Original Article

# Comparison of Intraocular Pressure with and without Central Corneal Thickness Correction in people with Diabetes

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ABSTRACT

**Aim:** To determine intraocular pressure with and without central corneal thickness correction in individuals with diabetes.

**Study Design:** A cross-sectional study.

**Duration and Settings of the Study:** The study was conducted over a period of six months, from May to October 2025, at Isra University, Karachi.

**Methods:** A total of 203 diabetic patients aged 30-75 years were selected through a non-probability convenience sampling method. Intraocular Pressure (IOP) was evaluated in both eyes with a Goldmann applanation tonometer, and Central Corneal Thickness (CCT) was determined using pachymetry. Patients aged less than 30 years, contact lens wearers, and those with hazy media were excluded. Data was analyzed using SPSS version 20. Bar charts and pie charts were used to describe qualitative data, while range, mean, and Standard Deviation (SD) were used to express quantitative data. Normality was assessed using the Shapiro–Wilk test. Paired t-tests were applied to compare IOP before and after CCT correction. Statistical significance was set at $p < 0.05$. Effect sizes were also calculated.

**Results:** A total of 203 patients were examined during the study in the age range of 30 to 75 years. Out of 203 patients, 118 were male and 85 were female. Mean IOP before CCT correction was 12.42 ± 1.30 mmHg in the right eye and 12.33 ± 1.27 mmHg in the left eye. After correction of CCT, mean IOP was 13.91 ± 2.82 mmHg in the right eye and 13.58 ± 2.75 mmHg in the left eye calculated using Ehlers' formula. Mean differences were +1.49 mmHg in the right eye and +1.25 mmHg in the left eye. These increases were statistically significant ($p < 0.001$).

**Conclusion:** After CCT correction, intraocular pressure showed a statistically significant increase. Pachymetry should be considered essential for accurate IOP assessment in diabetic patients.

**Keywords:** Central Corneal Thickness; Diabetes Mellitus; Glaucoma Risk; Goldmann Applanation Tonometry; Intraocular Pressure; Pachymetry.

**This article may be cited as:** Kumar S, Qasim M, Asif M. Comparison of Intraocular Pressure with and without Central Corneal Thickness Correction in people with Diabetes. J Clin Comm Ophthalmol 2026; 04(02):55-59.

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*Date of Submission:* *12-11-2025*
*Date of Review:* *03-01-2026*
*Date of Acceptence:* *11-02-2026*

## INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder in which the body fails to regulate blood glucose properly due to inadequate insulin action or production. This occurs due to insufficient insulin production by the body or because the body cells become unresponsive to the insulin that is produced.

Diabetes has been classified into three main types. Type 1 Diabetes Mellitus (T1DM), also called Insulin Dependent Diabetes Mellitus (IDDM), occurs when the body cannot produce insulin, requiring affected individuals to get insulin through injections or an insulin pump.[1] This form is also known as juvenile diabetes. Type 2 Diabetes Mellitus (T2DM), or Non-insulin Dependent Diabetes Mellitus (NIDDM), occurs due to insulin resistance, a condition

in which body cells do not utilize insulin effectively with or without an absolute deficiency of insulin. This was previously known as adult-onset diabetes. The third type is gestational diabetes, which arises in women without prior diabetes when elevated blood sugar levels are detected during pregnancy.[2] The rise in diabetic prevalence occurs due to the rise in its main factors: overweight, obesity, and physical inactivity.[3] The worldwide incidence of diabetes continues to rise, with the prevalence among adults estimated at 8.8% of the world's population in 2017, and projections indicating a further increase to 9.9% by 2045.[4]

Glaucoma refers to a progressive optic nerve disease that gradually impairs vision and can eventually lead to blindness if not treated.[5] Glaucoma is associated with characteristic damage to the optic nerve and specific patterns of visual field loss.[6] This damage can lead to irreversible loss of vision worldwide.[7] Glaucoma is the leading cause of irreversible blindness worldwide.[8] Primary open angle glaucoma, the most common form, accounts for the majority of cases in the United States and Europe, while angle-closure glaucoma is also highly prevalent. These types are classified according to the anatomical configuration of the aqueous humor outflow pathways.[9] Glaucoma is diagnosed through fundoscopy, visual field assessment, and measurement of intraocular pressure (IOP) using tonometry. Globally approximately 57.5 million people were affected by glaucoma in 2020.[10]

The IOP readings are influenced by central corneal thickness (CCT). If the corneal thickness is above average (520um), the measured IOP tends to be greater than the actual pressure. And when thickness is below average, the measured IOP will be lower than its true value.[11] The diagnosis of glaucoma requires a thorough assessment of both structural and functional ocular changes. Structural evaluation focuses on the anterior chamber angle, which may be narrow or closed in angle-closure variants, as well as the optic nerve head, where characteristic features include Retinal Nerve Fiber Layer (RNFL) thinning and progressive optic disc cupping. Functional impairment is assessed through visual field testing, which identifies typical glaucomatous patterns of visual field loss. A comprehensive ophthalmic examination is therefore essential, incorporating the following key diagnostic tools: Gonioscopy for direct evaluation of the anterior chamber angle, funduscopic examination and Optical Coherence Tomography (OCT) for detailed assessment of the optic disc and RNFL integrity, Visual field perimetry to detect and quantify functional visual field defects.[12] The normal range for IOP is typically between 10 and 21mmHg.[13]

CCT significantly influences the diagnosis and management of glaucoma by affecting the accuracy of IOP readings. Thinner corneas may cause IOP values to appear lower than they are (underestimation), whereas thicker corneas can make readings seem higher (overestimation). Consequently, people with thinner CCT are at high risk of developing glaucoma and faster progression of disease.[14] Pachymetry is a diagnostic tool used to measure the thickness of the cornea. It is important for assessing the risk of errors in IOP measurement, as variations in corneal thickness can affect the results. On average, the central corneal thickness is about 545µm.[15]

## METHODS

This was a cross-sectional study conducted over a six-month period from May to October 2025. All participants examined after obtaining informed consent. A total of 203 diabetic patients aged 30-75 years of both genders were included. The calculated sample size was 203. Patients younger than 30 years, non-diabetic individuals, and contact lens wearers, those with a history of ocular trauma and surgery and those with hazy or unclear media were excluded. IOP was measured in both eyes using a Goldmann applanation tonometer after instillation of topical anesthetic drops and fluorescein strips. CCT was assessed by pachymetry. CCT-corrected IOP values were calculated using the Ehlers formula to adjust for corneal thickness variations. All the observations were recorded on a structured proforma. The primary outcome variable was the comparison between uncorrected and CCT-corrected IOP in diabetic patients. Secondary variables included age, gender, and mean CCT values. The sample size of 203 patients was based on convenience and feasibility; no formal power calculation was performed to determine adequacy for expected effect size.

All collected data was processed and analyzed using SPSS software (version 20). The Shapiro–Wilk test was applied to examine whether the data followed a normal distribution. Although some variables showed deviation from normality, paired t-tests were used for the primary analysis because the large sample size ($N > 200$) makes the test robust to such deviations. Uncorrected and CCT-corrected IOP values were compared within subjects (right and left eyes separately). In addition to p-values, effect sizes (Cohen's d for paired comparisons) were calculated to indicate the magnitude of observed differences. A two-tailed $p < 0.05$ was considered statistically significant.

## RESULTS

A total of 203 patients were examined during the study. The mean age of participants was 50.9 ± 10.6 years (range: 30–75 years). Out of 203 patients, 118 were male and 85 were female. Having a male to female ratio of 1.39:1. The mean IOP without correction of CCT was 12.42 ± 1.30 mmHg for the right eye and 12.33 ± 1.27 mmHg for the left eye. The mean IOP with correction of CCT was 13.91 ± 2.82 mmHg for the right eye and 13.58 ± 2.75 mmHg for the left eye. The mean difference in the right eye was 1.49 ± 1.53 mmHg and in the left eye 1.58 ± 1.58mmHg.

When we compared the uncorrected and corrected values, the difference was statistically significant in both eyes. In

**Table 1: Comparison of IOP with and without CCT Correction.**

| Eye | Mean IOP Without CCT (±SD) mmHg | Mean IOP with CCT (±SD) mmHg | Mean Difference ±SD (mmHg) | Minimum Difference (mmHg) | Maximum Difference (mmHg) | P-value |
|---|---|---|---|---|---|---|
| Right eye | 12.42 ± 1.297 | 13.91 ± 2.824 | 1.49 ± 1.53 | 0 | 4 | p<0.001 |
| Left eye | 12.33 ± 1.266 | 13.58 ± 2.749 | 1.58 ± 1.58 | 0 | 3 | p<0.001 |

(Paired T-Test applied)
IOP = Intraocular Pressure; CCT = Central Corneal Thickness; SD=Standard Deviation

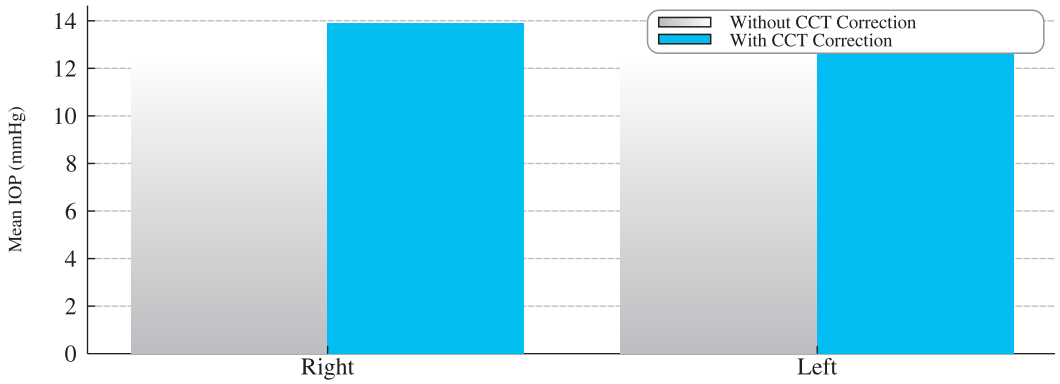


**Figure 1: Boxplots Showing Distribution of Uncorrected vs. CCT-Corrected IOP in Right and Left Eyes of Diabetic Patients.**

IOP = intraocular pressure; CCT = central corneal thickness

the right eye, the mean difference was about 1.5 mmHg, and in the left eye, about 1.6 mmHg. For both, the p-value was less than 0.001. This demonstrates the clinical importance of pachymetry in avoiding underestimation of glaucoma risk.

## DISCUSSION

The present study demonstrated that IOP values increased after CCT correction in both eyes of diabetic patients. In addition to CCT, diabetes has been shown to alter corneal biomechanical properties such as corneal hysteresis and corneal resistance factor. These changes, caused by advanced glycation end products, may influence applanation tonometry independently of corneal thickness. This suggests that both CCT and corneal biomechanics should be considered when interpreting IOP in diabetic patients. Although this difference was numerically small (1.49 mmHg in the right eye and 1.25 mmHg in the left eye), but it was statistically significant ($p < 0.001$). These findings validate that CCT has a measurable effect on IOP readings and confirms the need for its consideration in glaucoma risk assessment among diabetic patients.

Clinically, this result is important because an IOP of 20 mmHg may not be harmful in some individuals, but in others with different corneal thicknesses, the same pressure may increase the risk of glaucomatous damage. Therefore, corneal thickness correction provides a more reliable interpretation of IOP in diabetic eyes.

Our findings are consistent with Elsayed et al. (2019), who reported that type II diabetic patients with proliferative diabetic retinopathy had significantly elevated IOP and thicker corneas compared to controls, emphasizing the role of CCT in IOP interpretation.[16] Similarly in 2017, Das highlighted that all tonometers, including Goldmann applanation tonometer, are influenced by corneal thickness, with the strongest effect observed in GAT readings.[17] On the other hand, Ramm et al, observed that while CCT contributed to changes in IOP, corneal biomechanics played an even more critical role, suggesting that CCT correction alone may not fully account for variations.[18,19,20] Taken together, our results align with existing evidence: diabetes alters corneal thickness, leading to either overestimation or underestimation of IOP. While CCT correction significantly improves accuracy, a comprehensive approach considering both CCT and corneal biomechanics would provide the most reliable glaucoma risk assessment in diabetic patients.

Lack of a non-diabetic control group reduced the ability to compare differences directly. Only CCT was measured, while other corneal biomechanical factors (such as corneal hysteresis) were not evaluated. Cross-sectional design limits the ability to assess long-term effects of diabetes on IOP and glaucoma risk. The study was conducted at a single center, so findings may not be generalizable to other populations. As the study employed non-probability

convenience sampling, the results may not be fully generalizable to the wider diabetic population. Another limitation of this study is its cross-sectional design, which allows assessment of associations between variables but does not permit conclusions about causality.

## CONCLUSION

After CCT correction, IOP values changed significantly in people with diabetes. These results emphasize the importance of incorporating pachymetry into routine glaucoma risk assessment to avoid underestimation of IOP.

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**Acknowledgments:**

The authors gratefully acknowledge the valuable guidance of their teachers and supervisors, as well as the continuous encouragement and support of their families throughout this study. Their contributions were instrumental in the successful completion of this work.

**Conflict of Interest**

The author(s) declare no conflicts of interest.

**Funding**

This research received no specific financial support from any funding agency.

**AI Declaration**

No artificial intelligence tools were used in the preparation of this manuscript.

**Patient Consent:**

Informed consent was obtained from all participants included in this study.

**Ethical Approval**

Ethical approval for this study was granted by Research and Ethical committee of Health Research and Ethics Committee of Alex Ekwueme
Ethical approval for this study was obtained from the Institutional Review Board of Isra University, Karachi
(Approval No: REC/IPIO/2025/038-B)

**Authors' Contribution Statement**

SK: Conducted research, collected and analyzed data, drafted the manuscript. MA: To create and help out title, methodology, data collection, data analysis and conclusion. MQ: Project approval, critical revision, Co-supervisor.