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# Correlation of HbA1c Levels with Severity of Diabetic Retinopathy

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## Abstract

Diabetic retinopathy (DR) is a leading microvascular complication of diabetes mellitus and a major cause of preventable visual impairment. Glycated hemoglobin (HbA1c) reflects long-term glycemic control and is considered a key predictor of diabetic complications. However, data correlating HbA1c levels with the severity of DR in Bangladeshi patients remain limited. A prospective, cross-sectional study was conducted in Community Based Medical College, Bangladesh (CBMC,B) Hospital, Mymensingh, Bangladesh, from January 2023 to December 2024, to see the correlation between HbA1c levels and the severity of diabetic retinopathy in Bangladeshi patients. A total of 46 patients with diabetes mellitus were enrolled using purposive sampling. HbA1c levels were measured using standardized laboratory methods. A total of 46 patients with diabetes mellitus were included in the study. The mean age of the patients was 54.2±9.6 years; male-female ratio was 1.42:1. The mean duration of diabetes was 8.7±4.1 years. Regarding glycemic status, the mean HbA1c level was 8.4±1.6%. The majority of the patients (56.5%) had poor glycemic control (HbA1c ≥8.0%), while only 17.4% had HbA1c levels <7.0%. On fundoscopic examination, non-proliferative diabetic retinopathy (NPDR) was detected in 76.1% of patients, while proliferative diabetic retinopathy (PDR) was present in 23.9%. Among NPDR cases, mild, moderate, and severe forms were observed in 30.4%, 28.3%, and 17.4% of the patients respectively. The mean HbA1c levels showed a progressive rise with increasing severity of diabetic retinopathy. Patients with mild NPDR had a mean HbA1c of 7.2±0.9%, whereas those with moderate and severe NPDR had mean values of 8.1±1.2% and 8.9±1.4% respectively. The highest mean HbA1c level (9.6±1.3%) was observed in patients with PDR. This trend was statistically significant ($p<0.001$). Poor glycemic control (HbA1c ≥8.0%) was significantly associated with advanced diabetic retinopathy (severe NPDR and PDR) affecting 73.1% of patients compared to 21.7% of the patients having HbA1c <8.0% ($p<0.01$). Our data suggests that higher HbA1c levels are significantly associated with increased severity of diabetic retinopathy. Strict glycemic control may play a crucial role in preventing the progression of DR among Bangladeshi patients.

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**Keywords:** Diabetes mellitus, diabetic retinopathy, glycemic control, HbA1c, microvascular complication

## Introduction

Diabetes mellitus (DM) is a rapidly growing global public health challenge, affecting more than 500 million adults worldwide, with the burden disproportionately rising in low- and middle-income countries.[1] Chronic hyperglycemia associated with diabetes leads to long-term damage, dysfunction, and failure of various organs, particularly the eyes, kidneys, nerves, and cardiovascular system.[2] Among these complications, diabetic retinopathy (DR) is the most common microvascular manifestation and a leading cause of preventable blindness in the working-age population.[3] Diabetic retinopathy develops as a result of prolonged exposure to elevated blood glucose levels, which induce structural and functional changes in the retinal microvasculature. These changes include capillary basement membrane thickening, pericyte loss, microaneurysm formation, and retinal ischemia, ultimately leading to vision-threatening complications such as proliferative diabetic retinopathy (PDR) and diabetic macular edema.[4] The severity and progression of DR are influenced by multiple factors, including duration of diabetes, glycemic control, hypertension, dyslipidemia, and genetic

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susceptibility.[5] Glycated hemoglobin (HbA1c) is a widely accepted biomarker that reflects average blood glucose levels over the preceding two to three months. It plays a central role in assessing long-term glycemic control and guiding therapeutic decisions in diabetic patients.[6] Strong evidence from landmark clinical trials has demonstrated that improved glycemic control, as indicated by lower HbA1c levels, significantly reduces the risk of onset and progression of diabetic microvascular complications, including retinopathy.[7] Consequently, HbA1c has been incorporated into routine clinical practice as both a diagnostic and prognostic indicator in diabetes management. Recent studies have emphasized a direct and graded relationship between rising HbA1c levels and increasing severity of diabetic retinopathy.[8,9] Patients with poorly controlled diabetes are more likely to develop advanced stages of DR, including severe non-proliferative and proliferative forms, which are associated with irreversible visual loss if left untreated.[10]

Although several international studies have explored the relationship between HbA1c levels and diabetic retinopathy severity, data specific to Bangladeshi patients are limited. Local evidence is essential to understand disease patterns within the national context and to support evidence-based screening and management strategies. Therefore, this study was designed to see the correlation between HbA1c levels and the severity of diabetic retinopathy among Bangladeshi patients attending a tertiary level community based hospital. Establishing this association may reinforce the importance of strict glycemic control and early ophthalmic evaluation to reduce diabetes-related visual impairment in Bangladesh.

## Methods

This prospective, cross-sectional study was conducted in Community Based Medical College, Bangladesh (CBMC,B) Hospital, Mymensingh, Bangladesh, from January 2023 to December 2024. A total of 46 patients diagnosed with diabetes mellitus and attending the ophthalmology and medicine outpatient departments of the hospital were enrolled using a purposive sampling technique. Patients of both sexes aged 30 years and above were included to ensure adequate representation of adult diabetic patients. Patients with a confirmed diagnosis of diabetes mellitus for at least one year were included in the study. Participants who had measurable HbA1c levels within the preceding three months and who consented to undergo a detailed ophthalmic examination were considered eligible. Both type 1 and type 2 diabetic patients with any stage of diabetic retinopathy were included. However, patients with ocular conditions that could interfere with fundus evaluation, such as dense cataract, corneal opacity, or vitreous hemorrhage, were excluded. Individuals with a history of ocular trauma, retinal diseases unrelated to diabetes, previous retinal laser therapy, or intraocular surgery were also excluded. Pregnant women and patients with systemic conditions affecting HbA1c levels were omitted.

Demographic and clinical data were recorded using a structured questionnaire. HbA1c levels were measured using standardized laboratory methods. Comprehensive ocular examination, including dilated fundus examination with indirect ophthalmoscopy, was performed. Diabetic retinopathy was graded according to standard clinical classification into non-proliferative and proliferative stages. Data was entered into the compuer and analyzed using IBM

SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY, USA). Data was expressed as mean±SD (standard deviation) and frequency and percentage. Pearson's correlation coefficient was used to assess the relationship between HbA1c levels and diabetic retinopathy severity. A p-value <0.05 was considered statistically significant. This study was approved by the Ethical Review Committee of Community Based Medical College, Bangladesh (CBMC,B), Mymensingh, Bangladesh.

## Results

A total of 46 patients with diabetes mellitus were included in the study. The mean age of the participants was 54.2±9.6 years, with most patients (43.5%) belonging to the 51–60 years age group. A male predominance was observed (58.7%); male-female ratio was 1.42:1 (Table-I). The mean duration of diabetes was 8.7±4.1 years. Regarding glycemic status, the mean HbA1c level was 8.4±1.6%. The majority of the patients (56.5%) had poor glycemic control (HbA1c ≥8.0%), while only 17.4% had HbA1c levels <7.0%. On fundoscopic examination, non-proliferative diabetic retinopathy (NPDR) was detected in 76.1% of patients, while proliferative diabetic retinopathy (PDR) was present in 23.9%. Among NPDR cases, mild, moderate, and severe forms were observed in 30.4%, 28.3%, and 17.4% of the patients respectively (Table-II). The mean HbA1c levels showed a progressive rise with increasing severity of diabetic retinopathy. Patients with mild NPDR had a mean HbA1c of 7.2±0.9%, whereas those with moderate and severe NPDR had mean values of 8.1±1.2% and 8.9±1.4% respectively. The highest mean HbA1c level (9.6±1.3%) was observed in patients with PDR. This trend was statistically significant (p<0.001) (Table-III). Poor glycemic control (HbA1c ≥ 8.0%) was significantly associated with advanced diabetic retinopathy (severe NPDR and PDR) affecting 73.1% of patients compared to 21.7% of the patients having HbA1c <8.0% (p<0.01) (Table-IV).

**Table-I:** Age and gender distribution of the study patients (N=46)

| Variables | Frequency | Percentage |
|---|---|---|
| Age group (in years) | | |
| 31–40 | 6 | 13.1 |
| 41–50 | 10 | 21.7 |
| 51–60 | 20 | 43.5 |
| ≥60 | 10 | 21.7 |
| Gender | | |
| Male | 27 | 58.7 |
| Female | 19 | 41.3 |

**Table-II:** Clinical characteristics of the study patients (N=46)

| Variables | Frequency | Percentage |
|---|---|---|
| HbA1c level (%) | | |
| <7.0 | 8 | 17.4 |
| 7.0–7.9 | 12 | 26.1 |
| ≥8.0 | 26 | 56.5 |
| Severity of diabetic ratinopathy | | |
| Mild NPDR | 14 | 30.4 |
| Moderate NPDR | 13 | 28.3 |
| Severe NPDR | 8 | 17.4 |
| PDR | 11 | 23.9 |

**Table-III:** Mean HbA1c levels according to the severity of diabetic retinopathy

| Severity of Diabetic Retinopathy | HbA1c level (%) Mean±SD | p-value |
|---|---|---|
| Mild NPDR | 7.2±0.9 | <0.001[S] |
| Moderate NPDR | 8.1±1.2 | |
| Severe NPDR | 8.9±1.4 | |
| PDR | 9.6±1.3 | |

One-way ANOVA was applied; S=significant.

**Table-IV:** Association between HbA1c level and advanced diabetic retinopathy

| HbA1c level (%) | Diabetic Retinopathy | | p-value |
|---|---|---|---|
| | Advanced | Non-advanced | |
| <8.0 | 5 (21.7) | 18 (78.3) | <0.01[S] |
| ≥8.0 | 19 (73.1) | 7 (26.9) | |

Chi-square test was applied; S=significant

## Discussion

The present study demonstrated a significant positive correlation between HbA1c levels and the severity of diabetic retinopathy (DR) among Bangladeshi patients. This finding reinforces the pivotal role of long-term glycemic control in the development and progression of diabetic microvascular complications. The observed progressive rise in mean HbA1c levels from mild non-proliferative diabetic retinopathy (NPDR) to proliferative diabetic retinopathy (PDR) highlights the dose-response relationship between chronic hyperglycemia and retinal damage.[10-16] Several large-scale epidemiological and clinical studies showed that increase in HbA1c is associated with a substantial rise in the risk of microvascular complications, including retinopathy in diabetic patients.[10,11]

In the present study, patients with proliferative DR had the highest mean HbA1c levels, which is consistent with findings from studies conducted in other countries in the Middle East, South Asia and Far East.[14-16] Chronic hyperglycemia induces oxidative stress, inflammation, and endothelial dysfunction, leading to capillary occlusion and retinal ischemia. These pathological mechanisms stimulate the release of vascular endothelial growth factor, promoting neovascularization and progression to PDR.[17-19] HbA1c is not only a marker of metabolic control but also a surrogate indicator of retinal disease burden. The association between poor glycemic control (HbA1c ≥8.0%) and advanced stages of DR observed in this study aligns with previous reports indicating that patients with persistently elevated HbA1c levels are more likely to present with severe NPDR or PDR.[14-16]

The findings of this study provide local evidence supporting the integration of HbA1c monitoring with regular retinal examinations in routine diabetes care. International guidelines recommend maintaining HbA1c levels below 7.0% to reduce the risk of microvascular complications; however, achieving this target remains challenging in resource-limited settings.[6,20]

The strengths of this study include its prospective design and standardized assessment of both glycemic status and retinopathy severity. Nevertheless, the relatively small sample size and purposive sampling technique may limit the generalizability of the findings. Despite these limitations, the study contributes valuable data from a

Bangladeshi perspective, where such evidence is scarce. Future multicenter studies with larger sample sizes and longitudinal follow-up are warranted to further elucidate causal relationships and progression patterns in diabetic retinopathy.

## Conclusion

This study demonstrated a significant positive correlation between HbA1c levels and the severity of diabetic retinopathy among Bangladeshi patients. Higher HbA1c values were associated with advanced retinal disease, highlighting the critical role of long-term glycemic control. Regular HbA1c monitoring combined with timely retinal screening may help prevent progression of diabetic retinopathy and reduce diabetes-related visual impairment. Moreover, strict glycemic control should be emphasized in primary care settings.

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