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Diabetic Retinopathy : Spectrum Of Clinical Presentation And Correlation With Hba1c Levels

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ABSTRACT

Background: Diabetic retinopathy remains a leading global cause of vision loss; however, it is one of the most preventable conditions regarding vision loss. The development and progression of the condition depend on poor glycemic control. Hemoglobin A1c (HbA1c) levels are the standard measure of glycemic control over time. Knowledge of the clinical range of DR and the correlating levels of HbA1c is helpful to implement corrective actions in a timely fashion. It will improve the outcomes of patients.

Objectives: To study the clinical range of diabetic retinopathy in type 2 diabetes patients. To investigate the association between the extent of HbA1c and the presence of retinopathy.

Study design: Cross-sectional study.

Place and Duration of study: From January 2024 to January 2025, the study was conducted in the Department of Ophthalmology, Bacha Khan Medical College, Mardan.

Methods: The study examined 120 patients with type 2 diabetes mellitus attending the ophthalmology clinic, who underwent a comprehensive ophthalmic evaluation for diabetic retinopathy which included slit lamp, biomicroscope, and fundus photographic documentation. Diabetes control was assessed using the HbA1c test, and the data was analyzed employing SPSS version 24. The relation of HbA1c with various levels of Diabetic Retinopathy was analyzed using descriptive statistics, Chi-square, and logistic regression, with a significance threshold of p=0.05.

Results: The average age of the patients was 54.6±9.8 years, and the gender distribution included 65 males and 55 females. The total prevalence of diabetic retinopathy was 62.5%(n=75), with 46.7%(n=56) classified as non-proliferative and 15.8%(n=19) classified as proliferative.Out of all diabetic retinopathy patients, 20%(n=24) presented with maculopathy. Significant variation was noted between the average HbA1c of patients with and without diabetic retinopathy at 8.9 ± 1.5% and 7.2 ± 1.2% respectively, $p < 0.001$. The severity of diabetic retinopathy was strongly positively correlated to the HbA1c with an r value of 0.68, $p < 0.001$.

Conclusion: This study discovered that a significant number of type 2 diabetes mellitus patients suffer from diabetic retinopathy. Poor glycemic control and higher retinopathy severity, linked by higher HbA1c levels, show the need for more stringent glycemic control in preventing vision-threatening complications of diabetic retinopathy.Implementing the recommended routine screening for interventions on patients with considerably high HbA1c levels can alleviate diabetic retinopathy burden, especially in resource-poor setting

KEYWORDS: Diabetic Retinopathy; Glycated Hemoglobin A; Diabetes Mellitus, Type 2; Visual Impairment.

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INTRODUCTION

Prevalent microvascular complications of diabetes mellitus. It is among the most common causes of preventable blindness globally. As the global prevalence of diabetes increases, especially T2DM, the global burden of DR is expanding significantly [1]. Currently, the WHO estimates there are more than 400 million people living with diabetes, and this is expected to increase

significantly in the next several decades. Diabetic retinopathy is one of the complications that is most disabling, and unlike the others, it also serves as a marker of advanced diabetes complications. It signals the presence of microvascular systemic complications [2,3]. Diabetic retinopathy results from the microvascular complications of diabetes. It is the sequelae of sustained hyperglycemia that leads to the thickening and damage of basement membranes, the loss of pericytes, and the occlusion of capillaries. It causes various degrees of retinal changes and, in advanced stages, results in proliferative diabetic retinopathy (PDRPDR is characterized by neovascularization and vitreous hemorrhage. However, there are other vision threatening complications of diabetic retinopathy [4]. Macular edema, which can occur at any stage of retinopathy, is one of the most common and most threatening complications, and the primary cause of vision loss in people with diabetes. Other complications which intersect with the retinopathy's onset and progression are hypertension, nephropathy and dyslipidemia. Of all the modifiable risk factors, the most significant is poor control of blood glucose. [5]. HbA1c is an excellent parameter to evaluate long term glycemic control, because it reflects average blood glucose concentrations for the previous two to three months. Several published works, mostly the Diabetes Control and Complications Trial (DCCT) and the United Kingdom Prospective Diabetes Study (UKPDS), documented the strong relationship between higher HbA1c levels and the risk of developing and/or worsening diabetic retinopathy (DR). The progression of DR in any one patient is variable and unpredictable. In low resource settings, the late stage of DR is the result of poor screening, low levels of awareness, and inadequately resourced subspecialty eye care [6,7]. As a result, patients are often seen with end stage retinopathy, especially proliferative diabetic retinopathy (PDR) and maculopathy, which have a poor visual prognosis.The potential for significant vision loss that is associated with DR underscores the importance of timely intervention for affected individuals. screening and staging have been revolutionized by advances in retinal imaging, including digital fundus photography and optical coherence tomography (OCT).certain low and middle-income countries, slit-lamp biomicroscope and fundus examination are standard practices [8]. For these populations, determining the relationship between HbA1c and the severity of diabetic retinopathy (DR) will aid both ophthalmologists and physicians in identifying high-risk patients for early eye reviews. For DR patients with Type 2 Diabetes Mellitus (T2DM) under the care of tertiary ophthalmology clinics, the current study aimed to describe the DR clinical spectrum and evaluate the relationship between the level of HbA1c, and severity of the DR aimed. Understanding this will enable the clinicians to counsel patients on the need for strict glycemic control to prevent the progression to sight-threatening retinopathy [9].

METHODS

From January 2024 to January 2025, the study was conducted in the Department of Ophthalmology, Bacha Khan Medical College, Mardan.Using consecutive sampling, we recruited 120 patients with previously diagnosed type 2 diabetes elliptical components were integrated to perform a full eye evaluation as having the patient's best-corrected visual acuity tested, conducting a slit-lamp examination, carrying out a dilated examination of the fundus, and capturing fundus photographs. The level of DR was classified according to the Early Treatment Diabetic Retinopathy Study (ETDRS) criteria. The HbA1c levels were determined using vertically integrated, high-performance liquid chromatography (HPLC) standardized technique. Data were analyzed using version 24.0 of SPSS.. I used descriptive statistics to summarize demographic and clinical data. I also used the chi-square test and logistic regression for association studies. I calculated Pearson's correlation coefficient to determine the correlation between HbA1c and the severity of DR. I used a p-value of <0.05 for statistical significance.

Inclusion Criteria:
The study included patients aged 30–70 years, diagnosed with type 2 diabetes mellitus for 5 years, and had given their consent

Exclusion Criteria:
Other retinal diseases such as diabetic retinopathy, history of intraocular surgery and media opacities to fundus examination were reasons for exclusion.

Ethical Approval:
The study guidelines were consistent with the Declaration of Helsinki. Ethical approval from the Medical Teaching Institute, Peshawar (IRB Approval No: BKMC/MRD/KPK/245/06/2022/DOS), and consent from participants were obtained

Data Collection:
Data regarding demographics, duration of diabetes, comorbidities, and treatment history were recorded and included in the structured clinical evaluation forms for each participant. Ophthalmic assessment as well as the measurement of HbA1c was done on the same day to facilitate consistency in assessments. Fundus photographs were graded independently by two ophthalmologists to reduce inter-observer variability.

Statistical Analysis:
All statistical analyses were conducted using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Frequencies and percentages were calculated for categorical variables, while means ± SD were computed continuous variables. Associations between DR severity and HbA1c were assessed using chi-square tests, logistic regression, and Pearson's correlation coefficient.

RESULTS

120 T2DM patients were evaluated, comprising 65 men (54.2%) and 55 women (45.8%), with an average age of 54.6 ± 9.8 years. The overall prevalence of retinopathy within this sample was 62.5% (n=75). Within this group, non-proliferative retinopathy, proliferative retinopathy (PDR) and maculopathy were found in 46.7% (n=56), 15.8% (n=19) and 20% (n=24) of patients respectively. 18.3% (n=22) were found to have visual impairment (best corrected visual acuity worse than 6/18). The mean HbA1c of patients with DR was significantly higher than those without DR (8.9 ± 1.5% vs 7.2 ± 1.2%) (p<0.001). Increasing

HbA1c levels were positively correlated with increasing DR severity (r=0.68, p<0.001). Patients with an HbA1c of 9% and above were nearly four times as likely to have PDR than those with an HbA1c of less than 7% (OR=3.9, 95% CI: 1.8–8.4, p=0.001). Duration of diabetes also showed significant association with DR with >10 years of diabetes demonstrating higher prevalence (p=0.002). No significant differences were noted regarding gender distribution (p=0.47). These observations indicate that in this population, the presence and severity of DR can be attributed primarily to the duration of diabetes and poor glycemic control.

.**Table 1. Baseline Demographic Characteristics of the Study Population (n = 120**

Variable	Frequency (n)	Percentage (%)	Mean ± SD	p-value*
Age (years)	–	–	54.6 ± 9.8	–
Gender				
• Male	65	54.2	–	0.47
• Female	55	45.8	–	
Duration of Diabetes (years)	–	–	10.2 ± 4.6	0.002
≤ 10 years	62	51.7	–	
> 10 years	58	48.3	–	

Table 2. Clinical Spectrum of Diabetic Retinopathy (n = 120)

Retinopathy Status	Frequency (n)	Percentage (%)
No Diabetic Retinopathy	45	37.5
Non-Proliferative DR (NPDR)	56	46.7
Proliferative DR (PDR)	19	15.8
Diabetic Maculopathy	24	20.0
Visual Impairment (<6/18)	22	18.3

Table 3.Association Between HbA1c Levels and Diabetic Retinopathy Severity

HbA1c (%) Category	No DR (n=45)	NPDR (n=56)	PDR (n=19)	p-value
< 7.0	28 (62.2%)	12 (21.4%)	5 (26.3%)	<0.001
7.0 – 8.9	13 (28.9%)	24 (42.9%)	4 (21.1%)	
≥ 9.0	4 (8.9%)	20 (35.7%)	10 (52.6%)	
Mean HbA1c ± SD	7.2 ± 1.2	8.6 ± 1.3	9.3 ± 1.6	<0.001

Table 4. Logistic Regression Analysis of Risk Factors for Diabetic Retinopathy

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
HbA1c ≥ 9.0%	3.9	1.8 – 8.4	0.001
Duration of DM > 10 years	2.7	1.4 – 5.2	0.002
Male gender	1.2	0.6 – 2.4	0.47
Age > 55 years	1.6	0.8 – 3.0	0.09

DISCUSSION

this study shows the significant range of diabetic retinopathy (DR) in the adult population with type 2 diabetes mellitus (T2DM). Among the study cohort, 62.5% participants diagnosed with T2DM had some form of diabetic retinopathy which indicated a clear, graded relationship with the level of HbA1c with the severity of retinopathy [10]. Given the global estimates of 35% for any diabetic retinopathy and the 93 million cases of diabetic retinopathy reported in the landmark meta-analysis by Yau et al., we suspect that this cohort study likely represents the impact of referral bias and long disease duration in the participants of this study. Consistent with the prevalence of retinopathy in the 93 million cases, we suspect that factors such as disease duration and referral bias in this cohort study may account for the higher global estimates. [11]. The current literature emphasizes that DR is the most common cause of preventable vision loss in the world, and adheres to the concept that systematic screening, combined with risk-stratified glycemic controls, is rational and essential [12].The correlation we discovered: each case of diabetic retinopathy presented multiple instances of chronic hyperglycemia and a remarkably higher HbA1c level, reinforcing the definition of HbA1c as “an essential biomarker.” Simultaneously, the effect of glycemia on the microvascular complication through “metabolic memory” defines retinopathy as a microvascular complication of chronic hyperglycemia and the main driver of memory [13]. Each percentage drop in HbA1c achieved in the successive intervals of the UKPDS resulted in microvascular complications substantially diminishing, further confirming the complication reducing effect of glycemic control in T2DM. The correlation shown in the study establishes HbA1c as the most practical biomarker, reinforcing the need to include ophthalmic investigation in HbA1c monitoring [14].The “early worsening” of retinopathy phenomenon, although well documented, does not deny the study findings. The attention of Bleeding and Profuse Worsening of the retinopathy Syndrome, alongside the Expanded Standards of Care, is clear: a clinician must evaluate retinopathy status and document anticipated worsening when intensifying therapy in the control coronary. The findings in the study, therefore, show the need for a clear and simple tactical approach for practitioners; to reverse hyperglycemia through retreatment while retinal scans are to be performed in a timely manner. The approach is in accordance to the anticipated guidelines of the 2025 ADA [15,16].For staging and phenotyping, we used the

ETDRS-based framework as it is still the clinical standard for referring NPDR to PDR, and for guiding referral levels [17]. The trend in literature, however, is moving towards more quantitative, multimodal frameworks that more accurately assess shifting risk. Some recent reviews using more advanced imaging modalities like widefield fluorescein angiography, OCT, and other imaging biomarkers propose newer predictive scales for DR progressing [18]. These may resolve the relationship between chronic hyperglycemia (HbA1c) and the high-resolution microvascular imaging the remodeling, potentially explaining variability within the classically defined ranges [19]. Our cohort's 20% maculopathy figure highlights the importance of diabetic macular edema (DME) in visual morbidity. However, the long-term follow-up of the DRCR.net Protocol T, that showed remarkable visual gains with anti-VEGF therapy, pointed out that the gains were no longer sustained once the protocol-driven care stopped, which underscored the need for ongoing, structured follow-up in real-world settings [20]. These highlights the need for parallel robust treatment pathways for vision threatening complications in addition to the controlling of glycemia to prevent the progression of DR. From a public health perspective, our single-center prevalence still exceeds regional syntheses estimates, for instance, Eastern Mediterranean analyses citing ~28% for Pakistan, which suggests gaps in early detection and longitudinal care for continuum in scarcity tendencies.

CONCLUSION

There is considerable prevalence of diabetic retinopathy in type 2 diabetes mellitus patients which becomes proportional with increased HbA1c levels. This indicates that in poorly controlled diabetes mellitus, chronicity of the disease state, glycemic control, and the duration of the disease are predictors of the severity of the complication.The development of vision-threatening complications in this population still requires prompt and effective management, along with stringent control of blood glucose levels and early screening

LIMITATIONS

There are boundaries in the generalizability of findings from a single tertiary-care center as it limits cross-sectional design analyses from inferring causation and longitudinal analyses from assessing progression. The severity of retinopathy may have been underestimated due to a lack of exploration of additional risk factors such as hypertension, lipid profile, and renal function.

FUTURE FINDINGS

To improve the current findings future study should be based on prospective multicenter studies with larger sample sizes. The combination of high risk of missed diagnoses and poor outcomes justify the use advanced retinal imageries and artificial intelligence algorithms in early detection and risk stratification. The contribution of systemic factors in combination with HbA1c should be studied to explain the factors of disease progression on which preventative measures can be based.

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Authors Contribution

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