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Original article

Evaluation of patterns of Diabetic macular edema with OCT and its association with visual acuity at a tertiary centre

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ABSTRACT

Introduction: This study aimed to describe various morphologic patterns of diabetic macular edema (DME) demonstrated by optical coherence tomography (OCT) and correlate them with visual acuity. **Materials and methods:** A total of 158 eyes of 100 patients with diabetic retinopathy were studied. All patients with DME underwent OCT evaluation. The OCT scans were evaluated for the presence of diffuse retinal thickening (DRT), cystoid macular edema (CME), posterior hyaloidal traction (PHT), serous retinal detachment (SRD), and traction retinal detachment (TRD)., the retinal thickness was measured and correlated with visual acuity. **Results:** Optical coherence tomography was able to quantify the development of both foveal and extrafoveal macular thickening. Foveal thickness measured by OCT was highly correlated with visual acuity. Two hundred two OCT scans of 158 eyes of 100 patients were identified. OCT revealed five morphologic patterns of DME: DRT (61.88%) ;CME (24.75%)**,** SRD without PHT (6.93%);PHT without TRD (5.45%) ; PHT with TRD (0.99%).Increasing retinal thickness in all patterns was significantly correlated with worse visual acuity ($P < 0.05$). **Conclusions:** Optical coherence tomography was a useful technique for quantifying macular thickness in patients with diabetic macular edema. DME exhibits five different morphologic patterns on OCT. There is a significant correlation between retinal thickness and visual acuity.

KEYWORDS: Optical coherence tomography (OCT), Diabetic macular edema (DME), Posterior hyaloidal traction (PHT), Cystoid macular edema (CME), Diffuse retinal thickening (DRT)

INTRODUCTION

Diabetic retinopathy is the progressive dysfunction of the retinal vasculature caused by hyperglycemia. Diabetic retinopathy is a microangiopathy resulting from the chronic effects of the disease, and shares similarities with the microvascular alterations that occur in other tissues vulnerable to diabetes mellitus such as the kidneys and the peripheral nerves. The best predictor of diabetic retinopathy is the duration of the disease [1]. The first 5 years of type 1 diabetes has a very low risk of retinopathy. However, 27% of those who have had diabetes for 5–10 years and 71–90% of those who have had diabetes for longer than 10 years have diabetic retinopathy [2]. After 20–30 years, the incidence rises to 95%, and about 30–50% of these patients have proliferative diabetic retinopathy (PDR).

Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) provides valuable information regarding both the prevalence and the risk factors associated with the development of diabetic retinopathy. In the younger-onset group, which consists of patients whose age at diagnosis of diabetes was less than 30 years and who were taking insulin at the time of the examination (presumably those with type 1 diabetes), retinopathy, either proliferative or non proliferative, was seen in 13% of patients with less than a 5-year duration of diabetes and in 90% of patients with a duration of 10 to 15 years [3]. PDR, the most vision-threatening form of the disease, is present in approximately 25% of patients with type 1 diabetes after a 15-year duration of the disease.

For patients with an onset of diabetes at 30 years of age or older (those with type 2 diabetes) and a duration of diabetes less than 5 years, 40% of those taking insulin and 24% of those not taking insulin have retinopathy [4]. These rates

increase to 84% and 53%, respectively, with an increased diabetes duration of 15 to 19 years. PDR develops in 2% of patients with type 2 diabetes and duration less than 5 years and 25% of patients with duration of 25 or more years of diabetes. The prevalence of diabetic macular edema did not vary as much by diabetes type. The prevalence of diabetic macular edema is approximately 18% to 20% in patients with either type 1 or type 2 diabetes.

Optical coherence tomography (OCT)

OCT is a modern imaging technique for non-invasive and non-contact "in vivo" examination of the retina and the vitreoretinal interface on cross-section images or on a 3D image reconstruction, and for objective measurement of retinal thickness [5]. Optical coherence tomographic imaging is analogous to B-scan ultrasound imaging, except that it uses light instead of sound. The interface between different ocular tissues can be determined by changes in reflective properties between the tissues. Current experimental ophthalmic OCT instruments provide more structural information than any other ophthalmic diagnostic technique [6].

The main objective of this study was to evaluate various patterns of diabetic macular edema and its association with the visual acuity status of the patients under study.

MATERIALS AND METHODS

This study was conducted in the Post Graduate Department of Ophthalmology, Government Medical College Srinagar, which is the sole referral tertiary care hospital for Kashmir Valley. The study was an Observational, Retrospective type conducted from Jan 2013 to Dec 2013. The patients were selected as per inclusion and exclusion criteria. The patients were diagnosed on the basis of detailed history, comprehensive eye examination and appropriate investigations were done.

The Inclusion criteria included all the patients with diagnosed Diabetic Retinopathy with macular edema except those mentioned in the exclusion criteria. These underwent Optical Coherence Tomography, and topography of diabetic macular edema was assessed with the help of Spectral Domain Optical Coherence Tomography, a technique for high-resolution cross-sectional imaging of the retina. All patients with DME underwent line scan. The Exclusion criteria included the patients with macular edema due to other causes like retinal vein occlusion, hypertensive retinopathy, radiation retinopathy, uveitis, scleritis, following cataract extraction, following Nd:YAG Laser capsulotomy, panretinal photocoagulation, retinal dystrophies including retinitis pigmentosa, gyrate atrophy and Leukemias.

RESULTS

Optical coherence tomography was able to quantify the development of both foveal and extrafoveal macular thickening. Foveal thickness measured by OCT was highly correlated with visual acuity. Two hundred two OCT scans of 158 eyes of 100 patients were identified.

The maximum number of patients among males (43.75%) was in the age group of (41-50) years with range (18-65) years and that in case of females (40.38%) were in the age group of (51-60) years with range (17-65) years. The mean in case of male subjects was 51.10 $\pm$8.8 years, in case of female subjects was 46.65 $\pm$ 12.3 years and overall mean was 48.80 $\pm$10.9 years, Using Mann-Whitney U-Test, there was no significant difference as for as the age in male and female subjects is concerned, with p-value=0.182 (Table1).

Table 1: Age and Gender Distribution of Study Subjects (Mann-Whitney U-Test)

Age (Years)	Males		Females		Total		*P*-value
	n (48)	%	n (52)	%	n (100)	%	
≤20	1	2.08	4	7.70	5	5.0	**0.182 (NS)**
21-30	0	0.00	4	7.70	4	4.0	
31-40	2	4.17	4	7.70	6	6.0	
41-50	21	43.75	16	30.76	37	37.0	
51-60	19	39.58	21	40.38	40	40.0	
> 60	5	10.42	3	5.76	8	8.0	
Mean $\pm$ SD (Min;Max)	**51.10 $\pm$8.8 (18,65)**		**46.65 $\pm$12.3 (17,65)**		**48.80 $\pm$10.9 (17,65)**		

Maximum number of Study Subjects (48 %) were on both (Insulin + OHA), 30% of Study Subjects on OHA and 22 % on Insulin. The association of Foveal Thickness and Visual Acuity in Diabetic eyes was analyzed, and it was found that with increasing retinal thickness visual acuity decreases (Table 2).

The relationship of optical coherence tomography measurements of Foveal thickness with Visual Acuity, using Pearson Product Moment Correlation Method in 158 eyes with NPDR and PDR was evaluated. There is a Significant (Strong) Correlation between Foveal Thickness and Visual Acuity with coefficient of correlation (r = 0.81) (Table 2).

Table 2: Association of Foveal Thickness and Visual Acuity in Diabetic Eyes

Foveal Thickness (microns)	Mean Visual Acuity (LogMAR)
< 300	0.325
300-400	0.60
400-500	0.80
500-600	0.87
600-700	0.972
700-800	1.11
> 800	2.0

Variables	Means	Pearson Correlation Matrix	
		Foveal Thickness (µm)	V/A_LogMAR
Fovial Thickness (*µm*)	518.99	1.00	
VA_LogMAR	0.872	0.81	1.00

Linear Regression Analysis was used to explain the variation in the dependent variable (Foveal Thickness (*µm*)) and to see linear relation between Foveal Thickness & Visual Acuity. On comparison of optical coherence tomography measurements of Foveal thickness with Visual Acuity, using Linear Regression Method in 158 eyes with NPDR and PDR there is a Significant linear relation between Foveal Thickness and Visual Acuity with ($R^2 = 0.70$) and P-Value < 0.001 (Table 3).

Out of 202 scans, the most common morphological sub-type was DRT (61.88%) followed by CME (24.75%)**,** SRD without PHT (6.93%) PHT without TRD (5.45%) PHT with TRD (0.99%).Maximum Mean Thickness was seen in SRD without PHT (570.71) microns (Table 4). The association of Morphological Sub-types of Diabetic Macular Edema on OCT Imaging with Visual Acuity (LogMAR) was evaluated (Table 5).

Table 3: Linear Regression Analysis to see linear relation between foveal thickness and visual acuity

Dependent Variable	N	Multiple R	Squared Multiple R
Foveal Thickness *(µm)*	158	0.809	0.70

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	Coefficient	S.E	Std. Coefficient	Tolerance	t	p-Value
CONSTANT	203.257	19.40	0.000	.	10.48	< 0.001
VA_LogMAR	362.013	21.10	0.809	1.00	17.16	< 0.001

Table 4: Macular Thickness of Morphological Sub-types of Diabetic Macular Edema on Optical Coherence Tomographic Imaging

Morphological Sub-types	Number of Scans (%)	Mean Thickness (microns)	Range (microns)
DRT	125 (61.88)	526.32	(230 - 860)
CME	50 (24.75)	519.20	(310 - 820)
SRD Without PHT	14 (6.93)	570.71	(430 - 690)
PHT Without TRD	11 (5.45)	430.91	(290 - 660)
PHT With TRD	02 (0.99)	445.00	(420 – 470)

DRT→Diffuse Retinal Thickness; CME→ Cystoid Macular Edema; SRD→Serous Retinal Detachment; PHT → Posterior HyaloidTraction;TRD→Tractional Retinal Detachment

Table 5: Mean Visual Acuity of Morphological Sub-types of Diabetic Macular Edema

Morphological Sub-types	Number of Scans (%)	Mean Visual Acuity (LogMAR)	Range (microns)
DRT	125 (61.88)	0.886	(0.2 – 2.0)
CME	50 (24.75)	0.844	(0.6 - 2.0)
SRD Without PHT	14 (6.93)	0.914	(0.8 - 1.0)
PHT Without TRD	11 (5.45)	0.673	(0.3 – 1.0)
PHT With TRD	02 (0.99)	0.800	(0.8– 0.8)

DRT→Diffuse Retinal Thickness; CME→ Cystoid Macular Edema; SRD→Serous Retinal Detachment; PHT → Posterior HyaloidTraction;TRD→Tractional Retinal Detachment

DISCUSSION

Diabetic macular edema (DME) is one of the main causes of visual impairment in patients with diabetic retinopathy [7]. The common diagnostic tools for assessing macular edema are stereo-ophthalmoscopy and fluorescein angiography. Fluorescein angiography is a complementary method for further detecting vascular leakage. However, these methods are subjective and seem to be insensitive for small changes in retinal thickness [8]. In 1991 a revolutionary device was introduced in ophthalmology – optical coherence tomography (OCT) – and it dramatically improved the diagnosis of macular pathology [9]. OCT provides detailed information about retinal microstructure and measures retinal thickness with high precision and reproducibility [10].

The recently introduced spectral-domain OCT (SD OCT) machines have numerous improvements that enhance our ability to examine retinal microstructure and obtain more reliable measurements. The introduction of optical coherence tomography (OCT) further allows for objective evaluation of DME [11, 12, 13, 14]. In addition, OCT produces cross-sectional images of the retina that have been found to correlate well with retinal histology as demonstrated by light microscopy [15].

Our study was conducted on 100 patients diagnosed as Non Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR) on Fundus Fluorescein Angiography (FFA) and all the patients underwent Optical Coherence Tomography (OCT).

Our study highlights several important findings. In this study maximum numbers of patients were aged above 50 years. The maximum numbers of patients in male (43.75%) were in the age-group of (41-50) years with range (18-65) years and that in case of female (40.38%) were in the age group of (51-60) years with range (17-65) years. The (Mean $\pm$ SD) in case of male subjects was (51.10 $\pm$8.8), in case of female subjects was (46.65 $\pm$ 12.3) and overall (Mean $\pm$ SD) was 48.80 $\pm$10.9, Using Mann-Whitney U-Test, there was no significant difference as for as the age in male and female subjects is concerned, with p-value=0.182 (Table 1).Maximum number of Study Subjects (48%) were on both (Insulin + OHA), 30% of Study Subjects on OHA and 22 % on Insulin.

Our study shows out of 202 scans, the most common morphological sub-type was DRT (61.88%) followed by CME (24.75%), SRD without PHT (6.93%) PHT without TRD (5.45%) PHT with TRD (0.99%).Maximum Mean

Thickness was seen in SRD without PHT (570.71) microns (Table 5). The most common subtype seen in our study was diffuse retinal thickening, as has been reported by other studies [16, 17, 18], being present in (61.88%) of the scans, compared with 88% in Otani's study [16], and 60% in Yamamoto's study [17]. CME in the setting of DME was also present in (24.75%) of eyes in our study compared with 47% CME rate noted by Otani et al [16], and 40% by Yamamoto et al [17].

Our study shows relationship of optical coherence tomography measurements of Foveal thickness with Visual Acuity in 158 eyes with NPDR and PDR. There is a Significant (Strong) Correlation between Foveal Thickness and Visual Acuity with coefficient of correlation (r = 0.81), using Pearson Product Moment Correlation Method (Table 2). Increasing retinal thickness in all patterns was significantly correlated with worse visual acuity. Our results matched the results of Brian YK et al [19], Tomohiro O et al [20] and also related well with Cho HY et al [21] who showed that the foveal thickness and the logMAR scale of best corrected visual acuity showed a significantly positive correlation (correlation coefficient: 0.818, p=0.01). However there was no significant difference of visual acuity according to the patterns of diabetic macular edema.

The OCT topographic map of retinal thickness generally correlated with conventional clinical examination. Retinal thickening or hard exudate observed on slit-lamp biomicroscopic analysis almost always correlated with increased thickness on OCT, but there were some occasions in which OCT detected thickening in the absence of any abnormality on slit-lamp examination. Both measurements of central macular thickness and measurements of foveal thickness averaged over a central disk of 500-μm radius appeared to be more sensitive than slit-lamp examination for evaluating clinically significant macular edema. Edema was difficult to detect clinically when there was no hard exudate in the central macula. Optical coherence tomography retinal thickness also generally correlated with regions of fluorescein leakage; however, increased macular thickness occasionally was evident on OCT in the absence of leakage.

Whatever the cause, identifying the structural changes in patients with DME using OCT may allow more effective management of these patients. We have identified at least five different morphologic patterns of DME using OCT including: DRT, CME, SRD without PHT, PHT without TRD, and PHT with TRD. Each of these morphologic subtypes may represent distinct entities that require specific treatment regimens to achieve the best final result. In addition to identifying each of these patterns, OCT may be useful not only in determining which treatment should be applied, but also in following the progress of this process over time.

CONCLUSION

Our Study shows that OCT has potential to screen patients with early NPDR for the development of macular thickness .Optical coherence tomography is an excellent tool for quantifying macular thickness in patients with diabetic macular edema. Foveal thickness measured by OCT was highly correlated with visual acuity. DME exhibits five different morphologic patterns on OCT. There is a significant correlation between retinal thickness and visual acuity.

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