Original Article

Association of Central Macular Thickness with Serum HbA1c Levels in Patients of Diabetic Retinopathy

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Minahal Mateen[1], Samar Fatima[2], Bushra Akbar[3], Muhammad Saleem Bajwa[4], Asim Raza[5]
[1,2,3,5]Combined Military Hospital CMH Lahore, [4]Punjab Rangers Teaching Hospital, Lahore,

ABSTRACT

Purpose: To determine the association of central subfield macular thickness (CST) in patients of diabetic retinopathy with HbA1c.

Study Design: Cross sectional study.

Place and Duration of Study: Combined Military Hospital, Lahore from March 2025 to June 2025.

Methods: A total of 112 patients with diabetic retinopathy according to ETDRS classification were included and divided into two groups: patients with controlled (HbA1c≤7) and uncontrolled (HbA1c>7) diabetes. Spectral Domain OCT was done for CST and serum HbA1c levels were recorded. Independent samples t-test was used to compare CST in groups. The results were also stratified for gender and duration of diabetes. Statistical analysis was done by using Statistical Package for Social Sciences SPSS version 23. Pearson correlation was applied to quantify the relation between HbA1c and CST.

Results: The mean age of participants was 62.08±5.97 years. There were 74.1% patients with uncontrolled HbA1c levels (>7%). The mean CST for males was 295.36 µm (SD = 37.64), and for females was 302.84 ± 44.44. The mean CST in the controlled group was 257.62 ± 19.73 while in the uncontrolled group was 311.98 ± 35.53. CST was positively correlated with serum HbA1c levels (r=0.634). Patients with diabetes for more than 10 years had significantly higher CST (P=0.045). However, there was no gender-based difference in CST between the groups.

Conclusion: Poor glycemic control and longer duration of diabetes are associated with increased central subfield macular thickness in diabetic retinopathy.

Keywords: Diabetic Retinopathy, Blood Glucose, Optical Coherence Tomography.

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Correspondence: Minahal Mateen
Combined Military Hospital CMH, Lahore
Email: minahalmateen&gmail.com

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INTRODUCTION

Diabetic retinopathy is one of the major causes of visual loss around the world.[1] Diabetic macular edema (DME) which results from breakdown of blood-retinal barrier has increased the public health and clinical challenges. According to the World Health Organization (WHO), there will be an expected increase of 130 million diabetes patients by the end of the year 2030.[2] The figure is alarming since 30 % of all diabetics can develop diabetic retinopathy at some point in their life.[3]

The disease affects the microvasculature of retina in two ways, either by microvascular leakage or occlusion of these micro-vessels. Clinically, the disease is recognized by the presence of hemorrhages,

microaneurysms, cotton wool spots and hard exudates.[4] Macular edema is the major cause of decreased vision. The vision-threatening complications include vitreous hemorrhage, neovascular glaucoma and retinal detachment.

Several risk factors that may aggravate diabetic retinopathy include severity of diabetes indicated by serum HbA1c levels, duration of diabetes, hypertension, hyperlipidemia and pregnancy.[5,6] Serum HbA1c level is a measure of severity of diabetes in at least past three months as it reflects the control of blood sugar levels. HbA1c levels greater than 6.5% are diagnostic of diabetes.[7] However, levels less than this do not exclude diabetes. Patients whose serum HbA1c levels are more than 7 are at increased risk of DME.[8]

Recently, OCT has become an imperative tool in the assessment of diabetic retinopathy. It is a useful technique to measure thickness of macula in patients of DME. Studies have shown increased central macular thickness in patients with uncontrolled HbA1c.[9-11] However, limited data is available from our local population where diabetic retinopathy leads to severe visual loss due to late presentation. The situation becomes very important given the high prevalence of vision threatening diabetic retinopathy in Pakistan.[12] In a low to middle income country like ours where health literacy is low and specialized ophthalmic care is not accessible in many regions, the need for mass awareness for glycemic control is even more crucial. Many people cannot afford the burden of expense of intravitreal Anti-VEGF injection making prevention even more imperative. This can only be started once we are aware of the magnitude of the problem itself, especially the hazard that uncontrolled HbA1c levels pose for patients of diabetic retinopathy.

This study was conducted to compare mean value of CST in patients with controlled versus uncontrolled HbA1c levels.

METHODS

This cross-sectional study was conducted in Ophthalmology Department of Combined Military Hospital Lahore Pakistan, from March 2025 to June 2025. Sample size of 112 patients was calculated with 95% confidence level, 7% margin of error and expected percentage of patients with poorly controlled diabetes mellitus as 83%.[13] Approval of ethical review committee was taken **(Ref. No. 629/2025)** and participants were enrolled through non-probability consecutive sampling. Serum HbA1c > 6.5 was used as a cut off value for diabetes and ETDRS classification of Diabetic retinopathy was used to screen patients with diabetic retinopathy.[14] A total of 112 eyes of 79 patients were examined. Patients of 35–70 years of age, either gender, with diabetic retinopathy according to ETDRS classification and diabetes for more than 5 years were included. Patients with any media opacity that may interfere with fundus evaluation e.g., dense cataract and other retinal pathologies such as retinal vascular occlusions, age-related macular degeneration, glaucoma, optic neuropathy, history of previous retinal photocoagulation or intravitreal Anti-VEGF injections within the last three months and advanced diabetic eye disease were excluded.

Patients were divided into two groups based on glycemic control: HbA1c ≤ 7% (controlled) and HbA1c > 7 (uncontrolled). Written informed consent was taken from all patients, demographic details were noted, and ocular examination was done which included taking best corrected visual acuity using Snellen chart, slit lamp examination and fundoscopy with 90 D lens. Patients were classified according to ETDRS and recent blood HbA1c were recorded. OCT of macula was done by trained optometrist using Spectral Domain OCT. CST (mean retinal thickness in the central 1 mm zone of ETDRS grid was used for analysis. Kolmogorov-Smirnov test was applied, and data was found to be normally distributed in both controlled and uncontrolled HbA1c groups. For comparison of CST, Independent Samples t- test was applied. CST was stratified according to gender and duration of diabetes (less than 10 years versus more than 10 years).

Statistical analysis was done by using SPSS version 23. Among the 112 participants, 74 were male and 38 were female. The age ranged from 45 to 70 years while the mean age was 62.08±5.97 years. There were 74.1% patients with uncontrolled diabetes (HbA1c levels >7%).

The mean CST was significantly higher in patients with uncontrolled HbA1c group when compared to patients with controlled HbA1c group. The difference was statistically significant, $p<0.001$ (Table 1). Patients who were diabetic for less than 10 years had significantly lower CST (M = 284.56 µm, SD = 39.51) than those who were diabetic for 10 years or more (M = 304.48 µm, SD = 38.88); $t(110) = -2.536$, $p = .013$ (Table 1). Pearson's correlation analysis which was done to quantify the association between the Central Macular Thickness and HbA1c levels showed a significantly positive correlation ($r= 0.634$, $p<0.001$).

Table 1: *Stratification of CST according to duration, diabetes control and gender.*

	Groups		Central Subfield Thickness (um), Mean±SD	T-test	p-value
HbA1C status	Controlled diabetes n=29	N=29	257.62±19.72	-10.16	<0.001
	Uncontrolled diabetes n=83	N=83	311.97±35.53		
Duration of Diabetes (Years)	<10 Years	37	284.56± 39.51	-2.536	0.013
	>10 Years	75	303.48±38.88		
Gender	Male	74	295.36±37.63	-0.887	0.37
	Female	38	302.84±44.44		

DISCUSSION

The results of this study showed a statistically significant increase in CST in patients with uncontrolled HbA1c levels as compared to those with controlled HbA1c levels. This ultimately reflects the direct impact of blood sugar levels on the development of diabetic macular edema. Thus, routine monitoring of blood glucose levels coupled with early detection through OCT is vital in preventing vision threatening complications of diabetes.

The WHO Global report on diabetes as well as a recent fact sheet published by WHO in 2024 showed that prevalence of diabetes and its related complications have shown a significantly faster rise in low- and middle-income countries.[3,15]

In 2023, Malani et al concluded that value of CST increases significantly in patients with high HbA1c levels.[16] They also reported a positive correlation between the two variables. Another study conducted at Al-Azhar university also showed an increase in central subfield thickness in patients with poorly controlled diabetes.[17]

In this particular study, the frequency of patients with uncontrolled HbA1c levels was 74.1% which is similar to a study carried out in Saudia Arabia in 2024 where 83% of the participants had poorly controlled HbA1c levels (≥7).[13] Such high figures warrant immediate attention from policy makers to develop a comprehensive national policy aimed at preventing and addressing complications of diabetic retinopathy arising from poor glycemic control. A coordinated mass awareness campaign led by both public and private sectors aimed at combating diabetes would be the most effective approach to address the issue at grassroots level.

Spectral Domain OCT was used to quantify CST in both groups. This technology not only helps in diagnosing macular edema but also allows early detection of subclinical macular changes that occur before the onset of visual symptoms.[18]

Regarding gender distribution, previous studies showed increased CST in diabetic males as compared to diabetic females.[19,20] However, this was not found in our study. This difference may be attributed to other systemic factors such as blood pressure, serum lipid profile and lifestyle of patients in general. Further longitudinal studies are required to better understand these associations.

Wong WM et al, reported increase in CST with increasing HbA1c level as well as reduction of CST after first Anti-VEGF injection in patients with good glycemic control.[21] This reinforces the crucial role of HbA1c in both the progression and management of diabetic retinopathy. The Pathophysiology being centered at the microvascular level as chronic hyperglycemia, disrupts the blood retinal barrier leading to increased vascular permeability and fluid leakage which can be seen as diabetic macular edema and increased macular thickness on OCT.[2]

In our study, patients with diabetes for more than 10 years had a significantly greater central macular thickness compared to those with a shorter disease duration. Sharma reported similar findings, highlighting the impact of chronic hyperglycemia on macular changes.[10] In this context, our study was designed to enhance understanding of the extent of ocular complications associated with poor glycemic control.

This study is not only valuable for eye care clinics but also crucial for raising awareness among the public and policy makers about the serious magnitude of this problem. While our results were significant, the study has its limitations. For instance, systemic factors like blood pressure, serum lipid profile and body mass index were not considered. In addition, the differences between our groups were only observed at a single point of time. Further large-scale longitudinal studies can provide a more definite insight into how central macular thickness changes with varying glycemic control over time.

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Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(Ref No. 629/2025)**.

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Authors Designation and Contribution

Minahal Mateen; Postgraduate Trainee: *Concepts, Design, Literature Search, Data Acquisition, Data Analysis, Statistical Analysis, Manuscript Preparation, Manuscript Editing.*

Samar Fatima; Assistant Professor: *Concepts, Data Acquisition, Data Analysis, Manuscript Editing, Manuscript Review.*

Bushra Akbar; Consultant Eye Specialist: *Literature Search, Data Acquisition, Data Analysis, Manuscript Editing.*

Muhammad Saleem Bajwa; Consultant Eye Specialist: *Concepts, Literature Search, Data Analysis.*

Asim Raza; Assistant Professor: *Data Analysis, Statistical Analysis.*