0.01 levels (2-tailed).

RESULTS

In our study, six different optical coherence tomographic patterns were seen (Table-I). Diffuse retinal thickening was seen in 199 (99.5%) eyes, cystoid macular edema in 119 (59.5%), sub retinal fluid in 48 (24%), epiretinal membrane in 15 (7.5%), vitreomacular traction in 11 (5.5%) and taut posterior hyaloid membrane in 4 (2%) eyes. Our results showed that diffuse type is present in almost all cases and with this type, we found (mostly) CME and other types also.

Our results showed that the mean of Right Visual Acuity was 0.2988 ± 0.1922 and for Left side, it was 0.3897±0.1139 by using meter as a unit (Table-II). The minimum and maximum values for right and left sides were 0.10 and 0.50 (meter) respectively.

In present research, our results showed that the mean of Right Macular Thickness was 437.10±82.57 (microns) and for Left side, it was 414.01 ±69.35 (microns) (Table- III). The minimum and maximum values for right side were 350 and 540(microns); and for left side they were 370 and 510 (microns) respectively.

Type of Maculopathy	No of Eyes n=200	%age
Diffuse Retinal Thickening	199	99.5
Cystoid Macular Edema	119	59.5
Subretinal Fluid	48	24
Epiretinal Membrane	15	7.5
Vitreomacular Traction	11	5.5
Taut Post Hyaloid Membrane	4	2

Table-I. Types of Maculopathy as measured by OCT in patients with diabetic macular edema.

In present research, our results showed that the mean of Right Macular Thickness was 437.10±82.57 (microns) and for Left side, it was414.01 ±69.35 (microns) (Table- III). The minimum and maximum values for right side were 350 and 540(microns); and for left side they were 370 and 510 (microns) respectively.

Our results showed that the minimum and maximum visual acuity was 0.10 and 0.50(meter) respectively (Table-IV). The minimum and maximum macular thickness was 350.00 and 540.00 (microns) respectively. The mean of visual acuity was 0.29±.19 (meter) and for macular thickness, it was 437.1±82.57 (microns). The

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Right Visual Acuity	100	0.10	0.50	0.298	0.192
Left Visual Acuity	100	0.10	0.50	0.389	0.113

Table-II. Visual acuity of patients with diabetic macular edema. Measurements were carried out by both in right and left eyes.

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Right Macular Thickness (microns)	100	350.00	540.00	437.10	82.57
Left Macular Thickness (microns)	100	370.00	510.00	414.01	69.35

Table-III. Statistical data about macular thickness measured in diabetic patients with diabetic macular edema.

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Visualacuity	100	.10	.50	.2988	.19229
Macular Thickness (microns)	100	350.00	540.00	.437.1000	82.57589
Valid N (list wise)	100				

Table-IV. Comparative results of right visual acuity and right macular thickness of patents with diabetic macular edema.

		Visual acuity	Macular thickness
Visual acuity	Pearson Correlation	1	-.355**
	Sig. (2-tailed)		.000
	N	100	100
Macular thickness	Pearson Correlation	-.355**	1
	Sig. (2-tailed)	.000	
	N	100	100

*** Correlation is significant at the 0.01 level (2-tailed).*

Table-V. Correlation of visual acuity and macular thickness in right eyes of patients with diabetic macular edema.

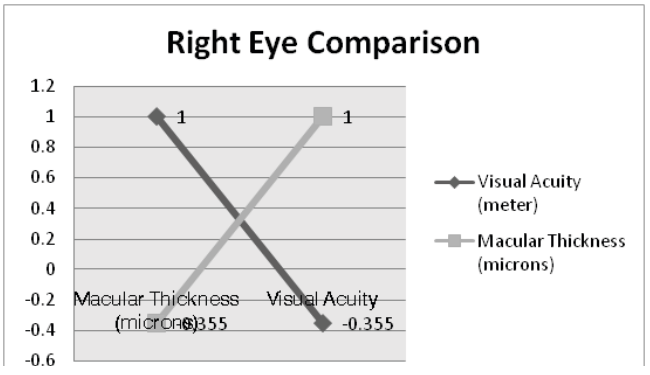

Figure-1. Comparative data on visual acuity and macular thickness of right eye of patients with diabetic macular edema. The inverse relationship between two is clearly indicated. Dark grey line shows visual acuity measured in meters as described in the text; light green line shows macular thickness measured in microns as described in the text. It is obvious that higher the visual acuity (meters), lower is macular thickness (microns).

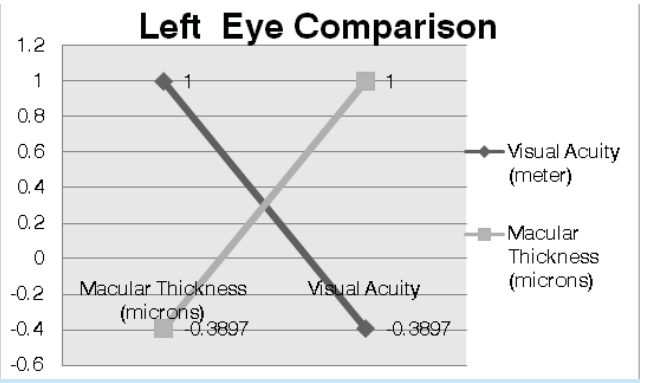

Figure-2. Comparative data on visual acuity and macular thickness of left eye of patients with diabetic macular edema. The inverse relationship between two is clearly indicated. Dark grey line shows visual acuity measured in meters as described in the text; light green line shows macular thickness measured in microns as described in the text. It is obvious that higher the visual acuity (meters), lower is macular thickness (microns).

correlation coefficient showed inverse correlation between the two variables (-.355) (Fig: I). Our results showed that P-value was significant at 0.01 level (Table-V).

We have demonstrated that the minimum and maximum visual acuity was 0.10 and 0.50 (meter) respectively (Table-VI). The minimum and maximum macular thickness was 370.00 and 510.00 (microns) respectively. The mean of visual acuity was 0.38±.11 (meter) and for macular thickness, it was 414.01±69.35 (microns). The correlation coefficient showed inverse correlation between the two variables (-0.362) (Fig: II). Our results showed that P-value was significant at 0.01 level (Table-VII).

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Visual acuity	100	.10	.50	.3897	.11399
Macular thickness(microns)	100	370.00	510.00	414.0101	69.35116
Valid n(list wise)	100				

Table-VI. Comparative results of left visual acuity and left macular thickness of patients with diabetic macular edema

		Visual acuity	Macular thickness
Visual acuity	Pearson Correlation	1	-.362**
	Sig. (2-tailed)		.000
	N	100	100
Macular thickness	Pearson Correlation	-.362**	1
	Sig. (2-tailed)	.000	
	N	100	100

*** Correlation is significant at the 0.01 level (2-tailed).*

Table-VII. Correlation of visual acuity and macular thickness in left eyes of patients with diabetic macular edema.

DISCUSSION

Diabetes mellitus is the condition in which blood glucose level remains persistently high. It is the leading cause of blindness all over the world including the developed countries. It can affect the overall quality of life and one's ability to work. If it is not managed, it can even threaten life. According to Clark J[25] in patients with Diabetes Mellitus, the main cause of visual loss is diabetic macular edema. So it was planned to conduct a study in which assessment of DME should be done through the most advanced investigations since treatment plans greatly depend upon proper and comprehensive diagnosis.

The present study DME was assessed by OCT and visual acuity. We studied 100 known cases (200 eyes) of DME with an average age of 51.04±6.26 years. The minimum and maximum ages were noted as 42& 63years respectively. Andrew M[26] proved that with the development of contemporary OCT systems, now it is possible to calculate the objective macular thickness and to assess the relationship of DME and visual acuity quantitatively. Regarding OCT we have six different patterns, diffuse retinal thickening(99.5%), cystoid macular edema(59.5%), subretinal fluid(24%), epiretinal membrane(7.5%), vitreomacular traction (5.5%) and taut post hyaloids membrane (2%), showing more comprehensive types of DME. The findings related to diffuse retinal thickening were seen to some extent in each case. Most of the abnormalities related to retinal swelling or cystoid macular edema were more marked in the outer rather than the inner retinal layers. Located in the outer retinal layers, highly reflective areas are hard exudates. Hee20…..27 reported a significant correlation between OCT measurements of retinal thickness and log acuity. These authors have correlated the retinal thickness with visual acuity and have calculated the average values of the thickness for each visual acuity level. The data so obtained have been correlated with average thickness values with visual acuity. They reported good correlation[27,28] between the two parameters. We find inverse correlation between the two parameters, when compared statistically.

Specifically for subretinal fluid (SRF) we did not find even a single case having only SRF with all other normal retinal layers. It shows that perhaps this finding appears in later stages of the disease or in more advanced cases. More over SRF cannot be diagnosed with clinical examination or even with fundus fluoresce in angiography. The precise diagnosis can only be diagnosed by OCT. Although it was attempted to have correlation between the OCT laminar patterns and cellular elements of retinal histologic sections but it required manipulation of the images[29].

Otani15 studied cross sectional images of DME cases. They reported that retinal swelling was more pronounced in the outer retinal layers rather than the inner retinal layers. Cystoid macular edema was present in the outer layers of retina. These findings are almost similar as seen in our study. Kim[30] described various morphologic patterns of DME as demonstrated by OCT and correlated them with visual acuity. Massin P[31] studied the role of OCT before and after vitrectomy of those cases who had DME and underwent vitrectomy. They reported that OCT made it possible to diagnose subtle vitreomacular traction and precisely assessed pre and postoperative macular thickness.

Regarding visual acuity, on right side, it was 0.29±0.19 (meter) and on left side, it was 0.38±0.11 (meter). The macular thickness was 437.10±82.57 (microns) on right side and 414.01±69.35 (microns) on left side. The best-corrected visual acuity was significantly correlated with central foveal thickness. Our results, on right side, showed a significant negative correlation (correlation coefficient: -0.355, $p<0.01$) between them. On left side, a significant negative correlation (correlation coefficient: -0.362, $p<0.01$) was noted. Similar to our results, Chiba N[32] compared visual acuity with foveal sensitivity and reported reduction of visual acuity. In another study conducted by Voutilainen KR[33] it was proved that poor glycaemic control was the most important predictive factor for the development of maculopathy as well as deterioration of visual acuity. They also reported strong correlation

between the developments of maculopathy with deterioration of visual acuity, as observed in our study. Previous studies revealed that the loss of visual acuity is well correlated with foveal thickening[34].

If we compare all clinical examination methods, OCT is a more specific and sensitive method for macular thickness measurements and for assessment of the attachment of vitreous strands to the edges of fovea and macula. The clinical analysis based on OCT, for each type of clinically significant macular edema, can give useful information about the pathogenesis of the edema and to optimize the treatment.

Taken together our findings of OCT imply that diabetic macular edema is a disease of broad spectrum and its treatment should be decided according to the subtypes of macular edema.

CONCLUSION AND RECOMMENDATIONS

Although we have achieved great advances in diabetic care, still its complications remain there for different reasons. In developing countries, the resources to gain good diabetic controls, are not generally available further, proper consideration should also be given to other clinical problems that may accelerate the deleterious diabetic effects.

With the increase in diabetic macular edema, visual acuity decreases proportionally. Moreover, OCT assessment of DME gives detailed and advanced types of DME. For proper diagnosis and management only clinical examination cannot be relied upon.

Moreover, OCT assessment of DME gives detailed and advanced types of DME. For proper diagnosis and management only clinical examination cannot be relied upon. Comprehensive and detailed assessment of the patients should be done including blood and ophthalmic investigations.

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