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Original Research Article

Frequency of Macular Edema in Diabetic Retinopathy

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Abstract: *Diabetic macular edema is a major vision-threatening complication of diabetic retinopathy and may lead to significant loss of central vision. Optical coherence tomography allows objective detection of macular edema and helps identify patients who require early intervention.* ***Objective:*** *To determine the frequency of macular edema among patients with diabetic retinopathy and to assess its association with demographic, clinical, and ophthalmic factors.* ***Methods:*** *This hospital-based cross-sectional study was conducted in the Ophthalmology Unit of Ayub Teaching Hospital, Abbottabad, Pakistan, from 12 June 2025 to 12 September 2025. A total of 196 patients aged 40–80 years with type 2 diabetes mellitus and diagnosed diabetic retinopathy were enrolled using non-probability consecutive sampling. Demographic data, body mass index, duration of diabetes, HbA1c, visual acuity, diabetic retinopathy stage, and optical coherence tomography findings were recorded. Macular edema was diagnosed using OCT findings, including increased central macular thickness and macular retinal thickening. Data were analyzed using SPSS version 20. Associations were assessed using chi-square test or Fisher's exact test, with $p \leq 0.05$ considered statistically significant.* ***Results:*** *The mean age of patients was 56.8 ± 9.4 years. There were 106 male patients (54.1%) and 90 female patients (45.9%). The mean duration of diabetes was 9.2 ± 4.8 years, mean HbA1c was 8.4 ± 1.3%, and mean central macular thickness was 336.4 ± 91.2 microns. Macular edema was detected in 100 patients, giving an overall frequency of 51.0%. The frequency increased with advancing diabetic retinopathy stage, from 22.0% in mild non-proliferative diabetic retinopathy to 81.3% in proliferative diabetic retinopathy. Patients with macular edema had significantly higher age, BMI, duration of diabetes, HbA1c, random blood sugar, central macular thickness, and poorer visual acuity compared with those without macular edema. Macular edema was significantly associated with increasing age, higher BMI, longer duration of diabetes, poor glycemic control, and advanced diabetic retinopathy stage, while gender and residence showed no significant association.* ***Conclusion:*** *Macular edema was present in approximately half of the patients with diabetic retinopathy in this tertiary-care Pakistani cohort. Older age, overweight or obesity, longer diabetes duration, poor glycemic control, and advanced diabetic retinopathy were significantly associated with macular edema. Routine OCT-based macular assessment should be prioritized in high-risk diabetic retinopathy patients to support early diagnosis and timely management.*

Keywords: Diabetic Retinopathy; Macular Edema; Diabetes Mellitus, Type 2; Optical Coherence Tomography; Visual Acuity.

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Introduction

Diabetes mellitus is a major global public health problem and is increasing rapidly in both high-income and low- and middle-income countries. The Global Burden of Disease analysis reported a substantial rise in diabetes prevalence and projected a continuing increase in diabetes-related morbidity over the coming decades (1). Among the microvascular complications of diabetes, diabetic retinopathy is one of the most important causes of avoidable visual impairment and blindness. A recent global meta-analysis estimated that diabetic retinopathy affects a large proportion of adults with diabetes, with diabetic macular edema representing a clinically important vision-threatening complication (2).

Diabetic macular edema is characterized by retinal thickening and fluid accumulation in the macular region due to breakdown of the inner blood-retinal barrier, capillary leakage, inflammation, vascular endothelial growth factor activity, and chronic hyperglycemia-induced microvascular damage. It may occur at any stage of diabetic retinopathy, but its frequency usually increases with longer duration of diabetes, poor glycemic control, advanced retinopathy, hypertension, nephropathy, obesity, and other metabolic risk factors (3). The burden of diabetic retinopathy and diabetic macular edema varies across regions because of differences in diabetes duration, access to screening, population age structure, health-care systems, and availability of ophthalmic imaging (4). The clinical relevance of diabetic macular edema lies in its direct effect on central visual acuity. Even when peripheral retinal changes are mild, macular involvement can cause reading difficulty, reduced contrast sensitivity, impaired work capacity, and loss of independence. Tan et al. emphasized that diabetic retinopathy care is moving toward earlier detection, risk stratification, and integration of imaging-based screening into routine diabetes services (5). Evidence from South Asian populations also suggests that diabetic eye disease remains underdiagnosed and undertreated, partly because many patients present late or undergo ophthalmic examination only after visual symptoms appear (6).

Optical coherence tomography has become the preferred imaging modality for detecting and quantifying diabetic macular edema because it provides objective measurement of central macular thickness and identifies retinal fluid even when clinical examination is equivocal. Population-based OCT studies have shown that diabetic macular edema may be missed when screening relies only on fundus examination or photography (7). Recent multicenter data also indicate that demographic and metabolic factors, including glycemic status, body mass index, and retinopathy severity, are associated with development of diabetic macular edema (8). Anatomical OCT biomarkers, including central macular thickness and macular volume, are increasingly used as surrogate markers of disease severity and treatment response (9).

In Pakistan, the need for diabetic eye screening is particularly high because the country has one of the largest diabetes burdens globally; the IDF Diabetes Atlas reported approximately 34.5 million adults living with diabetes in Pakistan in 2024. Local population-based evidence from rural Pakistan has also shown a considerable burden of diabetic retinopathy and highlighted gaps in regular screening (10). However, data on OCT-confirmed macular edema among patients already diagnosed with

diabetic retinopathy remain limited in many Pakistani tertiary-care settings.

The rationale of the present study is based on the increasing diabetes burden in Pakistan, delayed presentation of diabetic eye disease, limited routine availability of OCT-based screening in many public-sector settings, and the scarcity of local data from Khyber Pakhtunkhwa. Determining the frequency of macular edema among patients with diabetic retinopathy and identifying associated clinical factors can help ophthalmologists and physicians prioritize high-risk patients for OCT assessment, early referral, timely treatment, and structured diabetic eye screening programs in Pakistan.

Methodology

This study was designed as a hospital-based cross-sectional study and was conducted in the Ophthalmology Unit of Ayub Teaching Hospital, Abbottabad, Pakistan, over a three-month period from 12 June 2025 to 12 September 2025. The study was planned to determine the frequency of macular edema among patients with diabetic retinopathy presenting to the ophthalmology outpatient department. The methodology was structured according to standard reporting principles for observational cross-sectional studies, as recommended by the STROBE framework.

A total of 196 patients were enrolled using a non-probability consecutive sampling technique. The sample size was calculated through the WHO sample size calculator by using a 95% confidence level, an anticipated frequency of macular edema in diabetic retinopathy of 51.1%, and an absolute precision of 7%, as mentioned in the synopsis. The study population included patients aged 40 to 80 years, of either gender, who had type 2 diabetes mellitus and were diagnosed with diabetic retinopathy on ophthalmic examination. Patients with impaired glucose tolerance, gestational diabetes mellitus, and pregnant women were excluded to avoid misclassification and confounding due to temporary or pregnancy-related glucose disturbances.

Type 2 diabetes mellitus was defined as fasting blood glucose ≥126 mg/dL after at least eight hours of fasting, random plasma glucose ≥200 mg/dL, HbA1c ≥6.5%, or a documented history of using antidiabetic medication. These diagnostic thresholds are consistent with current diabetes diagnostic criteria described by the American Diabetes Association. Diabetic retinopathy was diagnosed by an ophthalmologist through detailed retinal examination using ophthalmoscopy and slit-lamp biomicroscopy with a 90-diopter lens. The severity of diabetic retinopathy was categorized as mild non-proliferative diabetic retinopathy, moderate non-proliferative diabetic retinopathy, severe non-proliferative diabetic retinopathy, and proliferative diabetic retinopathy according to the retinal findings described in the study protocol.

After approval from the ethical review committee of Ayub Teaching Hospital, Abbottabad, all eligible patients presenting to the ophthalmology outpatient department during the study period were assessed for inclusion. The study protocol was explained to each patient in understandable language, and written informed consent was obtained before enrollment. Confidentiality of the collected information was maintained throughout the study, and the data were used only for research purposes.

Demographic and clinical information was collected on a predesigned structured proforma. The recorded variables included age, gender, occupation, educational status, monthly income, socioeconomic status, residence, weight, height, body mass index, duration of diabetes, HbA1c, visual acuity, stage of diabetic retinopathy, and optical coherence tomography findings. Body mass index was calculated by dividing weight in kilograms by height in meters squared and was categorized as underweight, normal weight, overweight, or obese according to the categories used in the study proforma.

All enrolled patients underwent a complete ophthalmic assessment. Fundus examination was performed under slit-lamp biomicroscopy using a 90-diopter lens to assess the presence and stage of diabetic retinopathy. Optical coherence tomography was performed to evaluate central macular thickness and to identify macular edema. Macular edema was considered present when there was visible retinal thickening involving the macular region, central macular thickness exceeding 300 microns on OCT, reduction in visual acuity, or associated macular findings such as hard exudates, hemorrhages, or microaneurysms. Current ophthalmology practice guidelines also support the classification of diabetic retinopathy severity and assessment of diabetic macular edema as part of routine diabetic eye evaluation.

The primary outcome variable was the frequency of macular edema among patients with diabetic retinopathy. The secondary variables included the distribution of macular edema according to age, gender, body mass index, duration of diabetes, glycemic control, residence, and stage of diabetic retinopathy. Potential effect modifiers such as age, gender, BMI, random blood sugar or HbA1c level, and duration of diabetes were controlled through stratification, as planned in the synopsis.

Data were entered and analyzed using SPSS version 20. Quantitative variables, including age, weight, height, body mass index, HbA1c, visual acuity, OCT-measured central macular thickness, duration of diabetes, and monthly income, were assessed for normality using the Shapiro–Wilk test. Normally distributed quantitative variables were presented as mean ± standard deviation, while non-normally distributed variables were presented as median with interquartile range. Categorical variables, including gender, occupation, education, socioeconomic status, residence, BMI category, stage of diabetic retinopathy, and presence or absence of macular edema, were presented as frequencies and percentages. After stratification, the chi-square test or Fisher's exact test was applied to determine the association of macular edema with relevant demographic and clinical variables. A p-value of ≤0.05 was considered statistically significant.

Results

A total of 196 patients with type 2 diabetes mellitus and diabetic retinopathy were enrolled from the Ophthalmology Unit of Ayub Teaching Hospital, Abbottabad. The mean age of the study population was 56.8 ± 9.4 years, with most patients belonging to the 51–60 years age group. There were 106 male patients (54.1%) and 90 female patients (45.9%). Most participants were from urban areas, belonged to the middle socioeconomic class, and had no education or education up to matric/intermediate level. The mean body mass index was 26.8 ± 4.5 kg/m², and 133 patients (67.8%) were either overweight or obese. (Table 1)

Table 1. Demographic characteristics of patients with diabetic retinopathy, n=196

Variable	Frequency / Mean	Percentage / SD
Age, years	56.8	±9.4
40–50 years	48	24.5%
51–60 years	72	36.7%
61–70 years	55	28.1%
71–80 years	21	10.7%
Male	106	54.1%
Female	90	45.9%

Urban residence	113	57.7%
Rural residence	83	42.3%
No formal education	55	28.1%
Primary/Middle	48	24.5%
Matric/Intermediate	55	28.1%
Graduate or above	38	19.4%
Lower socioeconomic status	69	35.2%
Middle socioeconomic status	104	53.1%
Upper socioeconomic status	23	11.7%
Monthly income, PKR	52,800	±23,600
Weight, kg	72.1	±11.8
Height, meters	1.64	±0.09
BMI, kg/m²	26.8	±4.5
Underweight	7	3.6%
Normal weight	56	28.6%
Overweight	82	41.8%
Obese	51	26.0%

The mean duration of diabetes was 9.2 ± 4.8 years. More than half of the patients had diabetes for more than five years, and 56 patients (28.6%) had diabetes for more than 10 years. The mean HbA1c was 8.4 ± 1.3%, suggesting suboptimal glycemic control in most participants. The mean central macular thickness on OCT was 336.4 ± 91.2 microns. Moderate non-proliferative diabetic retinopathy was the most frequent stage, followed by severe non-proliferative diabetic retinopathy and proliferative diabetic retinopathy. (Table 2)

Table 2. Clinical and ophthalmic characteristics of study participants, n=196

Variable	Frequency / Mean	Percentage / SD
Duration of diabetes, years	9.2	±4.8
1–3 years	26	13.3%
3.1–5 years	38	19.4%
5.1–10 years	76	38.8%
>10 years	56	28.6%
HbA1c, %	8.4	±1.3
HbA1c <7.0%	38	19.4%
HbA1c 7.0–8.9%	94	48.0%
HbA1c ≥9.0%	64	32.7%
Random blood sugar, mg/dL	242.6	±73.5
Presenting visual acuity, logMAR	0.59	±0.31
Central macular thickness, microns	336.4	±91.2
Mild NPDR	41	20.9%
Moderate NPDR	69	35.2%
Severe NPDR	54	27.6%
Proliferative diabetic retinopathy	32	16.3%

Macular edema on OCT was identified in 100 patients, giving an overall frequency of 51.0% among patients with diabetic retinopathy. The frequency of macular edema increased progressively with advancing stage of diabetic retinopathy. It was lowest among patients with mild non-proliferative diabetic retinopathy and highest among patients with proliferative diabetic retinopathy. (Table 3)

Table 3. Frequency of macular edema according to stage of diabetic retinopathy

Stage of diabetic retinopathy	Total, n	Macular edema present, n (%)	Macular edema absent, n (%)
Mild NPDR	41	9 (22.0%)	32 (78.0%)
Moderate NPDR	69	29 (42.0%)	40 (58.0%)
Severe NPDR	54	36 (66.7%)	18 (33.3%)
Proliferative diabetic retinopathy	32	26 (81.3%)	6 (18.8%)
Total	196	100 (51.0%)	96 (49.0%)

Patients with macular edema were older and had a higher mean BMI, longer duration of diabetes, higher HbA1c, greater central macular thickness, and poorer visual acuity compared with those without macular edema. The differences were statistically significant for age, BMI, duration of diabetes, HbA1c, OCT thickness, and visual acuity. (Table 4)

Table 4. Comparison of clinical parameters between patients with and without macular edema

Variable	Macular edema present, n=100	Macular edema absent, n=96	p-value
Age, years	58.9 ± 8.7	54.7 ± 9.6	0.002
BMI, kg/m²	27.9 ± 4.3	25.7 ± 4.4	<0.001
Duration of diabetes, years	10.4 ± 4.7	7.9 ± 4.5	<0.001
HbA1c, %	8.8 ± 1.2	7.9 ± 1.3	<0.001

Random blood sugar, mg/dL	257.8 ± 70.4	226.7 ± 72.8	0.003
Central macular thickness, microns	409.6 ± 70.3	260.1 ± 24.6	<0.001
Visual acuity, logMAR	0.72 ± 0.31	0.47 ± 0.25	<0.001

On stratified analysis, macular edema was significantly associated with increasing age, higher BMI, longer duration of diabetes, poor glycemic control, and advanced diabetic retinopathy stage. Gender and residence were not significantly associated with macular edema. (Table 5)

Table 5. Stratified association of demographic and clinical factors with macular edema

Variable	Total, n	Macular edema present, n (%)	Macular edema absent, n (%)	p-value
Age group				0.001
40–50 years	48	15 (31.3%)	33 (68.8%)	
51–60 years	72	34 (47.2%)	38 (52.8%)	
61–70 years	55	36 (65.5%)	19 (34.5%)	
71–80 years	21	15 (71.4%)	6 (28.6%)	
Gender				0.120
Male	106	60 (56.6%)	46 (43.4%)	
Female	90	40 (44.4%)	50 (55.6%)	
Residence				0.534
Urban	113	55 (48.7%)	58 (51.3%)	
Rural	83	45 (54.2%)	38 (45.8%)	
BMI category				0.002
Underweight	7	2 (28.6%)	5 (71.4%)	
Normal weight	56	18 (32.1%)	38 (67.9%)	
Overweight	82	46 (56.1%)	36 (43.9%)	
Obese	51	34 (66.7%)	17 (33.3%)	
Duration of diabetes				<0.001
1–3 years	26	5 (19.2%)	21 (80.8%)	
3.1–5 years	38	14 (36.8%)	24 (63.2%)	
5.1–10 years	76	40 (52.6%)	36 (47.4%)	
>10 years	56	41 (73.2%)	15 (26.8%)	
HbA1c category				<0.001
<7.0%	38	9 (23.7%)	29 (76.3%)	
7.0–8.9%	94	48 (51.1%)	46 (48.9%)	
≥9.0%	64	43 (67.2%)	21 (32.8%)	
Stage of diabetic retinopathy				<0.001
Mild NPDR	41	9 (22.0%)	32 (78.0%)	
Moderate NPDR	69	29 (42.0%)	40 (58.0%)	
Severe NPDR	54	36 (66.7%)	18 (33.3%)	
Proliferative diabetic retinopathy	32	26 (81.3%)	6 (18.8%)	

Overall, approximately half of the patients with diabetic retinopathy had OCT-confirmed macular edema. The frequency was higher among older patients, overweight and obese individuals, patients with poor glycemic control, those with longer duration of diabetes, and those with severe non-proliferative or proliferative diabetic retinopathy. These findings suggest that patients with long-standing and poorly controlled diabetes require careful macular assessment by OCT during routine diabetic retinopathy screening.

Discussion

The present study found OCT-confirmed macular edema in 51.0% of patients with diabetic retinopathy, indicating a high burden of sight-threatening macular involvement in this tertiary-care Pakistani cohort. This frequency is higher than population-based estimates because our sample included only patients with established diabetic retinopathy and was recruited from an ophthalmology unit, where more advanced or symptomatic cases are expected. Lin et al. reported a lower prevalence of diabetic macular edema in a northeastern Chinese population, which is consistent with broader population screening rather than hospital-based recruitment (11). Similarly, Shumye et al. described diabetic macular edema among adult diabetic clinic attendees and emphasized that clinical setting and screening approach influence observed prevalence (12). Alshehri et al. reported a much lower DME frequency in a tele-screening program using OCT and fundus photographs, again supporting the effect of earlier screening and inclusion of less advanced diabetic cases (13). In contrast, Shaikh et al. reported diabetic macular edema and systemic risk factors in a Pakistani cross-sectional study, supporting the need for local risk-based screening strategies (14).

A major finding of our study was the progressive rise in macular edema with increasing retinopathy severity, from 22.0% in mild NPDR to 81.3% in proliferative diabetic retinopathy. This pattern is biologically plausible because advanced retinopathy reflects more extensive capillary non-perfusion, vascular leakage, and inflammatory activity. García-Ulloa et al. also found that diabetic retinopathy with macular edema was associated with worse systemic and ocular risk profiles in recently diagnosed type 2 diabetes (15). Zhang et al. reported that longer diabetes duration, higher HbA1c, and retinopathy severity were associated with diabetic macular edema, although their findings on BMI differed from ours, possibly because of population differences, referral patterns, and residual confounding (16).

Patients with macular edema in our study were older, had longer diabetes duration, higher HbA1c, higher random blood sugar, and poorer visual acuity. These findings are consistent with Wang et al., who showed that duration and metabolic risk factors influence diabetic macular edema across early- and late-onset diabetes groups (17). Sharma et al. also

demonstrated that poor glycemic control was associated with increased macular thickness, supporting our finding of higher HbA1c and greater central macular thickness among patients with edema (18). Although renal parameters were not assessed in the present study, Suzuki et al. showed a relationship between diabetic nephropathy and macular edema, suggesting that future Pakistani studies should include albuminuria and renal function markers (19). Cao et al. further highlighted that endocrine and metabolic abnormalities may contribute to macular edema risk, indicating the multifactorial nature of DME (20).

The mean central macular thickness was markedly higher in patients with macular edema, and visual acuity was significantly worse. Yoon et al. reported that anatomical characteristics and treatment course influence long-term outcomes in diabetic macular edema, reinforcing the importance of OCT-based evaluation (21). Muayad et al. also demonstrated an association between progressive kidney function decline and diabetic macular edema in type 2 diabetes, supporting the concept of systemic microvascular clustering (22). In Pakistan, Mateen et al. reported an association between HbA1c and central macular thickness, which closely supports our local findings (23).

Gender and residence were not significantly associated with macular edema in our study. This suggests that metabolic and ocular disease-related factors may be more important than demographic factors in this cohort. The main limitations include the single-center design, cross-sectional nature, and absence of data on blood pressure, lipid profile, nephropathy, and treatment history. Nevertheless, the findings emphasize that Pakistani patients with long-standing, poorly controlled diabetes and advanced retinopathy should undergo routine OCT assessment to detect macular edema before irreversible visual loss occurs.

Conclusion

Macular edema was detected in 51.0% of patients with diabetic retinopathy, showing a high burden of sight-threatening macular involvement. Its frequency increased with advancing diabetic retinopathy stage and was significantly associated with older age, higher BMI, longer duration of diabetes, poor glycemic control, and increased central macular thickness. These findings highlight the need for routine OCT assessment in patients with diabetic retinopathy, especially those with long-standing and poorly controlled diabetes, to enable early detection and timely treatment of macular edema.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-AYTH-223/89-24)

Consent for publication
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

ZI (PGR)
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Review of Literature, Data entry, Data analysis, and drafting articles.
WS (PGR)
Conception of Study, Development of Research Methodology Design
DZ (Professor)
Study Design, manuscript review, critical input

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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