RESEARCH PAPER

# CORRELATION BETWEEN SERUM VITAMIN D LEVEL WITH DIABETIC RETINOPATHY: A OBSERVATIONAL PROSPECTIVE STUDY

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**Abstract**

**Background**: Diabetic retinopathy (DR) is a leading microvascular complication of diabetes mellitus and a major cause of vision loss worldwide. Emerging evidence suggests that vitamin D deficiency may contribute to the development and progression of DR through its anti-inflammatory, antioxidative, and angiogenic regulatory effects.

**Objective**: To assess the correlation between serum vitamin D levels and diabetic retinopathy in patients with Type 1 and Type 2 diabetes mellitus and evaluate its relationship with glycemic control.

**Methods**: This prospective observational case-control study was conducted in the Department of Ophthalmology, MMIMSR, Mullana, Haryana, over one year. A total of 60 diabetic patients aged ≥20 years were enrolled and divided into two groups: patients with DR (study group) and those without DR (controls). Comprehensive ocular examinations, including fundus photography, Fundus Fluorescein Angiography (FFA), and Optical Coherence Tomography (OCT), were performed. Biochemical investigations included fasting and post-prandial blood sugar, HbA1c, and serum vitamin D levels. Statistical analysis was performed using SPSS v22, with correlation analysis between vitamin D, HbA1c, and DR severity.

**Results**: Vitamin D deficiency was observed in 71.7% of patients, with a significant negative correlation between serum vitamin D and HbA1c levels ($r = -0.42$, $p = 0.001$). Lower vitamin D levels were associated with higher severity of DR across all stages.

**Conclusion**: Serum vitamin D deficiency is highly prevalent in diabetic patients and is inversely correlated with glycemic control and DR severity, highlighting the importance of monitoring and managing vitamin D status in diabetes care.

**Keywords**: Diabetic retinopathy, Vitamin D deficiency, Glycemic control

**How to cite this article:** Sangwan D, Pandey ML, Verma A. Correlation Between Serum Vitamin D Level with Diabetic Retinopathy: A Observational Prospective Study. Int J Drug Deliv Technol. 2026;16(62s): 15-26. DOI: 10.25258/ijddt.16.62s.3

**Source of support:** Nil.

**Conflict of interest:** None.

## Introduction

With over 62 million people in India already diagnosed with the condition, diabetes is quickly becoming recognized as a possible epidemic.[1,2] The country having the greatest number of diabetes mellitus sufferers worldwide in 2000 was India (31.7 million), followed by China (20.8 million), and the United States (17.7 million), in that order. The prevalence of diabetes is expected to double globally from 171 million in 2000 to 366 million in 2030, with India experiencing the largest increase, according to Wild et al.[3]

Two kinds of diabetes mellitus exist based on the pathophysiology of Type 1 and Type 2 diabetes. Insulin-dependent diabetes mellitus, also known as type 1 diabetes mellitus (IDDM), is brought on by an autoimmune response that destroys the beta cells in the pancreas and the cells that produce insulin.. Three main factors—increased glucose production, decreased insulin production, and insulin resistance—define type 2 diabetes mellitus. Strict blood glucose management has been shown to reduce the risk of microvascular complications from diabetes, although the mechanism of the development of retinopathy is yet unknown.[4]

Diabetes mellitus, particularly Type 2 Diabetes Mellitus (T2DM), represents one of the most significant public health challenges of the 21st century. With an alarming rise in its global prevalence, T2DM has become a major contributor to morbidity and mortality. This chronic metabolic disorder is primarily characterized by insulin resistance and relative insulin deficiency, leading to persistent hyperglycemia.[5]

Uncontrolled or poorly managed diabetes Retinopathy is associated with severe complications affecting various organ systems including the cardiovascular system, kidneys, eyes, and nerves. Glycemic control remains the cornerstone of diabetes management, and Hemoglobin A1c (HbA1c) is widely recognized as a reliable marker for long-term glycemic control, reflecting the average plasma glucose concentration over the previous two to three months.[6,7]

Vitamin D (VD) is an essential micronutrient often referred to as “the sunshine vitamin”.Although it is classified as a vitamin, it is actually a hormone due to its steroid structure and mechanism of action . When exposed to sunshine, it is synthesized in the skin; if insufficiently created, it needs to be consumed through food. Vitamin D facilitates the normal growth and mineralization of teeth and bones by encouraging the absorption of calcium and phosphate. Apart from its significance for bone health, multiple researches indicate that vitamin D also supports immune system and musculoskeletal function, aids in the prevention and management of cardiovascular disease, and helps treat specific types of cancer. Depression, autoimmune illnesses, obesity, hypertension, type 1 and type 2 diabetes, and hypertension can all result from a VD deficiency.[8]

While lifestyle factors such as diet, physical activity, and obesity play crucial roles in the development and progression of T2DM, recent research has shed light on the potential role of micronutrients in modulating glucose metabolism. Among these, vitamin D, a fat-soluble secosteroid hormone traditionally known for its role in calcium and bone homeostasis, has emerged as a potential modulator of glucose metabolism and insulin sensitivity. A growing body of evidence suggests that vitamin D deficiency, which is widely prevalent across the globe including in sun-rich countries, may be associated with an increased risk of developing insulin resistance and T2DM. Furthermore, observational studies have pointed toward a possible inverse relationship between vitamin D levels and HbA1c, suggesting that low vitamin D levels may be associated with poor glycemic control.[4]

Vitamin D exists in two major forms: D2 (ergocalciferol) and D3 (cholecalciferol). The latter is synthesized in the skin upon exposure to ultraviolet B (UVB) rays and is also obtained from dietary sources. After hydroxylation in the liver and kidneys, vitamin D is converted into its active form, 1,25-dihydroxyvitamin D (calcitriol), which exerts its biological effects through binding to the vitamin D receptor (VDR), present in various tissues including pancreatic β-cells and skeletal muscles. The presence of VDRs in β-cells and insulin-sensitive tissues suggests a potential role for vitamin D in glucose homeostasis.[8]

The mechanisms through which vitamin D may influence glycemic control are multifactorial. Firstly, vitamin D may enhance insulin secretion by modulating calcium flux within pancreatic β-cells. Calcium is an essential component of insulin exocytosis, and optimal vitamin D status helps maintain intracellular calcium levels required for proper β-cell function. Secondly, vitamin D is believed to improve insulin sensitivity by acting on peripheral tissues such as adipose tissue and skeletal muscle. It influences the expression of insulin receptors and enhances insulin-mediated glucose transport. Thirdly, vitamin D has immunomodulatory and anti-inflammatory properties, which may mitigate the chronic low-grade inflammation observed in T2DM that contributes to insulin resistance.[9,10]

Many physiological systems depend on vitamin D (VD), and vitamin D deficiency has reached pandemic proportions, putting over half of the world's population at danger.[6] Inadequate levels of vitamin D have been linked to an increased risk of mortality, cancer, and cardiovascular disease, as well as the onset of diabetes.[11,12,13]

Furthermore, there is evidence linking vitamin D deficiency to neurological disorders like Parkinson's disease and multiple sclerosis..[14,15]

It is still unclear how vitamin D insufficiency and diabetic retinopathy are related in people with type 2 diabetes. Nonetheless, other research indicates a direct association and link between vitamin D insufficiency and diabetic retinopathy.[11]

Because of its effects on angiogenesis and the immune system, vitamin D may have a part in the pathophysiology of diabetic retinopathy. Vitamin D reduces the growth of natural killer cells, lymphocytes, and several pro-inflammatory cytokines, which has an anti-inflammatory impact.[16] Furthermore, it has been demonstrated that, in a mouse model of oxygen-induced ischemic retinopathy, calcitriol, the active metabolite of vitamin D, is a strong inhibitor of retinal neovascularization.[17] In light of these connections, we need to be looked into the connection between vitamin D deficiency and diabetic retinopathy.

Blood vessel damage in the retina of the eye is linked to diabetic retinopathy (DR), a dangerous condition that affects those who have the disease. One of the many vital nutrients, vitamin D (VD) controls immunological function, inflammation, and angiogenesis, among other bodily processes. A higher risk of developing diabetic retinopathy may be associated with a VD deficiency, most research suggest. The pathophysiologic processes behind the apparent link between diabetic retinopathy and VD are not entirely understood or established. According to recent studies, vitamin D controls autophagy, has an anti-inflammatory effect, and is crucial for bone metabolism. It also functions as a potent antioxidant, drastically lowering the production of free radicals.[18,19]

Vitamin D deficiency is highly prevalent worldwide 15 . Compared to 1,25-dihydroxyvitamin D3, the active hormone, serum 25(OH)D is a more accurate measure of vitamin D deficiency16 As a result, it is generally acknowledged that a subject's serum 25(OH)D concentration serves as a reliable predictor of their vitamin D status. The preservation of mineral homeostasis and the control of bone remodeling are two of vitamin D's primary biological functions.[20]

Nonetheless, this vitamin has a wide range of pleiotropic effects that were identified over 2 decades ago.[21] The possible effects of vitamin D on glucose homeostasis and the etiology of type 2 diabetes have been better understood as a result of this field of study. Numerous studies have already demonstrated how common vitamin D insufficiency is in both type 1 and type 2 diabetes.[22] Furthermore, the possibility that vitamins play a role in the emergence of diabetic micro- and macroangiopathic problems is gaining attention..[23,24]

According to certain research, 1,25-dihydroxy vitamin D can protect the structure and function of the retina by reducing ROS, reducing inflammation, and inhibiting apoptosis.[25]Recent studies on diabetes have focused on vitamin D's anti-inflammatory and antioxidant qualities..[26,27]

Furthermore, retinopathy severity and blood vitamin D concentrations were found to be inversely correlated in a number of clinical and epidemiological studies, with vitamin D deficiency acting as an independent predictor of DR 19-22 Leucine-rich repeat, pyrin domain-containing protein 3, or NLRP3 levels and vitamin D concentrations in vitreous fluid are also thought to be correlated and to play a crucial role in the pathophysiology of diabetic retinopathy disease.

In a mouse model, there is some experimental data about the protective role of vitamin D against the development of diabetic retinopathy.Nevertheless, there is very little data supporting vitamin D's role.

Given the increasing prevalence of T2DM and the widespread deficiency of vitamin D, there is an urgent need to investigate this correlation in varied populations. Identifying and addressing vitamin D deficiency in diabetic patients could serve as a cost-effective and easily implementable strategy to support glycemic control and reduce the burden of complications. Furthermore, such an approach may also have broader health benefits including improvements in immune function, cardiovascular health, and overall well-being.[15]

The present study is designed to explore the correlation between vitamin D levels ,HbA1c and in Diabetic Retinopathy in both Type-1 and Type-2.

## Materials and Methods

This study included 60 patients and was conducted over a period of 12 months. All eligible patients attending the diabetic clinic of MMIMSR Mullana were enrolled according to inclusion and exclusion criteria. A detailed history was obtained, including duration and nature of symptoms, sunlight exposure, dietary habits, tobacco and alcohol use. Treatment history, including oral hypoglycemic drugs, insulin, vitamin D supplementation, and previous ophthalmic interventions, was recorded. Ocular examination included visual acuity assessment using Snellen's chart, anterior segment examination, intraocular pressure measurement using Goldmannapplanation tonometry, fundoscopy using an indirect ophthalmoscope, and fundus photography. Fundus fluorescein angiography (FFA) was performed to assess the severity of retinopathy, and optical coherence tomography (OCT) was conducted for macular evaluation.Blood investigations including fasting blood sugar (FBS), postprandial blood sugar (PPBS), random blood sugar (RBS), glycated hemoglobin (HbA1c), and serum vitamin D levels were measured. Vitamin D estimation was performed using a Vitros immunodiagnostic device. Standard laboratory procedures were followed using a Hitachi Modular DDPP analyzer (CLIA; ROCHE Cobas E 411). Samples were processed within 40–45 minutes using red vacutainers without anticoagulant.Physical activity assessed using active leisure time criteria, classifying subjects as sedentary or active. Dietary intake of vitamin D and calcium was assessed using a validated semi-quantitative food frequency questionnaire. All collected data entered into Microsoft Excel and subsequently analyzed using Statistical Package for Social Sciences (SPSS) software version 22.0 (IBM Corp., Armonk, NY, USA). Quantitative variables such as age, serum vitamin D levels, and HbA1c were expressed as mean ± standard deviation (SD), while qualitative variables were presented as frequencies and percentages. The association between categorical variables was analyzed using the Chi-square test or Fisher's exact test wherever appropriate. Comparison of means between two groups (diabetic retinopathy vs. non-retinopathy) was performed using the independent Student's t-test, while comparison among more than two groups (different grades of diabetic retinopathy) was carried out using one-way analysis of variance (ANOVA). Correlation between serum vitamin D levels and severity of diabetic retinopathy was assessed using Pearson's correlation coefficient. A p-value of less than 0.05 was considered statistically significant for all analyses.

## Results

The age-wise distribution of patients shows that the majority were in the 50–59 years age group, accounting for 31.7% of the study population. Patients aged 40–49, 60–69, and 70–79 years each represented a substantial proportion, ranging from 18.3% to 20%. The youngest (20–29 years) and oldest (≥80 years) age groups were least represented, each comprising only 3.3% of the total 60 patients.

**TABLE 1 : Age-wise Distribution of Patients**

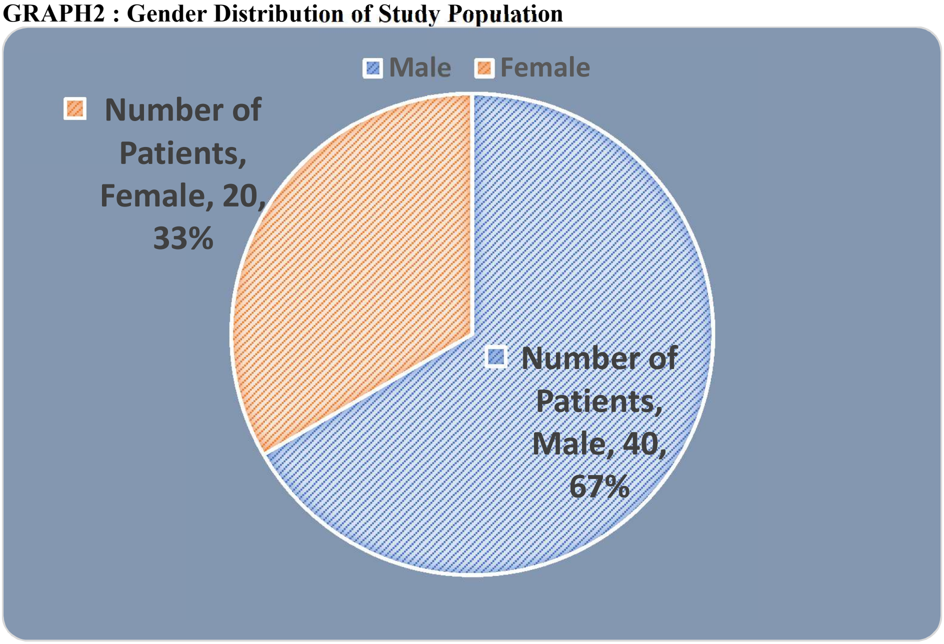
| **Age Group (years)** | **Number of Patients** | **Percentage (%)** |
|---|---|---|
| 20–29 | 2 | 3.3 |
| 30–39 | 3 | 5.0 |
| 40–49 | 12 | 20.0 |
| 50–59 | 19 | 31.7 |
| 60–69 | 11 | 18.3 |
| 70–79 | 11 | 18.3 |
| ≥80 | 2 | 3.3 |
| **Total** | **60** | **100** |

The gender distribution of the study population indicates a male predominance, with 66.7% of patients being male. Females comprised one-third of the population at 33.3%. Overall, out of 60 patients, two-thirds were male and one-third were female, highlighting a significant gender disparity in the study group.

**TABLE 2 : Gender Distribution of Study Population**

| **Gender** | **Number of Patients** | **Percentage (%)** |
|---|---|---|
| Male | 40 | 66.7 |
| Female | 20 | 33.3 |
| **Total** | **60** | **100** |

**GRAPH2 : Gender Distribution of Study Population**

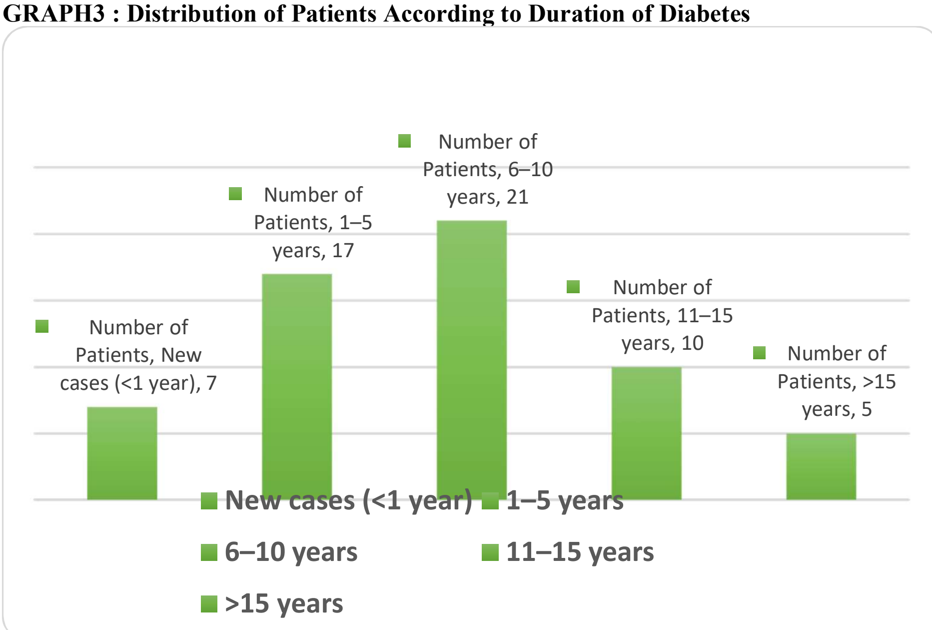



The distribution of patients according to the duration of diabetes shows that the largest proportion, 35%, had diabetes for 6–10 years. Patients with 1–5 years of diabetes accounted for 28.3%, while new cases (<1 year) comprised 11.7%. Those with a longer duration of 11–15 years and >15 years represented 16.7% and 8.3% of the study population, respectively, indicating a higher prevalence in patients with a mid-term duration of the disease.

**TABLE 3 : Distribution of Patients According to Duration of Diabetes**

| **Duration of Diabetes** | **Number of Patients** | **Percentage (%)** |
|---|---|---|
| New cases (<1 year) | 7 | 11.7 |
| 1–5 years | 17 | 28.3 |
| 6–10 years | 21 | 35.0 |
| 11–15 years | 10 | 16.7 |
| >15 years | 5 | 8.3 |
| **Total** | **60** | **100** |

**GRAPH3 : Distribution of Patients According to Duration of Diabetes**




The distribution of patients based on Best Corrected Visual Acuity (BCVA) shows that 30% had normal vision (6/6–6/12), while 28.3% experienced mild visual impairment (6/18–6/24). Moderate visual impairment (6/36–6/60) was observed in 21.7% of patients, and severe visual impairment, including counting fingers, hand movements, or perception of light, affected 20%. Overall, nearly half of the patients had some degree of visual impairment, highlighting a significant burden of reduced vision in the study population.

**TABLE 4 : Distribution of Patients According to Best Corrected Visual Acuity (BCVA)**

| **BCVA Category** | **Number of Patients** | **Percentage (%)** |
|---|---|---|
| 6/6 – 6/12 (Normal vision) | 18 | 30.0 |
| 6/18 – 6/24 (Mild visual impairment) | 17 | 28.3 |
| 6/36 – 6/60 (Moderate visual impairment) | 13 | 21.7 |
| <6/60 (Severe visual impairment: FC, HM, PL etc.) | 12 | 20.0 |
| **Total** | **60** | **100** |

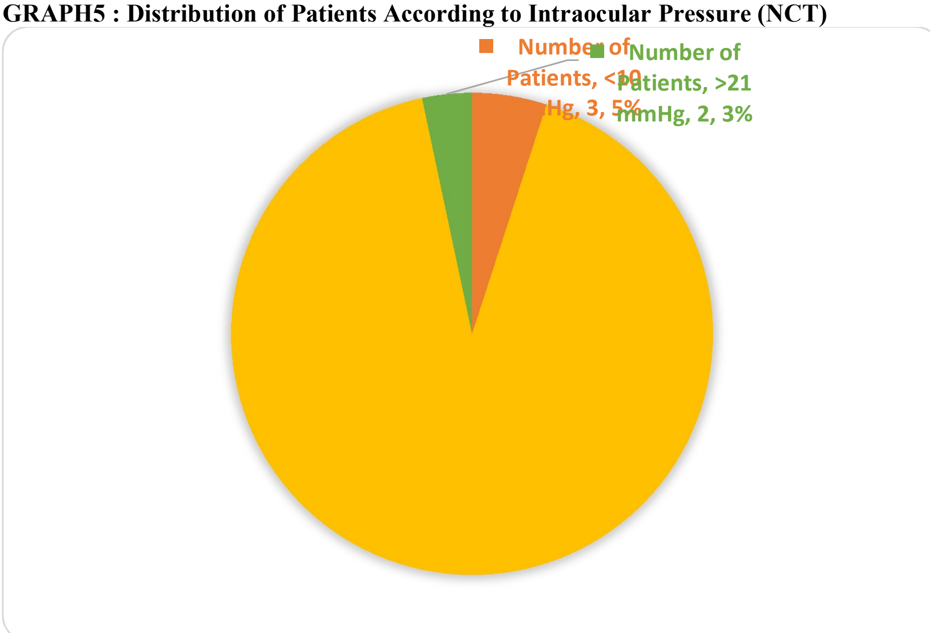
The distribution of patients according to intraocular pressure (IOP) measured by non-contact tonometry (NCT) shows that the majority, 91.7%, had IOP within the normal range of 10–21 mmHg. Low IOP (<10 mmHg) was observed in 5% of patients, while only 3.3% had elevated IOP (>21 mmHg). These findings indicate that most patients in the study maintained normal intraocular pressure.

**TABLE 5 : Distribution of Patients According to Intraocular Pressure (NCT)**

| **IOP Range (mmHg)** | **Number of Patients** | **Percentage (%)** |
|---|---|---|
| <10 mmHg | 3 | 5.0 |
| 10–21 mmHg | 55 | 91.7 |

| | | |
|---|---|---|
| >21 mmHg | 2 | 3.3 |
| **Total** | **60** | **100** |

**GRAPH5 : Distribution of Patients According to Intraocular Pressure (NCT)**

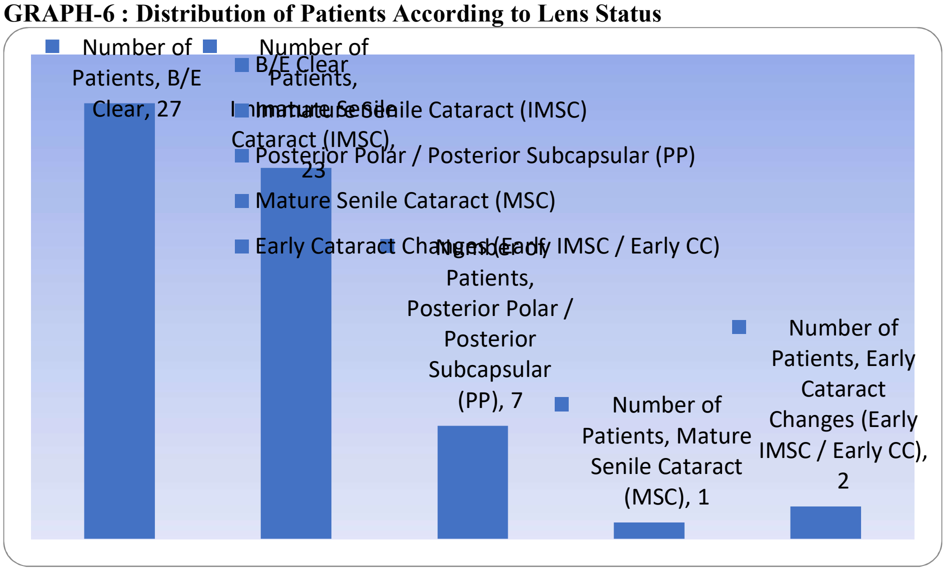



The distribution of patients according to lens status shows that 45% had clear lenses in both eyes, while 38.3% presented with immature senile cataract (IMSC). Posterior polar or posterior subcapsular cataracts were seen in 11.7% of patients, and mature senile cataract and early cataract changes were less common, observed in 1.7% and 3.3% of patients, respectively. Overall, the majority of patients either had clear lenses or early-stage cataract changes.

**TABLE 6 : Distribution of Patients According to Lens Status**

| Lens Status | Number of Patients | Percentage (%) |
|---|---|---|
| B/E Clear | 27 | 45.0 |
| Immature Senile Cataract (IMSC) | 23 | 38.3 |
| Posterior Polar / Posterior Subcapsular (PP) | 7 | 11.7 |
| Mature Senile Cataract (MSC) | 1 | 1.7 |
| Early Cataract Changes (Early IMSC / Early CC) | 2 | 3.3 |
| **Total** | **60** | **100** |

**GRAPH-6 : Distribution of Patients According to Lens Status**

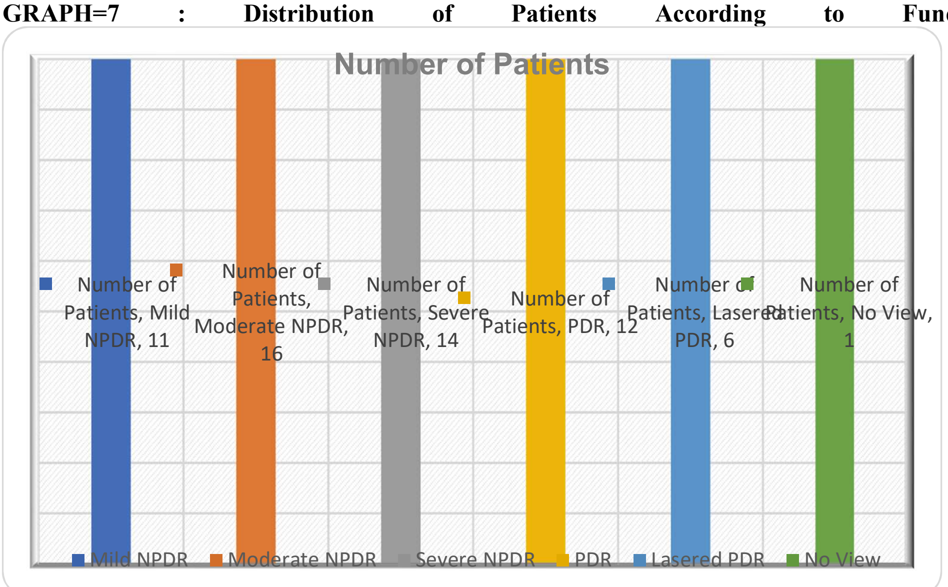



The distribution of patients based on fundus findings shows that moderate non-proliferative diabetic retinopathy (NPDR) was the most common, affecting 26.7% of patients, followed by severe NPDR in 23.3% and mild NPDR in 18.3%. Proliferative diabetic retinopathy (PDR) was observed in 20% of patients, with 10% having previously lasered PDR. Only 1.7% of patients had no fundus view, indicating that most patients exhibited some degree of diabetic retinal changes.

**TABLE 7 : Distribution of Patients According to Fundus Findings**

| Fundus Finding | Number of Patients | Percentage (%) |
|---|---|---|
| Mild NPDR | 11 | 18.3 |
| Moderate NPDR | 16 | 26.7 |
| Severe NPDR | 14 | 23.3 |
| PDR | 12 | 20.0 |
| Lasered PDR | 6 | 10.0 |
| No View | 1 | 1.7 |
| **Total** | **60** | **100** |

**GRAPH=7 : Distribution of Patients According to Fundus Findings**

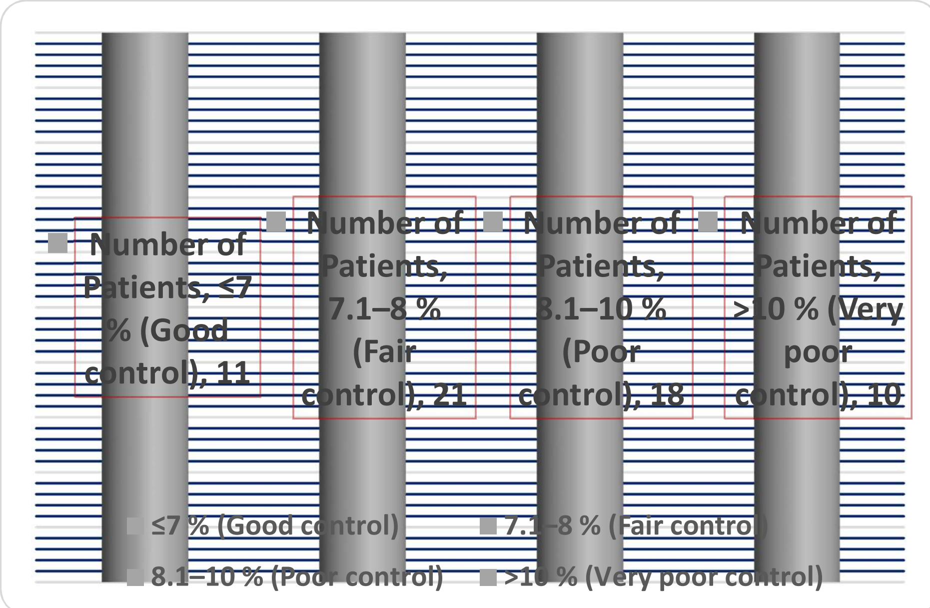



The distribution of patients according to HbA1c levels shows that the largest proportion, 35%, had fair glycemic control (7.1–8%), while 30% had poor control (8.1–10%). Good control (≤7%) was observed in 18.3% of patients, and 16.7% had very poor control (>10%). Overall, the majority of patients had suboptimal glycemic control, highlighting the need for better diabetes management in the study population.

**TABLE 8 : Distribution of Patients According to HbA1c Levels**

| HbA1c Level (%) | Number of Patients | Percentage (%) |
|---|---|---|
| ≤7 % (Good control) | 11 | 18.3 |
| 7.1–8 % (Fair control) | 21 | 35.0 |
| 8.1–10 % (Poor control) | 18 | 30.0 |
| >10 % (Very poor control) | 10 | 16.7 |
| **Total** | **60** | **100** |

**GRAPH8 : Distribution of Patients According to HbA1c Levels**

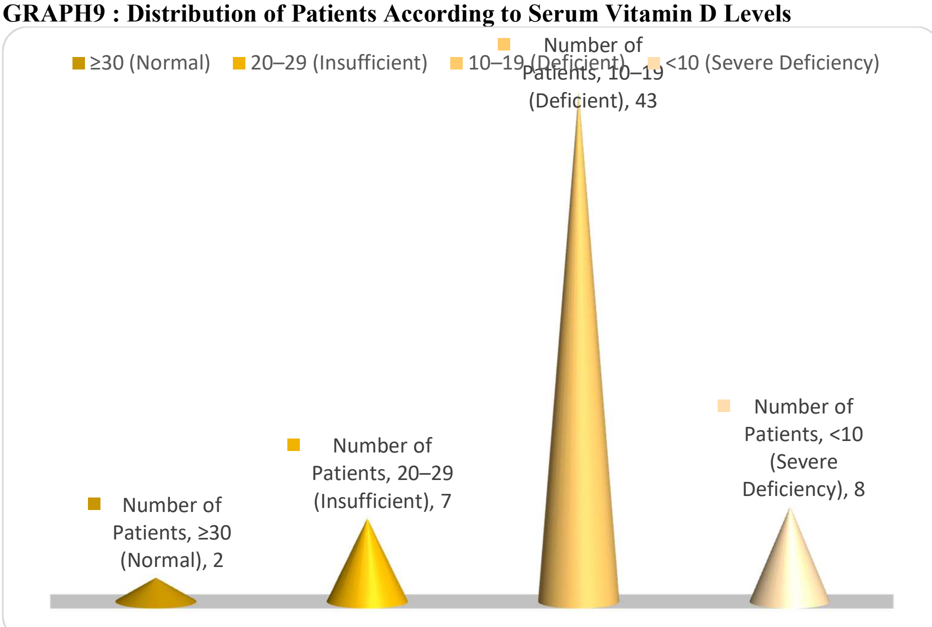



The distribution of patients according to serum vitamin D levels shows that a vast majority, 71.7%, were vitamin D deficient (10–19 ng/ml), while 13.3% had severe deficiency (<10 ng/ml). Only 11.7% of patients had insufficient levels (20–29 ng/ml), and just 3.3% had normal vitamin D levels (≥30 ng/ml). These findings indicate a high prevalence of vitamin D deficiency among the study population.

**TABLE 9 : Distribution of Patients According to Serum Vitamin D Levels**

| Vitamin D Level (ng/ml) | Number of Patients | Percentage (%) |
|---|---|---|
| ≥30 (Normal) | 2 | 3.3 |
| 20–29 (Insufficient) | 7 | 11.7 |
| 10–19 (Deficient) | 43 | 71.7 |
| <10 (Severe Deficiency) | 8 | 13.3 |
| **Total** | **60** | **100** |

**GRAPH9 : Distribution of Patients According to Serum Vitamin D Levels**



The association between serum vitamin D levels and severity of diabetic retinopathy shows that most patients with DR had vitamin D deficiency (10–19 ng/ml), affecting all stages from mild NPDR to lasered PDR. Severe vitamin D deficiency (<10 ng/ml) was less common but observed in patients across moderate NPDR, severe NPDR, and PDR. Only one patient with normal vitamin D levels had no fundus view, indicating a possible link between lower vitamin D levels and increased severity of diabetic retinopathy.

**TABLE 10 : Association Between Serum Vitamin D Levels and Severity of Diabetic Retinopathy**

| Severity of Diabetic Retinopathy | Severe Deficiency (<10 ng/ml) | Deficiency (10–19 ng/ml) | Insufficient (20–29 ng/ml) | Normal (≥30 ng/ml) | Total |
|---|---|---|---|---|---|
| Mild NPDR | 1 | 8 | 2 | 0 | 11 |
| Moderate NPDR | 2 | 11 | 3 | 0 | 16 |
| Severe NPDR | 3 | 10 | 1 | 0 | 14 |
| PDR | 2 | 9 | 1 | 0 | 12 |
| Lasered PDR | 0 | 5 | 1 | 0 | 6 |
| No View | 0 | 0 | 0 | 1 | 1 |
| **Total** | **8** | **43** | **8** | **1** | **60** |

The correlation between HbA1c levels and severity of diabetic retinopathy indicates that higher HbA1c levels are generally associated with more advanced stages of retinopathy. Patients with good glycemic control (≤7%) mostly had mild or moderate NPDR, while those with poor (8.1–10%) and very poor control (>10%) showed a higher prevalence of severe NPDR and PDR. Overall, the data suggest that suboptimal glycemic control is linked to increased severity of diabetic retinopathy in the study population.

**TABLE 11 : Correlation Between HbA1c Levels and Severity of Diabetic Retinopathy**

| HbA1c Level (%) | Mild NPDR | Moderate NPDR | Severe NPDR | PDR | Lasered PDR | Total |
|---|---|---|---|---|---|---|
| ≤7 % | 4 | 3 | 2 | 1 | 1 | 11 |
| 7.1–8 % | 4 | 7 | 5 | 3 | 2 | 21 |
| 8.1–10 % | 2 | 4 | 4 | 5 | 3 | 18 |
| >10 % | 1 | 2 | 3 | 3 | 1 | 10 |
| **Total** | **11** | **16** | **14** | **12** | **6** | **60** |

The correlation between serum vitamin D levels and HbA1c shows a mean vitamin D level of 15.9 ± 6.2 ng/ml and a mean HbA1c of 8.9 ± 2.1%. A significant negative correlation was observed ($r = -0.42$, $p = 0.001$), indicating that lower vitamin D levels are associated with higher HbA1c. This suggests that vitamin D deficiency may be linked to poorer glycemic control in the study population.

**TABLE 12 : Correlation Between Serum Vitamin D Levels and HbA1c**

| Parameter | Mean ± SD | Correlation Coefficient (r) | p-value | Significance |
|---|---|---|---|---|
| Serum Vitamin D (ng/ml) | 15.9 ± 6.2 | **-0.42** | **0.001** | Significant |
| HbA1c (%) | 8.9 ± 2.1 | | | |

**Discussion**

Diabetic retinopathy (DR) is a leading microvascular complication of diabetes mellitus and a major cause of vision impairment and blindness worldwide. Its prevalence is increasing alongside the global rise in type 2 diabetes mellitus (T2DM), making early identification of risk factors crucial for prevention and management. Chronic hyperglycemia contributes to retinal microvascular damage through oxidative stress, inflammation, and endothelial dysfunction. Recently, vitamin D has gained attention for its pleiotropic effects beyond bone metabolism, including anti-inflammatory, antioxidative, and angiogenic regulatory properties.[28,29]

Several studies suggest that vitamin D deficiency may exacerbate microvascular complications in T2DM, potentially influencing the onset and progression of DR. However, data remain limited and sometimes inconsistent, particularly in prospective settings. Understanding the relationship between serum vitamin D levels and DR could offer insights into novel preventive strategies and therapeutic interventions. This study aims to prospectively assess the correlation between serum vitamin D status and the presence and severity of DR in patients with T2DM.[30]

Our study was designed as a prospective observational case-control study conducted in the Department of Ophthalmology at Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Haryana. The study was carried out over a period of one year after obtaining institutional ethical clearance. All diagnosed diabetic patients aged 20 years and above who attended the Ophthalmology Department and met the inclusion criteria were considered for enrollment. A minimum of 100 patients with Type 1 and Type 2 diabetes mellitus were included, and participants were divided into two groups: a control group consisting of diabetic patients without diabetic retinopathy, and a study group consisting of diabetic patients with varying severities of diabetic retinopathy. Fundus photographs were captured for documentation and analysis.

Eligible patients underwent a detailed clinical history review and systemic examination. Ocular assessment included visual acuity measurement using the Snellen chart, anterior segment examination, intraocular pressure measurement with Goldmannapplanation tonometry, and fundoscopy using indirect ophthalmoscopy. Fundus photography, Fundus Fluorescein Angiography (FFA), and Optical Coherence Tomography (OCT) were performed to document retinal status and evaluate the severity of diabetic retinopathy and macular involvement.

Biochemical investigations were performed, including fasting blood sugar (FBS), post-prandial blood sugar (PPBS), random blood sugar (RBS), glycosylated hemoglobin (HbA1C), and serum vitamin D levels. Serum vitamin D was estimated using CLIA-based automated analyzers, and patients were categorized into normal, insufficient, deficient, and severely deficient groups. Data were analyzed using SPSS version 22, applying statistical tests such as Chi-square, Student's t-test, and multivariate regression analysis. Potential predictors including age, sex, HbA1C, BMI, duration of diabetes, physical activity, and lipid-lowering therapy were also evaluated.

The age-wise distribution of patients shows that the majority were in the 50–59 years age group, accounting for 31.7% of the study population. Patients aged 40–49, 60–69, and 70–79 years each represented a substantial proportion, ranging from 18.3% to 20%. The youngest (20–29 years) and oldest (≥80 years) age groups were least represented, each comprising only 3.3% of the total 60 patients.

The gender distribution of the study population indicates a male predominance, with 66.7% of patients being male. Females comprised one-third of the population at 33.3%. Overall, out of 60 patients, two-thirds were male and one-third were female, highlighting a significant gender disparity in the study group.

The distribution of patients according to the duration of diabetes shows that the largest proportion, 35%, had diabetes for 6–10 years. Patients with 1–5 years of diabetes accounted for 28.3%, while new cases (<1 year) comprised 11.7%. Those with a longer duration of 11–15 years and >15 years represented 16.7% and 8.3% of the study population, respectively, indicating a higher prevalence in patients with a mid-term duration of the disease.

The distribution of patients based on Best Corrected Visual Acuity (BCVA) shows that 30% had normal vision (6/6–6/12), while 28.3% experienced mild visual impairment (6/18–6/24). Moderate visual impairment (6/36–6/60) was observed in 21.7% of patients, and severe visual impairment, including counting fingers, hand movements, or perception of light, affected 20%. Overall, nearly half of the patients had some degree of visual impairment, highlighting a significant burden of reduced vision in the study population.

The distribution of patients according to intraocular pressure (IOP) measured by non-contact tonometry (NCT) shows that the majority, 91.7%, had IOP within the normal range of 10–21 mmHg. Low IOP (<10 mmHg) was observed in 5% of patients, while only 3.3% had elevated IOP (>21 mmHg). These findings indicate that most patients in the study maintained normal intraocular pressure.

The distribution of patients according to lens status shows that 45% had clear lenses in both eyes, while 38.3% presented with immature senile cataract (IMSC). Posterior polar or posterior subcapsular cataracts were seen in 11.7% of patients, and mature senile cataract and early cataract changes were less common, observed in 1.7% and 3.3% of patients, respectively. Overall, the majority of patients either had clear lenses or early-stage cataract changes.

The comparative analysis of our study with previous research demonstrates consistent findings regarding the role of vitamin D in diabetic retinopathy (DR). In our prospective observational study of 60 Type 2 diabetic patients, the majority were aged 50–59 years, with a male predominance (66.7%), and most patients exhibited mid-term diabetes duration (6–10 years). Clinically, nearly half had some degree of visual impairment, and fundus examination revealed moderate to severe non-proliferative DR in most cases. Glycemic control was suboptimal, with a mean HbA1c of 8.9 ± 2.1%, and vitamin D deficiency was highly prevalent (71.7%), with a significant negative correlation between serum vitamin D levels and HbA1c ($r = -0.42$, $p = 0.001$). These findings align with previous studies, including Chi L et al. (2021), Luo BA et al. (2017), and Yu G et al. (2026), all of which reported an increased risk and severity of DR in patients with lower vitamin D levels. Overall, our study reinforces the clinical relevance of monitoring and correcting vitamin D deficiency to potentially reduce DR risk and progression in diabetic patients.[31,32,33]

Diabetic retinopathy (DR) is one of the most common microvascular complications of diabetes mellitus and remains a leading cause of preventable blindness globally. With the increasing prevalence of diabetes, particularly Type 2 diabetes mellitus (T2DM), DR represents a significant public health concern. According to the World Health Organization, DR affects nearly one-third of all diabetic patients, and its early stages are often asymptomatic, making timely diagnosis challenging. Left untreated, progressive DR can result in severe visual impairment and blindness, negatively impacting the quality of life and increasing the economic burden due to medical costs and loss of productivity. Therefore, identifying modifiable risk factors and biomarkers that can predict or prevent the development and progression of DR is of paramount clinical importance.[33]

**Conclusion**

In our study, vitamin D deficiency was found to be highly prevalent among patients with diabetes mellitus and was significantly associated with poorer glycemic control and increased severity of diabetic retinopathy. Serum vitamin D levels showed a strong inverse correlation with HbA1c, indicating that lower vitamin D may contribute to both metabolic dysregulation and microvascular complications. These findings highlight the importance of routine assessment and management of vitamin D status in diabetic patients as part of comprehensive care. Early identification and correction of deficiency may help reduce the risk or progression of diabetic retinopathy and improve overall visual outcomes.

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