

Quadrant-Wise Assessment of Macular Thickness in Diabetics Without Diabetic Retinopathy and Non-Diabetic Patients Using Spectral Domain Optical Coherence Tomography



Zainab Naeem¹, Hafiza Fizza Zahid², Irfan Qayyum Malik³, Usama Iqbal⁴, Moughees Ahmad⁵

¹⁻⁵Gujranwala Medical College and Teaching Hospital, Gujranwala

ABSTRACT

Purpose: To measure retinal thickness across superior, inferior, nasal and temporal quadrants in diabetic patients without diabetic retinopathy and non-diabetic patients using spectral Domain Optical Coherence Tomography (SD-OCT).

Study Design: It is a Cross-sectional observational Study.

Place and Duration of Study: Gujranwala teaching hospital, Gujranwala from October 2024 to February 2025.

Methods: The study included 60 participants: 30 patients with previously diagnosed type 2 diabetes mellitus without diabetic retinopathy, and 30 non-diabetic individuals. Participants of both genders and aged 30–70 years, were recruited. All participants underwent a comprehensive ophthalmic evaluation, including best-corrected visual acuity, slit-lamp biomicroscopy for anterior and posterior segment examination to identify features of diabetic retinopathy or other ocular pathologies, and SD-OCT (Optovue iVue 3000, Medmont) for quantitative assessment of retinal thickness in all four quadrants. Statistical analysis was performed using SPSS version 26.

Results: There were 28 (46.6%) males. The mean retinal thickness was $297 \pm 18 \mu\text{m}$ in diabetics and $308 \pm 15 \mu\text{m}$ in non-diabetics, while the mean foveal thickness measured by SD-OCT was $244 \pm 14 \mu\text{m}$ and $237 \pm 9 \mu\text{m}$, respectively. Quadrant-wise analysis revealed that temporal retinal thickness was significantly reduced compared to the superior, inferior, and nasal quadrants in both diabetics without diabetic retinopathy and non-diabetic participants.

Conclusion: There was significant thinning across all four retinal quadrants, most marked in temporal quadrant in type 2 diabetic patients without diabetic retinopathy. These findings suggest that neurodegenerative changes in the retina may precede visible vascular changes.

Keywords: Diabetic retinopathy, optical coherence tomography, diabetes, Central retinal thickness.

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Correspondence: Zainab Naeem
Gujranwala Medical College and Teaching Hospital,
Gujranwala
Email: zainabnaeemkhan00@gmail.com

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INTRODUCTION

Of all the known complications of diabetes, most common complication in diabetic retinopathy (DR) and also a chief cause of preventable vision loss among working-age population worldwide.¹ The global burden of DR is expected to rise over coming years with increasing prevalence of DR.^{2,3} Traditionally, DR has been recognized and classified based on the appearance of microvascular lesions such as

microaneurysms, hemorrhages, and neovascularization detectable on fundoscopic examination or fundus photography.⁴ However, recent advances in retinal imaging and neuro-ophthalmological research suggest that retinal neurodegeneration may precede these visible vascular changes.⁵

The concept of diabetic retinal neurodegeneration includes apoptosis of retinal ganglion cells, gliosis, and dysfunction of the inner retinal layers, which may occur even before the start of clinically visible signs of retinopathy.⁶ Studies have demonstrated that neuronal injury in the retina is not only an early event but may also contribute to the progression of vascular lesions.⁷ This has prompted a shift in the paradigm of DR pathogenesis from a purely microvascular disorder to a neurovascular one.⁸

Spectral Domain Optical Coherence Tomography (SD-OCT) has now emerged as an important non-invasive tool for retinal imaging. It shows earlier detection of retinal pathologies even before development of clinically evident diabetic retinopathy.⁹ There is evidence of retinal thinning along with ganglion cell layer thinning in diabetic patients without apparent retinopathy.¹⁰ Retinal thickness varies across all quadrants of retina and having an understanding of quadrant wise thickness across all quadrants and how it changes progressively when disease progresses, can give a better insight of the concept of neurodegeneration in DR.¹¹ Several studies have shown significant thinning of quadrant wise retinal thickness but there is little data regarding which quadrant is most affected by neurodegeneration.¹² This study aims to evaluate and compare retinal thickness across all four macular quadrants (superior, inferior, nasal, and temporal) in type 2 diabetic patients with no posterior segment pathology and non-diabetic controls using SD-OCT. By identifying early subclinical structural changes, this research hopes to contribute to early diagnosis and prevention strategies for DR.

METHODS

This study was conducted at department of Ophthalmology, Gujranwala medical college/Teaching hospital Gujranwala from October 2024 to February 2025. Informed consent and approval from ethical review committee of the hospital was taken (**IRB. No 38/GMC**). Sixty eyes of 30 patients with Type 2 diabetes without diabetic retinopathy (group A) and 30

non-diabetic patients (group B) were included. After informed written consent, all the participants had complete ophthalmic examination consisting of visual acuity assessment (best corrected visual acuity (BCVA), slit lamp bio microscopy and SD-OCT. Data was collected according to the tenets of declaration of Helsinki. Nine standard ETDRS grid was used to assess retinal thickness using SD-OCT with central circle diameter to be 1mm called central subfield, the inner ring diameter of 3mm made up of four subfields, and the outer ring with 6mm diameter containing four subfields.

Group A, included patients who were known cases of type 2 diabetes mellitus (based on random and fasting blood sugar level and glycated hemoglobin test (HbA1C), no signs of DR on posterior segment examination using 90D lens and SD-OCT, no history of any past ocular surgery and no posterior segment pathologies like macular scar, Age-related macular degeneration, vitreomacular traction, or retinal detachment. Group B included non-diabetic patients with no past ocular surgery and no posterior segment pathology.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 26. Retinal thickness was measured and compared between diabetic and non-diabetic patients using an independent samples t-test. P value of < 0.05 was considered statistically significant.

RESULTS

A total of 120 eyes of 60 patients were included in this study, from Ophthalmology department of District Head Quarter Gujranwala. There were which 28 (46.6%) males and 32 (53.3%) females. The age groups with gender distribution are shown in Table 1. Mean retinal thickness in diabetics and non-diabetics was $297 \pm 18 \mu\text{m}$ and $308 \pm 15 \mu\text{m}$, respectively. Mean foveal thickness was 244 ± 14 and $237 \pm 9 \mu\text{m}$ in diabetics and non-diabetics, respectively. Quadrant wise (superior, inferior, nasal and temporal) retinal

Table 1: Age and gender distribution of the study sample.

Age Group (Years)	Male	Female	Total
30–45	6 (10%)	4 (6.66%)	10
46–60	15 (25%)	17 (28.35%)	32
61–70	15 (25%)	11 (18%)	18
Total	28	32	60

thickness is shown in Table 2. Temporal retinal thickness was significantly reduced as compared to other three quadrants in diabetics (without DR) and no-diabetic patients.

Table 2: *Quadrant-wise Retinal Thickness with p-values.*

Quadrant	Diabetic Patients (Mean \pm SD μm)	Non-Diabetic Patients (Mean \pm SD μm)	p-value
Superior	316 \pm 17	324 \pm 14	0.0058 **
Inferior	314 \pm 16	321 \pm 13	0.0097 **
Nasal	321 \pm 15	328 \pm 12	0.0056 **
Temporal	295 \pm 14	310 \pm 11	< 0.0001 ***

DISCUSSION

There was a statistically significant reduction in retinal thickness in diabetic patients without DR as compared to the controls, with the temporal quadrant exhibiting the most pronounced thinning. These findings strongly indicate the emerging concept that neurodegeneration occurs ahead of microvascular alternations that are usually used to diagnose DR.¹³ Bianco et al, emphasize that neuroinflammation and neurodegeneration are early and important components of DR pathogenesis, occurring even before the occurrence of microvascular changes.¹⁴ Persistent hyperglycemia triggers glial cell activation, cytokine release, and neuronal injury, leading to retinal dysfunction. These findings support the concept of diabetic retinal disease as a neurovascular disorder and emphasize the importance of early detection of neuronal changes for preventive strategies.

Despite DR being viewed as a microvascular complication, Rasheed et al, demonstrated a significant association between DR and diabetic peripheral neuropathy, with neurodegenerative changes in the retina occurring even in patients without clinical retinopathy.¹⁵ In a cohort of 500 type 2 diabetic patients, thinning of inner retinal layers (GC-IPL) correlated with severity of neuropathy, highlighting the concept that neural damage parallels or may precede vascular manifestations. These findings support the emerging view that diabetic retinal disease encompasses both neurodegenerative and microvascular pathology, suggesting that early neurodegeneration could be a biomarker for disease progression and a target for neuroprotective strategies.¹⁵

Ansari et al, also emphasized that retinal neurodegeneration is an early event in DR, often preceding

overt vascular abnormalities.¹⁶ Hyperglycemia-induced oxidative stress, inflammation, and neuronal apoptosis contribute to progressive retinal dysfunction. These mechanisms highlight the importance of targeting neuroprotective strategies alongside vascular therapies to prevent vision loss, reinforcing the concept of diabetic retinal disease as a neurovascular disorder.

Recently, Vinković et al, reported that high-definition optical coherence tomography angiography (HD-OCTA) and spectral-domain optical coherence tomography (SD-OCT) were capable of detecting subclinical retinal neurodegenerative and microvascular changes in patients with mild or no clinically evident diabetic retinopathy.¹⁷ Early alterations in retinal thickness, microvascular density, and capillary perfusion were identified, highlighting the value of OCT-based imaging in the early detection and monitoring of diabetic retinal disease prior to the onset of overt clinical signs. Aziz et al, applied multifractal analysis combined with multi-layer perceptron classification on OCT images to detect early diabetic retinopathy.¹⁸ The study demonstrated that computational analysis of retinal structural patterns can identify subtle neurodegenerative and microvascular changes before clinical signs are apparent, supporting the role of advanced OCT-based imaging and AI-assisted diagnostics in early detection and intervention.

Thus, it is need of hour to utilize different methodologies including SD-OCT for early detection of DR, long before it becomes clinically evident. Number of eyes can be saved with early screening of diabetics.

Limitations of this study include relatively small sample size and a cross-sectional study design.

CONCLUSION

This study focuses on the evolving concept of DR as a neurovascular complication rather than just a microvascular one. Using SD-OCT, we identified significant thinning across all four retinal quadrants, most marked in temporal quadrant in type 2 diabetic patients without DR. These findings suggest that neurodegenerative changes in retina may precede visible vascular changes. Such subclinical structural changes likely result from several factors including chronic hyperglycemia, oxidative stress, glutamate toxicity, and impaired neurotrophic support.

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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 (IRB.no 38/GMC)

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Authors Designation and Contribution

Zainab Naeem; PGR: *Concepts, Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Hafiza Fizza Zahid; PGR: *Design, Data acquisition, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Irfan Qayyum Malik; Associate Professor: *Concepts, Design, Literature search, Data analysis, Statistical analysis, Manuscript editing, Manuscript review.*

Usama Iqbal; Senior Registrar: *Concepts, Design, Literature search, Data analysis, Manuscript editing, Manuscript review.*

Moughees Ahmad; Senior Registrar: *Design, Literature search, Statistical analysis, Manuscript preparation, Manuscript review.*

