Original Article

# Comparative study of intraocular pressure variation among healthy and diabetic individuals

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## Abstract

**Background:** Diabetes and glaucoma share several common risk factors and pathophysiological similarities. Elevated intraocular pressure, a key pathogenic feature of glaucoma and its progression, has been found to be influenced in diabetic patients. Furthermore, a link between poor glycemic control and increased intraocular pressure has been documented. Given the rising prevalence of diabetes mellitus and its emergence as a new pandemic with widespread effects, it is crucial to thoroughly study its impact on various body systems and implement measures to reduce these adverse effects. Therefore, this study aims to investigate the variation in intraocular pressure and its relationship with different pathogenic risk factors in diabetes mellitus patients to develop effective prevention strategies. **Aim:** To study the variation in intraocular pressure among the subjects with Type II Diabetes Mellitus Settings and Study Design: This analytical cross-sectional study conducted at KGMU, Ophthalmology OPD. **Methods and Materials:** Study has been conducted on a total of 140 participants, comprising of 70 Type II DM cases and 70 age, gender-matched controls in 1year duration. Type II DM was confirmed by diagnosis while controls were selected to match in age & gender without diabetes. IOP measurement was done using non-contact tonometry and central corneal thickness was measured by non-contact method using NIDEK CEM-530 specular microscope. Regression analysis was used to assess association between Type II DM and IOP variation. Statistical analysis of the data was done using IBM SPSS Stats 25.0 version with Student t-test, Chi-square test, ANOVA, and Pearson's correlation with 95% CI is used. P <0.05 is considered significant. **Result:** Significant distinction in IOP between the between cases and control group is observed. And, also more the duration of diabetes with poor glycemic control may lead to raised IOP. **Conclusion:** The study rules out the risk factors for raised IOP in general & diabetic population. Thus, emphasizing the need for meticulous ocular care in diabetic individuals.

**Keywords:** Central corneal thickness (CCT), intraocular Pressure (IOP), non-Contact Tonometry (NCT), type II Diabetes Mellitus

## Introduction

Diabetes is a global pandemic that has silently affected more than 500 million people worldwide and has affected almost every tenth adult.[1] In the year 2008, WHO estimated the global burden individuals affected by diabetes to be 180 million and projected its doubling by the year 2030.[2]

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The current estimates for the year 2021 as released in the 10th edition of IDF Diabetes Atlas by International Diabetic Federation (IDF) show as many as 537 million adults with diabetes throughout the world.

Diabetes is a persistent chronic condition caused by dysfunction of pancreatic activity which results by impaired insulin synthesis or secretion. Insulin is responsible for glucose metabolism. Impaired glucose metabolism, results in "hyperglycemia". Hyperglycemia is responsible for various micro and macro-vascular complications affecting various organ systems of body. Owing to these metabolic



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implications, the comorbidity burden in diabetic patients is quite high[3,4]

Eye is one of the most important organs affected by hyperglycemic activity caused by diabetes. Almost one-third of diabetic patients have eye problems.[5] Diabetic retinopathy is one of the most common microvascular complications associated with diabetes which is primarily dependent on the level and duration of glycemic impairment. Apart from diabetic retinopathy, diabetes is also a risk factor for development of glaucoma. Intraocular pressure elevation, that is a characteristic pathogenic feature of glaucoma and its progression, has been shown to be affected in diabetic patients, moreover, a relationship between poor glycemic control and elevation of intraocular pressure has also been documented.[6] Intraocular pressure is generated by the flow of aqueous humor against resistance and is necessary for the sturdy shape of eyeball. Raised IOP has a detrimental effect on the optic nerve integrity.

Diabetes produces oxidative stress in trabecular meshwork, which is the site of aqueous changes in the anterior chamber of the eye, affects the increased aqueous outflow resistance leading to a rise in intraocular pressure.[7] The IOP increase in diabetes patients is mainly attributed to aqueous outflow resistance in trabecular meshwork because of glycation and crosslinking of meshwork glycoproteins.[8]

Taking care of increasing prevalence of diabetes mellitus and its syndromic impact, the present study has been conducted. So as to intervene and correct the only modifiable risk factor that is lowering of intraocular pressure to prevent the irreversible cause of blindness, which can be done by primary healthcare workers itself.

## Aim

To study the variation in intraocular pressure among the subjects with Type II Diabetes Mellitus.

## Objectives

1. To compare the intraocular pressure in Diabetics and Non-Diabetics.
2. To scrutinize the repercussion of duration of Type II Diabetes Mellitus on intraocular pressure.
3. To determine the relationship between HbA1c and intraocular pressure.

## Material and Method

This analytical cross-sectional study was conducted in Department of Physiology in collaboration with Department of Ophthalmology, after taking institutional ethical clearance. Sample size was calculated on basis of prevalence of Glaucoma in Type 2 Diabetes patients. A total of 140 patients, were enrolled from Ophthalmology OPD, King George's Medical University, Lucknow. Duration of study was one year.

Inclusion Criteria for subjects were adults of either sex aged 20 years and above. This was further divided into case grouped as 'A' which included subjects with fasting blood glucose >126 mg/dl, or post prandial blood glucose >200 mg/dl and HbA1c >6.4%. The other group comprised of controls grouped as 'B' which included fasting blood glucose: <100 mg/dl, post prandial: <140 mg/dl and HbA1c: <5.7%.

Exclusion criteria for the study were Female with gestational diabetes mellitus, Diabetic pregnant women, Type 1 Diabetes, Uveitis, Pterygium involving Cornea or Corneal opacity, previously diagnosed Glaucoma, H/o any medication affecting IOP, Moderate to severe strabismus, Difficulties in IOP measurement, H/o any Intraocular surgery.

At enrolment, details of age and sex were noted and medical history was enquired. A general examination of the patients was also carried out. Blood sugar fasting and postprandial was done. Patients then underwent detailed ocular evaluation including visual acuity. Intraocular pressure measurement was done using Non-Contact Tonometry (NIDEK NT-530/510) for each eye. Three measurements were taken for each eye, if the standard error of the three measurements exceeded 2 mmHg, then retest was done. Central corneal thickness was measured using non-contact method (NIDEK CEM- 530 Specular Microscope). Measurements were performed in scotopic conditions with patient's chin and forehead resting on the device. All CCTs and IOPs were measured in un-dilated state of the pupil.

CCT corrected IOP was derived using the following formula:

Corrected IOP = Measured IOP – (CCT – 545)/50 × 2.5 mm Hg.

Ocular measurements were done for both the eyes.

### Statistical analysis

Statistical analysis of the data was done using IBM SPSS Stats 25.0 version. Categorical data has been depicted in numbers and percentage. Continuous data has been depicted as mean and standard deviation. Comparison of categorical data between two groups has been made using Chi-square test. Comparison of continuous data between two groups has been made using independent samples 't'-test. Evaluation of relationship between diabetic duration and mean IOP was done using ANOVA. Bivariate correlations were assessed using Pearson's correlation coefficient ('r'). An 'r' value < 0.3 was considered as indicator of weak correlation, 0.3-0.49 as mild correlation, 0.5-0.69 as moderate correlation and > 0.7 as strong correlation. Positive ('+') or negative ('-') sign against r value was reflective of direct/positive or inverse/negative correlation. Multivariate assessment was done using Linear regression. For the purpose of statistical significance '*p*'

value less than 0.05 was taken as the criteria for a statistically significant relationship.

## Results

The present study was carried out to study the variation in intraocular pressure among the subjects with Type II Diabetes Mellitus. For this purpose, a total of 140 participants were enrolled in the study.

Age of the study population ranged from 35 to 80 years. Mean age of participants in Groups 1 and 2 was 56.61 ± 10.53 and 54.52 ± 11.93 years, respectively. The two groups were matched for age in statistical terms ($P = 0.092$) [Table 1].

Majority of participants in Group 1 (53.3%) as well as Group 2 (51.5%) were males. There was no statistically significant difference between two groups for sex profile of participants ($P = 0.741$) [Table 1].

Both uncorrected and corrected intraocular pressure values were significantly higher in Group 1 as compared to that in Group 2 [Table 2; Figure 1].

On overall evaluation mean IOP of those with HbA1c >6.5% were found to be significantly higher as compared to those having IOP levels <6.5% [Table 3; Figure 2].

However, on groupwise evaluation this relationship was not found to be significant statistically ($P > 0.05$) [Table 3].

## Discussion

Impairment of glucose homeostasis as a result of diabetes, leads to a chronic hyperglycemic effect. Chronic hyperglycemia gives rise to glucose toxicity. Glucose toxicity is such condition that is caused by impairment of pancreatic function of insulin secretion but in turn further reduces the capacity of pancreatic β-cells to secrete insulin resulting in a continuous vicious cycle resulting in hyperglycemia and impairment of insulin secretion. Increase in glucose levels give rise to a number of metabolic reactions resulting in production of oxidative stress due to continuous production of reactive oxygen species (ROS), such as super-oxides ($O_2^-$), hydroxyl radicals (OH-), peroxyl radicals (ROO-), and/or nitric oxide. Genetic and epigenetic changes, inflammation, an abnormal environment, and insulin resistance [IR] are four basic pathophysiological mechanisms that contribute to the β-cell destruction and tissue damage and in turn contribute to the risk of developing a host of diabetes-related complications affecting almost every organ system of the body and thus transforming the diabetes from a simple physiological condition of failed glucose homeostasis and hyperglycemia to a syndrome.[9] Hyperglycemia also induces changes in autonomic nervous system, vascular endothelial dysfunction, renin-angiotensin-aldosterone system, immune

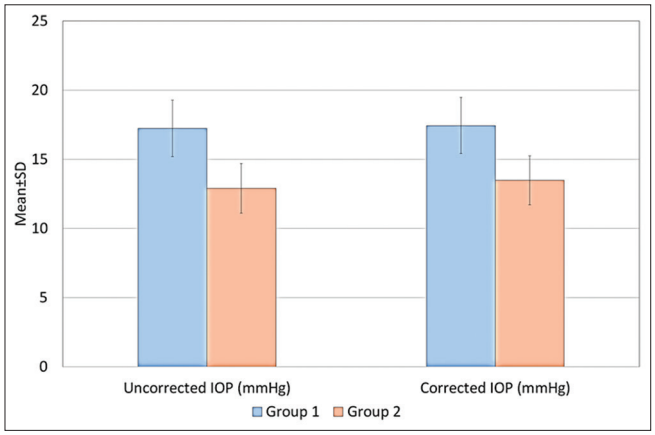


**Figure 1:** Comparison of Mean Uncorrected and corrected IOP between two study groups

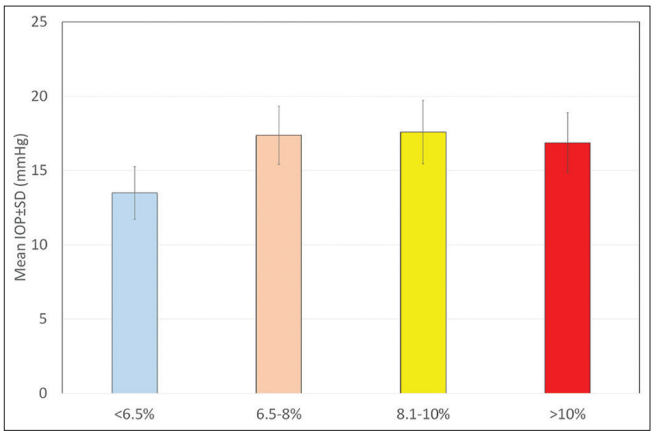


**Figure 2:** Relationship between HbA1c and intraocular pressure (Overall)

**Table 1: Comparison of Demographic Profile and General Characteristics of Cases and Controls**

| Characteristic | "Group 1" (*n*=70) | "Group 2" (*n*=70) | Statistical significance |
|---|---|---|---|
| Mean age±SD (Range) in years | 56.61±10.53 (35-78) | 54.52±11.93 (37-80) | $t$=2.849; $P$=0.092 |
| Male: Female | 33 (46.7%): 37 (53.3%) | 34 (48.5%): 36 (51.5%) | $\chi^2$=0.109; $P$=0.741 |

**Table 2: Comparison of Mean Uncorrected, corrected IOP and CCT between two study groups**

| Parameters | "Group 1" (*n*=70) | "Group 2" (*n*=70) | Statistical significance |
|---|---|---|---|
| Uncorrected IOP±SD (mmHg) | 17.25±2.05 | 12.91±1.80 | $t$=28.954; $P$<0.001 |
| Corrected IOP±SD (mmHg) | 17.45±2.03 | 13.49±1.77 | $t$=26.70; $P$<0.001 |
| Mean CCT±SD (μm) | 541.08±3.27 | 533.43±6.26 | $t$=19.656; $P$<0.001 |

**Table 3: Relationship between HbA1c and intraocular pressure**

| HbA1c Level | *n* | Mean corrected IOP | SD |
|---|---|---|---|
| Overall (*n*=660) | | | |
| <6.5% | 328 | 13.49 | 1.77 |
| 6.5-8% | 132 | 17.37 | 1.95 |
| 8.1-10% | 164 | 17.58 | 2.14 |
| >10% | 36 | 16.86 | 2.02 |
| *F*=231.78; *P*<0.001; *r*=0.566; *P*<0.001 | | | |
| Cases (*n*=330) | | | |
| <6.5% | 0 | 0 | 0 |
| 6.5-8% | 130 | 17.44 | 1.88 |
| 8.1-10% | 164 | 17.58 | 2.14 |
| >10% | 36 | 16.86 | 2.02 |
| *F*=1.858; *P*=0.158; "*r*"=-0.111; *P*=0.044 | | | |
| Controls (*n*=330) | | | |
| <6.5% | 328 | 13.49 | 1.770 |
| 6.5-8% | 2 | 12.78 | 0.035 |
| 8.1-10% | - | - | - |
| >10% | - | - | - |
| *F*=0.330; *P*=0.566; '*r*'=0.251; *P*<0.001 | | | |

function alterations, and a number of other harmful conditions.[10] These changes have an effect on aqueous humor outflow in the eye, which eventually modulates the intraocular pressure.[11]

In the present study, although for diabetic cases all the consecutive patients were enrolled, however, for non-diabetic participants, we made an attempt to include age- and sex-matched subjects from amongst non-diabetic participants. As matching is one of the pre-requisites for analytical cross-sectional study, it rules out the role of confounders while at the same time it increases the efficiency of the study.[12] Mean age of patients in two study groups was 56.61 ± 10.53 and 54.52 ± 11.93 years, respectively. Majority of participants in both the groups were females. There was no statistically significant difference between two groups for age and sex. The age profile of participants in the present study is comparable to that of Math and Mohta[13] who reported the mean age of diabetic and non-diabetic participants as 58.30 and 56.8 years, respectively, however, compared to the present study where majority of participants were females, in their study majority of participants (66%) were males.

In the present study both uncorrected as well as CCT corrected IO*P* values were significantly higher in diabetic as compared to non-diabetic eyes. There was a mean difference of 4.34 and 3.96 mmHg respectively between diabetic and non-diabetic eyes for uncorrected and corrected IOPs.

In the present study on overall evaluation mean IOP of those with HbA1c > 6.5% were found to be significantly higher as compared to those having IOP levels < 6.5% [Table 3; Figure 2]. The present study found a significant linear increment in IOP levels with increasing duration of diabetes, however, a significant but non-linear association between $HbA_{1c}$ levels and IOP was also seen. The relationship of IOP with diabetic duration and $HbA_{1c}$ levels is complex and seems to be an interplay of both. Cui *et al.*[14] in their study found a stronger correlation of IOP with duration of diabetes among those with $HbA_{1c}$ <7% as compared to those having $HbA_{1c}$ ≥7%.

Aljuhani *et al.*[15] similar to the present study found a significant incremental trend of IOP with increasing duration of diabetes but failed to find such incremental trends with increasing $HbA_{1c}$ levels. In the present study, in the diabetic group we also observed that patients having $HbA_{1c}$ >10% had IO*P* values lower than those having $HbA_{1c}$ <10%. This implies that level of glycemic control alone does not seem to increase the IOP, rather duration of diabetes is more important than the $HbA_{1c}$ levels at the time of investigation.

The findings of the study in view of these inconsistencies also depict the need to improve this model further by inclusion of other possible confounders that could affect the IOP.

## Limitations

Lack of adequate contemporary studies evaluating the relationship of diabetes with IOP in multivariate context. Sample size was small. Some other variables like diabetic medication, diabetic complications, personal habits, and dietary preferences should also have been included to assess their potential impact on IOP in context with diabetes.

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## Conflicts of interest

There are no conflicts of interest.

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