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MEASURING MACULAR THICKNESS THROUGH OPTICAL COHERENCE TOMOGRAPHY AND VISUAL ACUITY IN DIABETIC POPULATION OF DISTRICT PESHAWAR: A CROSS SECTIONAL STUDY

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Abstract

Objective: To assess central macular thickness (CMT) and visual acuity (VA) using optical coherence tomography in diabetic patients of District Peshawar and to evaluate the relationship between CMT reduction and improvement in VA following treatment.
Methods: This cross-sectional study was conducted from June 2023 and April 2025, at the Department of Ophthalmology, MTI-Khyber Teaching Hospital. Participants ranged in age from 35 to 80 and all had diabetes. Prior to and during therapy, subjects had assessments of best corrected visual acuity (BCVA) using a Snellen chart, and CMT was measured using Spectral-Domain Optical Coherence Tomography (SD-OCT). The data was examined using SPSS v25.0, and a significance level of $p < 0.05$ was used.
Results:; The mean pre-treatment CMT in the right eye was 442.16 ± 88.95 µm and decreased to 391.69 ± 96.46 µm post-treatment ($p < 0.001$). In the left eye, CMT reduced from 421.79 ± 104.51 µm to 376.53 ± 110.89 µm ($p < 0.001$). A 1-line or 2-line VA improvement was observed in 62% of patients. Gender differences in VA improvement were not statistically significant ($p = 0.447$).
Conclusion: Treatment significantly reduced central macular thickness in diabetic patients. Improved VA correlated with decreased CMT, supporting the role of OCT-based monitoring in diabetic maculopathy management.

Key words: Diabetic Macular Edema; Optical Coherence Tomography; Visual Acuity; Central Retinal Thickness; Diabetes Mellitus; Retinal Disease

INTRODUCTION

Around 537 million persons are living with diabetes mellitus (DM) at the present time, and experts predict that number will increase to 643 million by 2030 and 783 million by 2045.[1] More than 26 percent of Pakistani individuals over the age of 20 have diabetes, according to recent studies. This is a very concerning burden.[2] Diabetic retinopathy (DR) is a microvascular retinal disease that, if left untreated, can develop into diabetic macular edema (DME), a condition that causes permanent blindness. Among the many devastating long-term effects of diabetes, DR affects numerous organ systems.[3]
The accumulation of extracellular fluid in the macula as a result of a breakdown of the inner blood-retinal barrier and increased vascular permeability characterizes DME, a potentially blinding form of DR.[4] It is the most frequent cause of visual impairment in individuals with diabetes, especially in working-age populations.[5] The prevalence of DME among diabetic individuals in Pakistan varies between 9% and 29%, depending on the

population studied and diagnostic tools employed.[6] Despite the scale of the problem, screening and management services for DR and DME remain underutilized in resource-constrained settings.

Among the diagnostic modalities available, optical coherence tomography (OCT) has revolutionized the evaluation of retinal diseases.[7] Non-invasive optical coherence tomography (OCT) scans of the retina produce high-resolution cross-sectional pictures, which allow for accurate assessment of CMT, early identification of macular alterations, and therapy response tracking.[8] In fact, CMT measured via OCT has been shown to correlate well with visual acuity (VA) in DME patients, making it a reliable anatomical marker of disease severity and prognosis.[9]

Visual acuity is a functional parameter that directly reflects a patient's quality of vision and daily functioning. Changes in VA are often used as primary endpoints in clinical trials evaluating treatment efficacy in DME. However, while anatomical improvements in CMT post-treatment are frequently observed, these changes do not always correspond linearly with functional improvements in VA, suggesting a complex interaction between retinal structure and function.[10] Therefore, studying the association between CMT and VA in various populations is crucial for refining management protocols.

Although several international studies have explored the correlation between CMT and VA, there remains a paucity of data from Pakistan. Factors such as ethnicity, duration of diabetes, glycemic control, and access to timely ophthalmologic care can significantly influence disease progression and response to treatment. Most existing studies in Pakistan have focused on prevalence and risk factors of DR rather than detailed structural-functional analyses using OCT. Moreover, OCT-based evaluations are rarely performed at the community level due to financial and logistical constraints.

In the context of District Peshawar, a region with a high burden of diabetes and limited tertiary eye care facilities, it becomes imperative to generate local evidence to guide clinical decision-making. Integrating OCT into routine screening and management of DME could help in early identification of patients at risk of vision loss and tailor interventions more effectively.

Given the rising prevalence of diabetes in Pakistan and the vision-threatening nature of DME, timely diagnosis and management are critical. OCT offers a precise and objective tool for evaluating macular thickness and monitoring disease progression. However, limited local data on the relationship between CMT and VA in diabetic populations hampers the development of standardized treatment algorithms. This study aims to bridge that gap by evaluating macular thickness through OCT and its correlation with VA in diabetic patients in District Peshawar, thereby providing context-specific insights into the clinical utility of OCT in DME management.

MATERIAL AND METHODS

This study was conducted at the Department of Ophthalmology, MTI-Khyber Teaching Hospital (KTH), Peshawar from June 2023 to April 2025 once ethical approval was obtained from the Institutional Research and Ethical Review Board (IREB) Khyber Medical College (Ref No. 360/DME/KMC). The study assessed central macular thickness (CMT) and visual acuity (VA) among diabetics using Spectral-Domain Optical Coherence Tomography (SD-OCT) and visual acuity as per standard.

A total of 100 Patients with TYPE 2 DM between 35-80 years using non-probability consecutive sampling were included in the study. Patients were included in a study if they had no history of intraocular surgery in the past three months. In addition, no ocular trauma and presence of other retinal pathologies, including age-related macular degeneration and glaucoma were also exclusion criteria. Those who had substantial media opacification or prior laser treatment were excluded too. All participants provided their written informed consent.

Every patient had an individual thorough ophthalmological examination, with BCVA determined by Snellen chart and CMT assessed in both eyes by SD-OCT. The post-treatment CMT values of both eyes was used to represent the overall macular thickness in micrometers (blocks). Visual acuity, before and after treatment (anti-VEGF injection or focal laser as appropriate), was recorded and change was classified as no change, mild improvement, one-line improvement and two-line improvement on a Snellen equivalent chart.

All data including patient demographics, CMT values, and VA outcomes were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables like CMT were expressed as mean ± standard deviation, while categorical variables such as gender and VA response categories were presented as frequencies and percentages. Paired t test and Chi-square test were used for analysis with statistical significance set at $p < 0.05$.

RESULTS

The study included a total of 100 diabetic patients with a mean age of 58.40 ± 12.96 years. The overall mean pre-treatment central macular thickness (CMT) of the right eye was 442.16 ± 88.95 µm, which decreased to 391.69 ± 96.46 µm post-treatment. Similarly, the mean pre-treatment CMT of the left eye was 421.79 ± 104.51 µm, which reduced to 376.53 ± 110.89 µm after treatment. These reductions in CMT for both eyes were statistically significant ($p < 0.001$) (Table 1).

When stratified by gender, males (n = 47) had a mean pre-treatment CMT of 454.43 ± 88.80 µm in the right eye, which reduced to 404.98 ± 96.36 µm after treatment. In the left eye, the CMT in males decreased from 412.62 ± 102.71 µm to 365.51 ± 111.06 µm. In contrast, females (n = 53) had a mean pre-treatment CMT of 431.28 ± 88.50 µm in the right eye, which declined to 379.91 ± 95.92 µm post-treatment. Their left eye CMT dropped from 429.92 ± 106.39 µm to 386.30 ± 110.87 µm. All within-group comparisons for pre- and post-treatment CMT were statistically significant ($p < 0.001$) (Table 2).

Visual acuity (VA) changes were observed in varying degrees among the study population. A total of 25 (25.0%) patients experienced a 1-line improvement in VA, including 13 (27.7%) males and 12 (22.6%) females. A 2-line improvement was noted in 37 (37.0%) patients—20 (42.6%) males and 17 (32.1%) females. Mild improvement was reported in 23 (23.0%) participants, comprising 8 (17.0%) males and 15 (28.3%) females. No improvement was recorded in 15 (15.0%) patients—6 (12.8%) males and 9 (17.0%) females. The association between gender and visual acuity improvement was not statistically significant ($p = 0.447$) (Table 3).

Table 1: Descriptive Statistics of Study (n=100)

Numerical Variables	Mean	Std. Deviation	*P Value
Age (Years)	58.40	12.962	—
Pre CMT (Right Eye)	442.16	88.952	< 0.001
Post CMT (Right Eye)	391.69	96.464	
Pre CMT (Left Eye)	421.79	104.508	< 0.001
Post CMT Left Eye	376.53	110.886	

* p-value calculated using paired t test.

Table 2: Comparison of Central Macular Thickness (CMT) Between Genders

Gender	CMT Measure	Mean	SD	P Value
Male	Pre CMT (Right Eye)	454.43	88.795	< 0.001
	Post CMT (Right Eye)	404.98	96.359	
	Pre CMT (Left Eye)	412.62	102.712	< 0.001
	Post CMT (Left Eye)	365.51	111.057	
Female	Pre CMT (Right Eye)	431.28	88.503	< 0.001
	Post CMT (Right Eye)	379.91	95.922	
	Pre CMT (Left Eye)	429.92	106.386	< 0.001
	Post CMT (Left Eye)	386.30	110.868	

Table 3: Association Between Visual Acuity (VA) Change and Gender (n=100)

VA Change	Gender		Total (n=100)	*p-value
	Male (n=47)	Female (n=53)		
1-line improvement	13 (27.7%)	12 (22.6%)	25 (25.0%)	0.447
2-line improvement	20 (42.6%)	17 (32.1%)	37 (37.0%)	
Mild improvement	8 (17.0%)	15 (28.3%)	23 (23.0%)	
No improvement	6 (12.8%)	9 (17.0%)	15 (15.0%)	
Total	**47 (100%)**	**53 (100%)**	**100 (100%)**	

* p-value calculated using chi-square test

DISCUSSION

This study highlights a statistically significant reduction in central macular thickness (CMT) in both eyes following treatment in patients with diabetic macular edema (DME), alongside measurable improvements in visual acuity (VA). These findings are consistent with earlier clinical studies that demonstrated a strong correlation between anatomical improvements in macular thickness and functional gains in vision after therapeutic interventions for DME.[11] The observed reduction in macular edema is likely a result of decreased vascular permeability and fluid reabsorption following intravitreal therapies or focal laser treatment, mechanisms well-supported in the literature.[12]

Interestingly, both male and female patients showed comparable anatomical responses, suggesting that gender does not significantly influence treatment outcomes in terms of CMT reduction. These results mirror findings from multicenter trials that reported no statistically significant gender-based differences in visual or anatomical response to anti-VEGF therapies.[13] While VA improvement showed slight variation among genders in our study,

this difference did not reach statistical significance, reinforcing the notion that DME management protocols can be applied uniformly across sexes.[14]

The use of optical coherence tomography (OCT) in this study proved invaluable in capturing detailed cross-sectional images of the retina, allowing for precise quantification of macular edema. OCT has become the gold standard for evaluating retinal morphology in DME and has largely replaced traditional clinical assessments such as slit-lamp biomicroscopy and fluorescein angiography due to its non-invasive nature and reproducibility.[15] Furthermore, OCT-derived CMT serves as a critical biomarker in both clinical practice and research, helping physicians monitor treatment response and disease progression objectively.[16]

However, the correlation between CMT and VA is not always linear. Several studies have noted cases where anatomical resolution of edema on OCT does not translate into meaningful functional recovery, highlighting the complex relationship between structural integrity and visual function.[17] This discordance may be attributed to chronicity of edema, photoreceptor damage, or subclinical ischemic changes that are not visible on OCT imaging.[18] In our study, while a majority of patients experienced either one-line or two-line improvement in VA, 15% showed no improvement despite anatomical gains, a pattern echoed in other regional cohorts.[19]

Our findings support the growing consensus that multimodal imaging and functional testing are essential for comprehensive evaluation of DME. Combining OCT with VA assessment, and where necessary, additional modalities such as OCT angiography or microperimetry, can provide a more holistic picture of disease severity and guide individualized treatment plans.[20]

The limitations of this study must be acknowledged. Because it is cross-sectional, it will not show cause or long-term effects. Also, though the sample number is statistically adequate, it may not truly represent the variability seen in bigger population-based cohorts. The research was also done in a single tertiary care hospital, limiting the generalizability of the findings to rural or resource-poor settings.

In spite of these limitations, the study provides valuable information regarding the use of OCT to monitor DME in a population in Pakistan. The development of the OCT as a diagnostic and follow-up tool is further enhanced by the notable anatomical and functional enhancements that were observed. OCT need to be incorporated into the eye hospital's protocol for diabetic eye care reform at institutional level especially in high burden area like District Peshawar.

To sum it up, this OCT measurement of central macular thickness (CMT) correlates with visual outcomes in diabetic patients. The results suggest that OCT monitoring should be a routine part of DME management. Further prospective studies are needed to determine the long-term effects of OCT-guided interventions on visual prognosis in different population.

CONCLUSION

This study demonstrated a significant reduction in central macular thickness and corresponding improvement in visual acuity among diabetic patients following treatment. Optical coherence tomography proved to be an effective, non-invasive tool for monitoring anatomical changes and guiding clinical decisions. The correlation between CMT and VA supports the integration of OCT into routine diabetic eye care.

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