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Original Research Article

Comparison of HbA1c Levels in Diabetic Patients with and without Retinopathy

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Conflict of interest: Nil

Abstract

Background: Diabetic retinopathy is a common microvascular complication of type 2 diabetes mellitus and a leading cause of preventable blindness. Glycated haemoglobin (HbA1c) reflects long-term glycaemic control and is strongly associated with the risk of retinopathy. This study aimed to compare HbA1c levels in diabetic patients with and without retinopathy.

Methods: A hospital-based cross-sectional comparative study was conducted at Muzaffarnagar Medical College and Hospital over one year. A total of 180 patients with type 2 diabetes mellitus were enrolled and divided into two groups: 90 patients with diabetic retinopathy (DR group) and 90 without retinopathy (Non-DR group). Clinical evaluation, fundoscopic examination, and HbA1c estimation by high-performance liquid chromatography (HPLC) were performed. Data were analysed using SPSS v21; mean HbA1c levels were compared using the Student's t-test, with $p < 0.05$ considered significant.

Results: The mean HbA1c level was significantly higher in the DR group (9.1 ± 1.4%) compared to the Non-DR group (7.2 ± 1.1%; $p < 0.001$). A higher proportion of patients with diabetic retinopathy had HbA1c ≥9%. Longer duration of diabetes and older age were also associated with retinopathy.

Conclusion: Poor glycaemic control, reflected by elevated HbA1c, is strongly associated with diabetic retinopathy. Regular monitoring of HbA1c and timely ophthalmological screening are essential to prevent vision-threatening complications in patients with type 2 diabetes mellitus.

Keywords: HbA1c, Diabetic Retinopathy, Type 2 Diabetes Mellitus, Glycaemic Control, Microvascular Complications.

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Introduction

Diabetes mellitus is a major global public health problem and one of the leading causes of morbidity and mortality worldwide. The International Diabetes Federation estimates a continuous rise in the prevalence of diabetes, particularly in developing countries such as India, which is often referred to as the "diabetes capital of the world" [1]. Chronic hyperglycaemia in diabetes leads to long-term damage, dysfunction, and failure of various organs, especially the eyes, kidneys, nerves, heart, and blood vessels [2].

Diabetic retinopathy (DR) is one of the most common microvascular complications of diabetes mellitus and remains a leading cause of preventable blindness among the working-age population [3]. The development and progression of diabetic retinopathy are influenced by several factors, including duration of diabetes, poor glycaemic control, hypertension, and dyslipidaemia [4]. Early detection and appropriate management of risk factors are essential to prevent visual impairment and blindness.

Glycated hemoglobin (HbA1c) is a well-established biomarker that reflects the average blood glucose concentration over the preceding 8–12 weeks and is widely used for monitoring long-term glycaemic control in diabetic patients [5]. Several landmark studies, including the Diabetes Control and Complications Trial (DCCT) and the United Kingdom Prospective Diabetes Study (UKPDS), have demonstrated a strong association between elevated HbA1c levels and the risk of

microvascular complications, particularly diabetic retinopathy [6,7]. Poor glycaemic control, as indicated by higher HbA1c levels, leads to structural and functional changes in retinal microvasculature, including capillary basement membrane thickening, pericyte loss, microaneurysm formation, and retinal ischemia [8]. These pathological changes ultimately result in the development of non-proliferative and proliferative diabetic retinopathy. Despite advances in diabetes management, diabetic retinopathy continues to pose a significant burden due to late diagnosis and inadequate glycaemic control in many patients.

Although several studies have evaluated the relationship between HbA1c levels and diabetic retinopathy, data from rural and semi-urban populations in North India remain limited. Understanding this association in local settings is important for early risk stratification and preventive strategies. Therefore, the present study was undertaken to compare HbA1c levels in diabetic patients with and without retinopathy attending a tertiary care hospital and to assess the role of glycaemic control in the development of diabetic retinopathy.

Materials and Methods

Study Design and Setting: This was a hospital-based, cross-sectional comparative study conducted in the Departments of Medicine, Ophthalmology, and Biochemistry at Muzaffarnagar Medical College and Hospital, Muzaffarnagar, Uttar Pradesh, over a period of one year from October 2024 to October 2025

Study Population: A total of 180 patients with type 2 diabetes mellitus attending the outpatient and inpatient services were enrolled in the study during the study period.

Study Groups: The study population was divided into two groups based on fundoscopic examination:

- Group A (Diabetics with retinopathy): 90 patients
- Group B (Diabetics without retinopathy): 90 patients

Inclusion Criteria

- Patients aged 30–70 years
- Diagnosed cases of type 2 diabetes mellitus as per American Diabetes Association (ADA) criteria
- Duration of diabetes ≥ 1 year
- Patients who provided written informed consent

Exclusion Criteria

- Patients with type 1 diabetes mellitus
- Gestational diabetes mellitus
- Patients with anaemia, hemoglobinopathies, or recent blood transfusion (within 3 months)
- Patients with chronic kidney disease, chronic liver disease, or active infections
- Patients with ocular diseases other than diabetic retinopathy that could affect fundus findings

Clinical Evaluation: A detailed clinical history, including age, sex, duration of diabetes, treatment history, and presence of comorbidities, was recorded. A thorough general physical and systemic examination was performed for all participants.

Ophthalmological Examination: All patients underwent a comprehensive ocular examination by an ophthalmologist. Dilated fundus examination was performed using a direct ophthalmoscope and slit-lamp biomicroscopy with a +90D lens. Diabetic retinopathy was classified according to the Early Treatment Diabetic Retinopathy Study (ETDRS) classification into non-proliferative and proliferative diabetic retinopathy.

Laboratory Investigations

Venous blood samples were collected under aseptic precautions.

- HbA1c estimation was performed using high-performance liquid chromatography (HPLC) in the central biochemistry laboratory.
- Quality control procedures were strictly followed as per laboratory standards.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS software (version 21). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequency and percentages.

Comparison of mean HbA1c levels between the two groups was done using the independent Student's t-test. A p-value < 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of Muzaffarnagar Medical College.

Written informed consent was obtained from all participants before enrollment. Confidentiality of patient data was maintained throughout the study.

Results and Observations

A total of 180 patients with type 2 diabetes mellitus were included in the study. Among them, 90 patients had diabetic retinopathy (DR group) and 90 patients did not have diabetic retinopathy (Non-DR group).

Table 1: Distribution of Study Participants by Age

Age Group (years)	DR Group (n=90)	Non-DR Group (n=90)
30–40	8 (8.9%)	15 (16.7%)
41–50	22 (24.4%)	30 (33.3%)
51–60	36 (40.0%)	28 (31.1%)
>60	24 (26.7%)	17 (18.9%)
Mean ± SD	56.2 ± 8.4	52.1 ± 7.9

Diabetic retinopathy was more common in patients above 50 years of age.

Table 2: Gender Distribution of Study Participants

Gender	DR Group (n=90)	Non-DR Group (n=90)
Male	56 (62.2%)	52 (57.8%)
Female	34 (37.8%)	38 (42.2%)

Male predominance was observed in both groups.

Table 3: Duration of Diabetes in Study Groups

Duration of Diabetes	DR Group (n=90)	Non-DR Group (n=90)
1–5 years	18 (20.0%)	46 (51.1%)
6–10 years	34 (37.8%)	28 (31.1%)
>10 years	38 (42.2%)	16 (17.8%)
Mean ± SD (years)	9.6 ± 4.1	6.2 ± 3.5

Longer duration of diabetes was significantly associated with diabetic retinopathy.

Table 4: Comparison of HbA1c Levels Between Study Groups

Parameter	DR Group (n=90)	Non-DR Group (n=90)	p-value
HbA1c (%) Mean ± SD	9.1 ± 1.4	7.2 ± 1.1	<0.001

Mean HbA1c levels were significantly higher in patients with diabetic retinopathy compared to those without retinopathy.

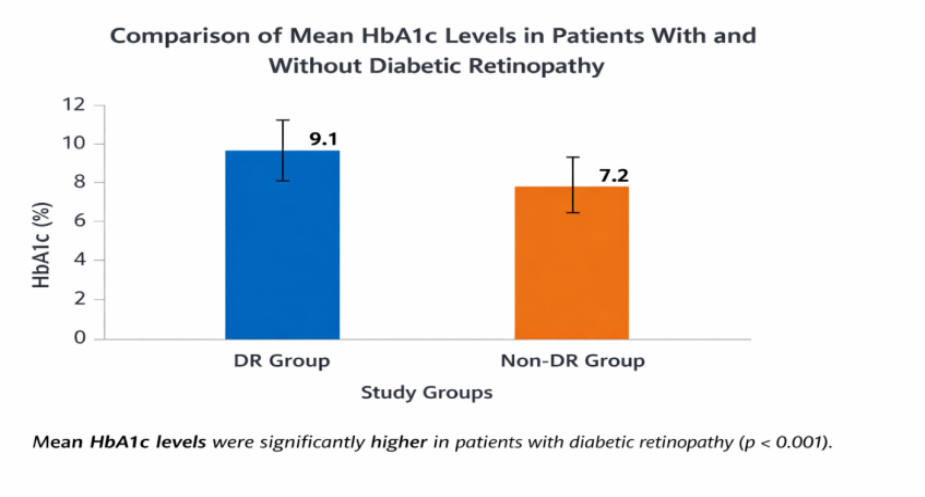

Figure 1: Comparison of HbA1c Levels Between Study Groups

Table 5: Distribution of HbA1c Levels in Study Groups

HbA1c Range (%)	DR Group (n=90)	Non-DR Group (n=90)
<7.0	6 (6.7%)	34 (37.8%)
7.0–8.9	28 (31.1%)	40 (44.4%)
≥9.0	56 (62.2%)	16 (17.8%)

A higher proportion of patients with diabetic retinopathy had poor glycemic control (HbA1c ≥9%).=

Table 6: Association Between HbA1c and Diabetic Retinopathy

HbA1c Category	DR Present	DR Absent	Total
HbA1c <7.0	6	34	40
HbA1c ≥7.0	84	56	140
Total	90	90	180

Statistical Test: Chi-square test
p-value:<0.001

Poor glycemic control showed a statistically significant association with the presence of diabetic retinopathy.

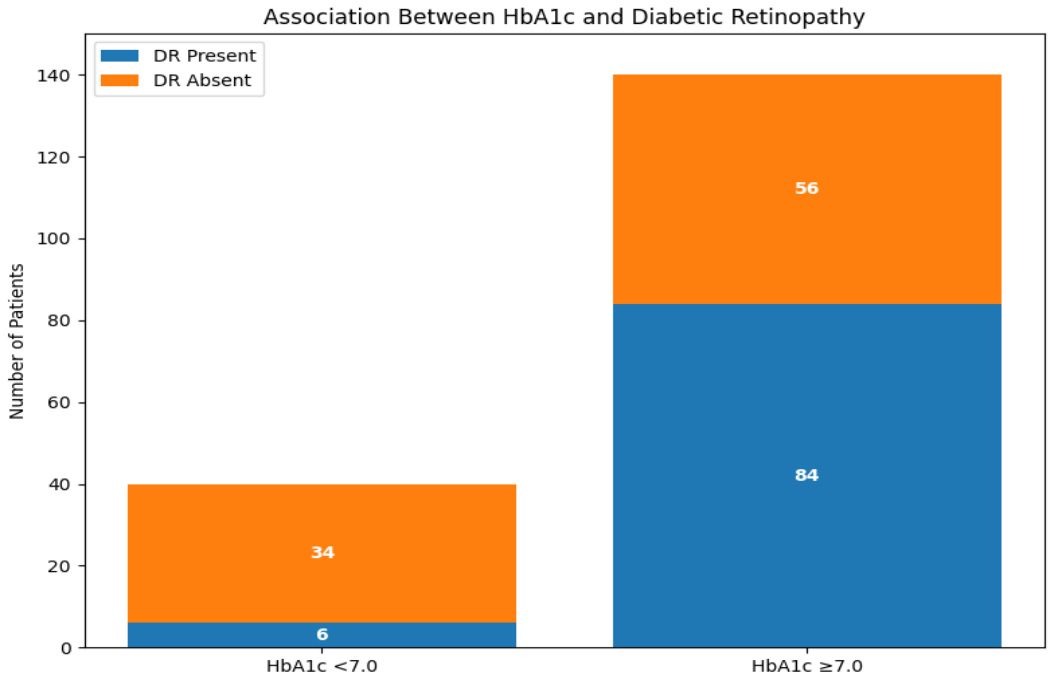

Figure 2: Association Between HbA1c and Diabetic Retinopathy

Discussion

Diabetic retinopathy is a major microvascular complication of diabetes mellitus and remains a leading cause of preventable visual impairment. The present study compared HbA1c levels in diabetic patients with and without retinopathy and demonstrated a significant association between poor glycaemic control and the presence of diabetic retinopathy.

In the present study, diabetic retinopathy was more frequently observed in patients aged above 50 years. Similar age-related trends have been reported by Yau et al., who observed an increased prevalence of diabetic retinopathy with advancing age and longer duration of diabetes [3]. Aging is often associated with cumulative exposure to hyperglycaemia, contributing to progressive microvascular damage.

A male predominance was observed in both groups, although gender was not found to be a significant independent risk factor for diabetic retinopathy. This finding is consistent with studies by Rema et al. and Raman et al., who reported no definitive gender predilection for diabetic retinopathy [9,10]. The higher number of male patients in the present study may reflect greater healthcare-seeking behavior among males in the study population.

Duration of diabetes showed a strong association with diabetic retinopathy in the present study. Patients with diabetic retinopathy had a significantly longer mean duration of diabetes compared to those without retinopathy. This observation is in agreement with the UK Prospective Diabetes Study (UKPDS), which identified duration of diabetes as one of the strongest predictors for the development and progression of diabetic retinopathy [4,7]. Chronic exposure to hyperglycaemia over time leads to irreversible microvascular changes in the retina.

The most important finding of the present study was the significantly higher mean HbA1c levels in patients with diabetic retinopathy (9.1 ± 1.4%) compared to those without retinopathy (7.2 ± 1.1%), with a statistically significant p-value (<0.001). This finding strongly supports the role of poor long-term glycaemic control in the pathogenesis of diabetic retinopathy. Similar results have been reported by Klein et al. and Stratton et al., who demonstrated a linear relationship between HbA1c levels and the risk of retinopathy progression [4,11].

Furthermore, a higher proportion of patients with diabetic retinopathy in the present study had HbA1c levels ≥9%, indicating poor glycaemic control. This observation is consistent with findings from the Diabetes Control and Complications Trial (DCCT), which showed that each 1% reduction in HbA1c was associated with a significant reduction in the risk of microvascular complications, including retinopathy [6]. These findings emphasize the importance of strict glycaemic control in preventing diabetic retinopathy. Pathophysiologically, chronic hyperglycaemia leads to increased polyol pathway flux, formation of advanced glycation end-products, oxidative stress, and activation of protein kinase C, all of which contribute to endothelial dysfunction and

retinal microvascular damage [8]. Persistent elevation of HbA1c reflects sustained hyperglycaemic exposure, thereby increasing the risk of retinal ischemia and neovascularization.

The significant association between elevated HbA1c levels and diabetic retinopathy observed in the present study highlights the utility of HbA1c as a reliable marker for identifying patients at higher risk of developing retinal complications. Regular monitoring of HbA1c, along with periodic ophthalmological screening, can facilitate early detection and timely intervention to prevent vision-threatening complications.

Limitations of the Study: The present study had certain limitations. Being a cross-sectional study, a causal relationship between HbA1c levels and diabetic retinopathy could not be established. Other contributing factors such as hypertension, lipid profile, and body mass index were not analyzed. Longitudinal studies with larger sample sizes are recommended to further validate these findings.

Conclusion

The study concludes that higher HbA1c levels are significantly associated with the presence of diabetic retinopathy in patients with type 2 diabetes mellitus. Poor glycaemic control, along with increasing age and longer duration of diabetes, contributes to the development of retinopathy. Regular HbA1c monitoring and timely ophthalmological screening are essential to prevent diabetic retinopathy and its vision-threatening complications.

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