ORIGINAL ARTICLE

Association of HbA1c and Duration of Diabetes with Refractive Errors in Type II Diabetic Patients

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Abstract:

Objectives: To evaluate the association between HbA1C levels, duration of diabetes, and refractive errors in patients with type II diabetes mellitus.

Methods: A cross-sectional study involving 200 patients with type II diabetes (400 eyes) was conducted over 3 months at the federal government Polyclinic Hospital. Eye examinations and HbA1C assessments were analyzed using SPSS v21, employing chi-square and regression analyses.

Results: Astigmatism (56%) was the most prevalent refractive error, followed by myopia (29.5%) and hyperopia (14.5%) with higher prevalence in males (52%) and patients aged >50 years (35%). Prediabetic patients exhibited the highest prevalence of refractive errors (62%). The duration of diabetes was significantly associated with refractive error severity ($\chi 2=30.21$, $p<0.001$).

Conclusions: Refractive errors, particularly astigmatism, are prevalent in diabetic patients. Longer duration of diabetes and suboptimal HbA1C levels exacerbate these changes. Routine eye exams and glycemic control are essential to prevent visual impairment. *Al-Shifa Journal of Ophthalmology 2025; 21(1): 29-36.*

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Introduction:

According to the International Diabetes Federation, diabetes mellitus is a significant global health concern affecting approximately 537 million adults worldwide [1-2]. Type II diabetes mellitus accounts for more than 90% of these cases and is associated with a range of systemic and microvascular complications, including retinopathy, cataracts, and refractive errors [3]. Refractive errors in diabetic populations are influenced by fluctuations in blood glucose levels. Elevated glucose levels have been shown to cause myopic shifts, whereas lower levels often lead to hyperopic changes, reflecting the osmotic effects of glucose on the lens [4]. A systematic review published in 2019 revealed that transient refractive changes due to hyperglycemia are common in patients with type II diabetes with poor glycemic control, exacerbating these effects [5]. Furthermore, prolonged diabetes duration has been associated with cumulative damage to the lens contributing to progressive refractive changes and an increased risk of uncorrected refractive errors [6].

Studies conducted in high-income countries have highlighted the burden of refractive errors among patients with diabetes, with prevalence rates of up to 62% [7]. However, research in Pakistan remains limited. This gap is significant given Pakistan's dual burden of a rising diabetes prevalence (estimated at 33 million adults) and limited access to comprehensive eye care services [7]. Factors such as low health literacy, poor glycemic management, and restricted availability of optometric services exacerbate the risk of diabetes-related visual impairments in this population. Despite advancements in diabetes care, the rising incidence of diabetes in Pakistan and the lack of accessible eye care infrastructure necessitate urgent attention. Refractive errors remain a leading cause of visual impairment, but they can be corrected easily if detected early. Moreover, the interplay between blood glucose levels, diabetes duration, and refractive changes underscores the need for regular ocular screenings in patients with diabetes. While global studies have explored the association between diabetes and refractive errors, there is a paucity of data from Pakistan, where the unique socioeconomic healthcare challenges may influence disease patterns. Understanding the prevalence and types of refractive errors in this population, along with their association with glycemic control and diabetes duration, is essential for developing targeted interventions. This study aimed to address this gap and contribute to the growing body of evidence on diabetes-related ocular complications.

The primary aim of this study was to evaluate the prevalence, types, and severity of refractive errors in patients with type II diabetes in Pakistan. Specifically, to assess the association between HbA1c and refractive errors, explore how glycemic fluctuations influence refractive outcomes, and examine the impact of diabetes duration on the severity of refractive errors.

Methodology:

A cross-sectional study was conducted at the federal government Polyclinic Hospital in Islamabad from 1st October to 31st December 2021. A purposive sample of 200 patients with type II diabetes aged 30 years or older was selected. While this sampling method was focused on specific patients, efforts were made to ensure the sample represented the wider population by including diverse age groups, gender, and duration of diabetes typically seen in a general hospital setting. Ethical approval was obtained from the Ethics Committee, and verbal consent was deemed sufficient due to the noninvasive nature of the study, which adhered to the Declaration of Helsinki.

The sample size was calculated using the formula: $n=Z2P(1-P)/d2$ n where $Z=1.96$ (95% confidence level), $P = 0.5$ (assumed prevalence of refractive errors), and $d=0.07$ (margin of error). This generated a minimum required sample size of 196, which was rounded up to 200 for feasibility. The inclusion criteria were type 2 diabetic patients aged ≥30 years with clear ocular media and no history of prior ocular surgery or retinopathy. The exclusion criteria were opaque ocular media, diabetic macular edema, or aphakia to avoid confounding factors affecting refractive error.

A structured questionnaire was used to capture demographic details, diabetes duration, and blood glucose levels. Comprehensive eye examinations included visual acuity assessment (Snellen or E chart for illiterate patients), refraction measurements using autorefractor and subjective refinement, and slit-lamp evaluations. HbA1C was measured by laboratory analysis and categorized per American Diabetes Association (ADA) standards as Normal: HbA1c levels <5.7%, Prediabetes: HbA1c levels between 5.7% and 6.4% and Diabetes: HbA1c levels ≥6.5%.

The data was analyzed using SPSS v21. Descriptive statistics were employed to summarize demographic and clinical characteristics. The association between categorical variables, such as HbA1c levels, diabetes duration and the prevalence of refractive errors was assessed using the chi-square test. Regression analysis was utilized to explore the relationship between diabetes duration and refractive error severity. The chi-square test was chosen due to its suitability for analyzing categorical data, such as HbA1c ranges and refractive error types. The significant p-value (<0.001) obtained from the chi-square test indicates a strong association between diabetes-related factors and refractive error prevalence. To ensure the reliability of the regression models, key assumptions, including linearity, homoscedasticity, normality, and absence of multicollinearity, were carefully validated.

Results:

Two hundred patients with type II diabetes (400 eyes) were included in the study. The mean age of the participants was 51.09 ± 10.55 years, with male predominance (58.2%). Age significantly influenced the prevalence of refractive errors. The highest frequency of refractive errors was observed in patients aged >50 years (35%), followed by those aged 40–50 years (34%) and 30–40 years (31%). Interestingly, hyperopia was more frequently observed in females, whereas astigmatism was common in both genders. We found astigmatism to be the most prevalent refractive error, affecting 56% of patients, followed by myopia (29.5%) and hyperopia (14.5%). Occupational analysis revealed that teachers (39.5%) and housewives (26%) were the most affected groups, with astigmatism being the predominant refractive error across all occupations. Other occupational groups, including businessmen (9.5%) and physicians (5.5%), showed lower frequencies of refractive errors.

HbA1c was strongly correlated with refractive errors. The highest prevalence (62.5%) of refractive errors was observed in patients in the prediabetic range (5.7–6.4%), whereas astigmatism accounted for 29%. Patients with HbA1c ≥ 6.5% exhibited a prevalence of 36.5%, primarily driven by astigmatism (27%). In contrast, patients with normal HbA1c (<5.7%) exhibited the lowest prevalence of refractive errors (1%). The duration of diabetes was significantly associated with the severity and prevalence of refractive errors ($\chi^2 = 30.21$, $p < 0.001$). Patients with diabetes duration >5 years exhibited the highest prevalence of refractive errors (50%), with astigmatism being the dominant type (33%). In comparison, patients with diabetes duration <2 years had the lowest incidence of refractive errors (25.5%). The progression and severity of refractive errors, particularly astigmatism, were directly proportional to the duration of diabetes.

To further elucidate the relationship between diabetes-related factors and refractive error severity, regression analyses were conducted. Simple linear regression models demonstrated significant independent associations between HbA1c levels and diabetes duration with refractive error severity ($p < 0.05$). These findings were corroborated by multiple linear regression analyses, which adjusted for potential confounders such as age and gender. The adjusted regression models revealed that both HbA1c levels and diabetes duration remained significant predictors of refractive error severity, collectively explaining 75.1% of the variance ($r^2 = 0.751$). For every 1% increase in HbA1c, refractive error severity increased by 0.41 diopters, and for each additional year of diabetes, severity increased by 0.28 diopters.

Table 1: Distribution of Diabetic Patients by Age and Sex

Age Group	Frequency	Percentage (%)
30–40 years	62	31
40–50 years	68	34
>50 years	70	35
Gender		
Male	104	52
Female	96	48

Table 2: Types of Refractive Errors in Patients with Diabetic

Refractive Error	Frequency	Percentage (%)
Myopia	59	29.5
Hyperopia	29	14.5
Astigmatism	112	56.0

Table 3: Association between HbA1c and refractive error

Blood Glucose Level HbA1C (%)	Myopia (%)	Hyperopia (%)	Astigmatism (%)	Total (%)
<5.7	0.5	0.5	0	1
5.7–6.4	23.5	10	29	62.5
≥6.5	5.5	4	27	36.5

Table 4: Severity of Refractive Errors according to Diabetes

Duration of Diabetes	Myopia (%)	Hyperopia (%)	Astigmatism (%)	Total (%)
<2 years	11.5	3.5	10.5	25.5
2–5 years	8	4	12.5	24.5
>5 years	10	7	33	50

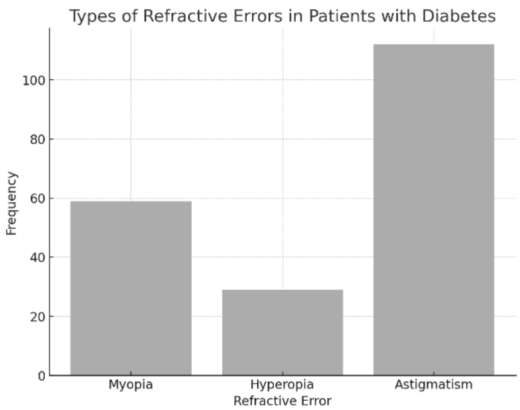

Figure 1

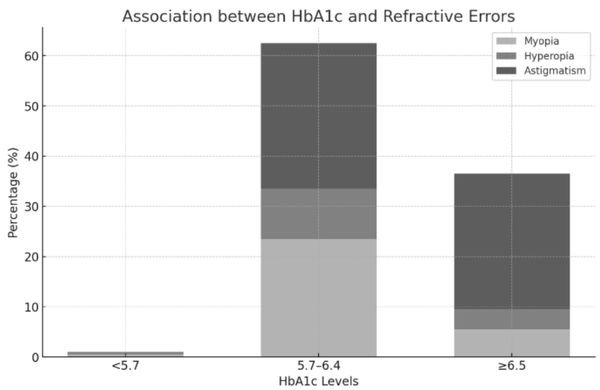

Figure 2

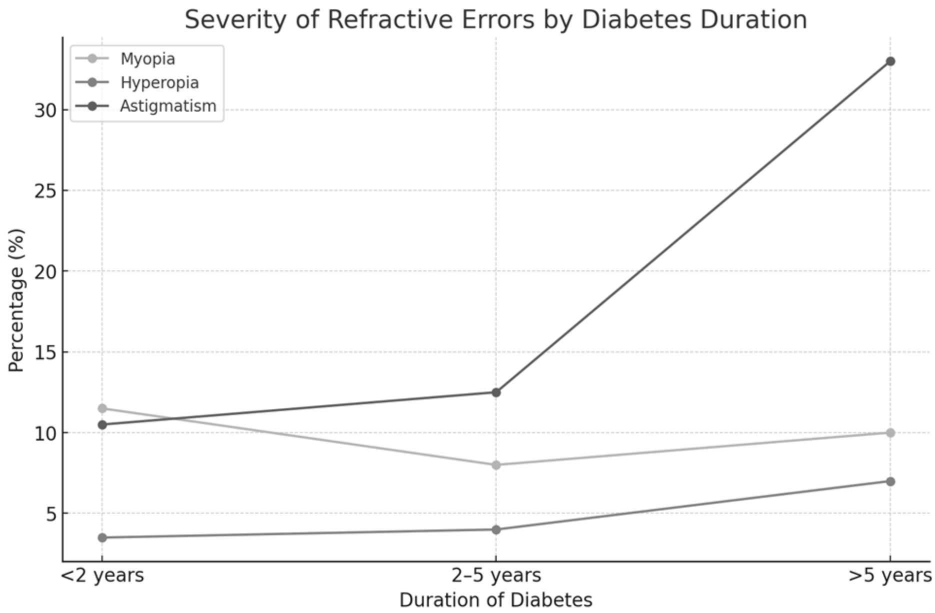

Figure 3

Discussion:

Our study found that astigmatism is the most common refractive error among patients with diabetes, consistent with findings from recent studies conducted in Pakistan and globally [7,8,9]. The high prevalence of astigmatism highlights the critical interplay between diabetes and ocular physiology, particularly alterations in lens and corneal structures driven by glycemic fluctuations. Chronic hyperglycemia influences lens curvature and refractive index, leading to changes in visual acuity [10]. These refractive shifts, especially astigmatism, are intensified in patients with prolonged diabetes duration, consistent with the findings of Sun H et al[11], who documented lens swelling and structural irregularities caused by hyperglycemia.

A significant observation in this study was the association between refractive errors and HbA1c levels, particularly in patients within the prediabetic range (5.7–6.4%). This transitional state of metabolic instability appears to precipitate refractive anomalies, emphasizing the impact of glycemic control on refractive stability. A recent study by Malik et al[9] and Wijesinghe et al[12] reported similar associations, attributing transient refractive errors to fluctuating blood glucose levels. Specifically, myopia often arises during hyperglycemia due to increased swelling of the lens, whereas hyperopia may occur in hypoglycemia or when lens changes are minor. These findings underscore the importance of maintaining optimal glycemic control to mitigate vision-related complications among individuals with diabetes.

Several recent studies have detailed the mechanisms underlying refractive changes in diabetes, with the lens serving as the primary site of glycemic impact. Changes in lens thickness, shape, and refractive index are driven by osmotic stress caused by hyperglycemia [12]. A systematic review by Das T et al [13] highlighted that increased lens thickness, a hallmark of diabetic lens pathology, significantly contributes to refractive instability. The extent of these changes varies among individuals and is influenced by glycemic control, duration of diabetes, and genetic predisposition.

This study observed a higher prevalence of refractive errors in males (52%) compared with females (48%), with astigmatism dominating both genders. Interestingly, hyperopia was more commonly observed among females, consistent with findings by Ahmed et al[7,8] and Zylbermann R et al [14], who attributed this trend to shorter axial lengths and shallower anterior chamber depths in women. Similarly, age is a significant determinant of refractive error type and severity. Patients aged >50 years demonstrated a hypermetropic shift, aligning with findings from Saleem MI et al[15] and Farooq et al[16], who linked advancing age to increased hyperopia due to reduced lens elasticity and nuclear sclerosis. These age-related shifts underscore the compounded impact of aging and diabetes on refractive status, necessitating targeted interventions for older individuals with diabetes.

The overall prevalence of refractive errors in this study mirrors global trends, with rates comparable to those of studies in South Asia and the Middle East. For example, the prevalence of refractive errors in diabetic populations has been reported to be 58% in Indian studies[13] and 61% in Pakistan [7,8]. Such similarities underscore the universality of refractive complications in diabetes, despite ethnic and geographical differences. However, ethnic variations in refractive error types persist, as highlighted by Farooq et al[16] and Saleem MI et al [15] who observed a higher prevalence of myopia in certain populations. This variability highlights the influence of genetic and environmental factors on refractive outcomes in patients with diabetes.

Glycemic control is central to stabilizing refractive errors in diabetic individuals. Chronic hyperglycemia induces osmotic stress in the lens, thereby altering its refractive properties and leading to transient or permanent changes. Studies by Malik et al[9] and Saleem et al[15] emphasized the reversibility of these changes with improved glycemic control. For example, patients with diabetes transitioning from poor to moderate glycemic control often report a reduction in refractive shift. This highlights the necessity of routine monitoring of HbA1c levels in individuals with diabetes, not only for systemic health but also for maintaining stable vision.

Our study also revealed occupational disparities in the prevalence of refractive error, with higher rates of astigmatism observed among teachers and housewives. These findings may reflect differences in environmental exposure, visual demand, and healthcare access. For example, teachers often experience prolonged near-work strain, potentially worsening astigmatism. Meanwhile, limited healthcare access among housewives may delay diagnosis and treatment, thereby worsening refractive outcomes. These insights align with the findings of Farooq A et al [16], which called for targeted awareness campaigns addressing vision care in high-risk occupational groups.

Uncorrected refractive errors remain the leading cause of visual impairment worldwide. The socioeconomic impact is particularly profound in Pakistan, where untreated refractive errors limit educational and employment opportunities. As emphasized in the WHO's Vision 2020 initiative, addressing Uncorrected Refractive Error (URE) is crucial for alleviating preventable blindness [17]. A study conducted in Lahore quantified the economic burden of refractive errors, estimating annual productivity losses exceeding PKR 20 billion [18]. This highlights the urgent need for accessible and affordable vision care services, particularly for vulnerable populations.

While the study provides valuable insights, it has limitations. This cross-sectional, hospital-based study, conducted without a control group, relied on purposive sampling, which may have introduced selection bias. Hospital-based sampling limits the generalizability of the findings, as it captures a specific subset of the diabetic population—those actively seeking care—who may differ from the general diabetic population in terms of disease severity, healthcare access, and socioeconomic status. The lack of a control group prevents direct comparisons between diabetic and non-diabetic individuals, which could have clarified the unique contributions of diabetes to refractive errors. The small sample size might also not fully represent the broader diabetic population, further limiting generalizability. Additionally, factors such as systemic hypertension, dyslipidemia, and genetic predispositions were not assessed, which may act as confounding variables.

Despite these limitations, the study emphasizes the importance of routine eye examinations in diabetes management, particularly for patients with poorly controlled diabetes or prolonged diabetes duration. Refractive errors like astigmatism are common in people with diabetes and can worsen with poor blood sugar control or longer diabetes duration. Monitoring HbA1c levels and maintaining good glycemic control can help prevent or stabilize these vision problems, especially in prediabetic individuals.

The study's results could inform vision screening programs in diabetic populations by identifying high-risk groups, such as individuals with poorly controlled blood sugar or long diabetes duration. Screening initiatives could prioritize these populations, ensuring early detection and timely correction of refractive errors. Targeted interventions, such as workplace vision screenings for teachers and improved healthcare access for housewives, could address occupational disparities. Public health efforts should focus on providing affordable vision care and raising awareness about diabetes-related eye health. Integrating routine vision screenings into diabetes management programs could enhance outcomes by preventing vision loss and improving quality of life.

Conclusion:

We found that refractive errors, particularly astigmatism, are highly prevalent among patients with type II diabetes. Prolonged diabetes duration aggravates refractive changes. Public health initiatives should focus on routine screenings and glycemic control to reduce visual impairment.

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