CITE PUBLICATIONS
Journal of Medicine and Applied Clinical Sciences
Volume: 1, Issue: 1, 2025 (July - December), Pages: 25-35
Research Article

Glycemic Status and its Relationship with Corneal Tomographic and Endothelial Parameters in Diabetes Mellitus

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Received: 2 August 2025 / Accepted: 21 November 2025 / Published: 31 December 2025

This study aims to compare corneal tomographic and endothelial parameters in diabetic patients with both controlled and uncontrolled glycemic status, as well as to investigate the relationships between corneal parameters, glycemic control, and the duration of diabetes. Conducted in a hospital setting, this cross-sectional study involved diabetic patients categorized into controlled and uncontrolled groups according to their HbA1c levels. Corneal tomography was executed utilizing Scheimpflug imaging, while endothelial evaluation was performed through non-contact specular microscopy. To maintain statistical independence, the right eye was predetermined for all inferential analyses. Between-group comparisons were carried out using suitable statistical tests, with effect sizes presented alongside p-values. Correlation and multivariable regression analyses were employed to assess the associations among corneal parameters, HbA1c levels, and the duration of diabetes. The findings revealed that patients with uncontrolled diabetes exhibited a significantly steeper flat keratometry (K1) in comparison to those with controlled glycemic status, with a moderate-to-large effect size, suggesting potential clinical significance. Conversely, other tomographic parameters such as steep keratometry, mean keratometry, central corneal thickness, anterior chamber depth, and corneal volume did not show significant differences between the groups and were associated with small effect sizes. Nevertheless, a greater dispersion of various tomographic parameters was descriptively noted in the uncontrolled diabetes cohort, indicating heightened structural variability. The density of endothelial cells was numerically elevated in the uncontrolled diabetes group; however, it did not achieve statistical significance and was associated with increased variability. Indices of endothelial morphology, such as the coefficient of variation and hexagonality, were similar across the groups. Correlation and multivariable regression analyses indicated no significant independent relationship between HbA1c and central corneal thickness or endothelial cell density after controlling for age, sex, and duration of diabetes. The magnitude of the observed regression coefficients fell below thresholds deemed clinically significant. Uncontrolled diabetes is linked to subtle changes in corneal curvature and increased structural variability, rather than consistent alterations in corneal thickness or endothelial parameters. These results imply heterogeneous, subclinical corneal involvement in diabetes and underscore the multifactorial nature of diabetes-related corneal changes. Larger longitudinal studies are necessary to elucidate their clinical implications.

Keywords: *Diabetes mellitus, Corneal tomography, Endothelial cell density, Glycemic control, Specular microscopy*

Introduction

Diabetes mellitus (DM) represents a significant global public health issue and is a notable contributor to visual impairment. Although diabetic retinopathy is the most well-known ocular complication, growing evidence suggests that diabetes also impacts the anterior segment of the eye, particularly the cornea, even when advanced retinal disease is not present. These corneal changes may remain asymptomatic for extended durations but can have significant consequences for intraocular pressure assessment, refractive stability, contact lens compatibility, and surgical results, particularly for candidates undergoing cataract and refractive surgeries (Su et al., 2008; Varshney et al., 2024). The cornea is metabolically active and is particularly sensitive to chronic hyperglycemia. The mechanisms proposed to explain diabetes-related corneal alterations include the activation of the polyol pathway, the accumulation of advanced glycation end products, oxidative stress, and the dysfunction of the endothelial Na^+/K^+-ATPase pump. These metabolic disruptions can affect stromal hydration, collagen structure, and endothelial cell integrity, leading to observable changes in central corneal thickness (CCT) and endothelial morphology, which can be detected using modern imaging techniques (Su et al., 2008; Al-Sharkawy, 2015; Beato et al., 2020). Diabetes-related corneal involvement, commonly referred to as diabetic keratopathy, encompasses changes in corneal thickness and endothelial cell characteristics, including endothelial cell density (ECD), variability in cell size, and hexagonality. Numerous studies have indicated an increase in central corneal thickness (CCT) and a decrease in ECD among diabetic patients when compared to non-diabetic controls; however, the extent and consistency of these alterations differ significantly across various studies (Dardyr et al., 2024; Papadakou et al., 2020; Chowdhury et al., 2021; Pandey et al., 2024). Additionally, other researchers have identified correlations between changes in corneal endothelial cells and factors such as glycemic control, the duration of diabetes, or the severity of diabetic retinopathy. Conversely, some studies have reported negligible or statistically insignificant differences, especially in patients with well-managed diabetes (Çolak et al., 2021; Jha et al., 2022; Kim & Kim, 2021; Storr-Paulsen et al., 2014). Recent advancements in anterior segment imaging techniques, including Scheimpflug-based corneal tomography and non-contact specular microscopy, enable accurate and reproducible evaluations of corneal structure and endothelial morphology. These innovative technologies aid in the identification of subtle, subclinical corneal changes that may occur prior to the emergence of overt clinical symptoms (Beato et al., 2020; Taşlı et al., 2020). Such objective assessments present an opportunity to investigate early corneal modifications linked to glycemic dysregulation and to enhance our understanding of their potential clinical significance. Despite a growing body of research, the findings concerning the effects of glycemic control on corneal parameters remain inconsistent. Variations exist in imaging techniques, sample sizes, duration of disease, inclusion criteria, and analytical methods among studies. Notably, numerous investigations assess both eyes without sufficiently addressing the correlation between them or depend solely on statistical significance without presenting effect sizes, which limits clinical interpretability. Moreover, data pertaining to the Indian population are still relatively scarce, despite the significant prevalence of diabetes and its ocular complications (Kadri et al., 2021; Shankar et al., 2020; Chowdhury et al., 2021). These methodological discrepancies may lead to varied findings and uncertainty regarding the clinical relevance of the corneal changes observed. It is clinically significant to understand the potential differences in corneal parameters between individuals with controlled and uncontrolled diabetes, as even minor corneal changes can affect intraocular pressure readings, refractive results, and preoperative evaluations for cataract or refractive surgery (Su et al., 2008; Opala et al., 2025). Additionally, elucidating the relationship between corneal parameters, glycemic control, and diabetes duration may assist in contextualizing corneal findings as indicators of subclinical variability rather than clear structural damage (Geilani et al., 2023). Consequently, the current study aimed to compare corneal tomographic and endothelial parameters in patients with controlled versus uncontrolled diabetes mellitus utilizing Scheimpflug-based corneal tomography and non-contact specular microscopy, while also investigating the associations between corneal parameters, glycemic control (HbA1c), and diabetes duration. By employing a single-eye analytical method and reporting both statistical significance and effect sizes, this study aspires to deliver a methodologically sound and clinically interpretable assessment of corneal changes related to diabetes.

Materials and Methods

Study Design and Setting

This cross-sectional comparative study was carried out at the Department of Ophthalmology in Shree C.H. Nagri Hospital from April 2019 to February 2020. The aim of the study was to compare the corneal tomographic and endothelial parameters in diabetic patients with controlled and uncontrolled glycemic levels.

Ethical Approval and Informed Consent

The study protocol was granted approval following an evaluation by the Institutional Ethics Committee (IEC) at the research center. All procedures were carried out in accordance with the principles set forth in the Declaration of Helsinki. Before enrollment, written informed consent was obtained from all participants, and the confidentiality of participant data was maintained throughout the study period.

Study Population and Sampling Strategy

Individuals diagnosed with diabetes mellitus who attended the ophthalmology outpatient department during the study period were evaluated for eligibility. A total of 50 participants were selected through convenience sampling, following the predetermined inclusion and exclusion criteria, as well as the feasibility within the study timeframe.

Eligibility Criteria

The inclusion criteria consisted of individuals aged between 40 and 80 years, possessing a confirmed diagnosis of diabetes mellitus (either type 1 or type 2), having a minimum duration of diabetes of five years, and the availability of glycated haemoglobin (HbA1c) measurement conducted within the last three months. The exclusion criteria encompassed any pre-existing corneal conditions such as dystrophy, degeneration, scarring, ectasia, or active keratitis; a history of ocular trauma or ocular surgery (including refractive procedures); current or recent use of contact lenses within the last three months; corneal edema, uveitis, severe dry eye disease, or other ocular surface disorders that could compromise corneal integrity; the use of topical or systemic corticosteroids or other medications known to affect corneal structure; and an inability to cooperate during the examination or poor fixation leading to unreliable imaging.

Definition of Glycemic Control

Glycemic status was determined by HbA1c levels assessed within three months prior to the ophthalmic evaluation. Participants with HbA1c levels below 7.0% were categorized as having controlled diabetes, whereas those with HbA1c levels of 7.0% or higher were categorized as having uncontrolled diabetes. As a result, participants were separated into two groups: controlled diabetes (n = 25) and uncontrolled diabetes (n = 25).

Baseline Clinical and Demographic Data Collection

Demographic and clinical data were documented utilizing a structured case record form, which encompassed age, sex, type of diabetes, duration of diabetes, systemic medications, associated comorbidities, the most recent HbA1c value, and pertinent ocular history.

Ocular Examination Protocol

A thorough ophthalmic examination was conducted for all participants, which included assessments of visual acuity, slit-lamp biomicroscopy, and measurements of intraocular pressure. Corneal imaging was carried out under standardized lighting and fixation conditions. To reduce diurnal variation, all measurements were taken between 10:00 AM and 1:00 PM. Participants were advised to blink normally prior to image acquisition. For both corneal tomography and specular microscopy, three consecutive scans were performed. The scan of the highest quality, as indicated by the quality indices recommended by the manufacturer, was chosen for analysis. All examinations were carried out by a single trained examiner to minimize inter-observer variability.

Study Instruments and Parameters

Corneal Tomography: Corneal tomography based on the Scheimpflug principle was conducted utilizing the Sirius system (CSO, Italy). The parameters documented comprised flat keratometry (K1), steep keratometry (K2), mean keratometry (Km), central corneal thickness (CCT), the magnitude of corneal astigmatism, corneal volume (CV), and anterior chamber depth (ACD). Only scans that satisfied the quality acceptance criteria established by the manufacturer were considered.

Specular Microscopy: The evaluation of corneal endothelial cells was conducted utilizing non-contact specular microscopy (Topcon SP-1P, Japan). The endothelial parameters assessed comprised endothelial cell density (cells/mm^2), the coefficient of variation in cell size (polymegathism), the percentage of hexagonal cells (pleomorphism), and the average area of endothelial cells. Only images exhibiting distinctly defined cell borders and containing a minimum of 50 analyzable cells were deemed acceptable.

Outcome Measures

The primary outcome measures consisted of the variations in central corneal thickness and endothelial cell density between the groups with controlled diabetes and those with uncontrolled diabetes. The secondary outcome measures encompassed keratometric indices (K1, K2, and mean K), corneal astigmatism, corneal volume, anterior chamber depth, and indices of endothelial morphology.

Unit of Analysis and Handling of Inter-eye Correlation

To prevent the breach of statistical independence caused by inter-eye correlation, only one eye per participant was utilized for all primary inferential analyses. The right eye was predetermined for selection for all participants. Data from the other eye were examined descriptively to evaluate inter-eye consistency, but were excluded from hypothesis testing.

Handling of Missing or Poor-Quality Data

Participants lacking complete clinical data or exhibiting substandard corneal imaging were excluded before the analysis. No missing data were noted for the primary outcome variables among the participants included.

Sample Size Consideration

Given that this study was exploratory, the sample size was established based on feasibility throughout the study period. A formal a priori sample size calculation was not conducted. Consequently, effect size estimates were provided to facilitate interpretation and to guide future studies with sufficient power.

Results

Study Population and Unit of Analysis

A total of 50 patients diagnosed with diabetes mellitus participated in the study. To prevent the breach of statistical independence caused by inter-eye correlation, one eye from each participant was designated as the unit of analysis, with the right eye chosen a priori for all inferential statistics. Data from the fellow eye exhibited similar directional trends and are presented descriptively solely for the purpose of internal consistency. Participants were categorized into two groups: those with controlled diabetes (HbA1c < 7.0%; n = 25) and those with uncontrolled diabetes (HbA1c ≥ 7.0%; n = 25). The overall mean age of the participants was 60.8 ± 7.5 years, with no statistically significant differences observed between the groups regarding age, sex distribution, type of diabetes, or duration of diabetes (all p > 0.05). As anticipated based on the study design, HbA1c levels varied significantly between the groups (p < 0.001) (Table 1). The baseline comparability between the groups reduces the potential for confounding due to demographic factors and disease duration, thereby facilitating a meaningful comparison of corneal parameters.

Table 1. Baseline demographic and clinical characteristics (n = 50)

Variable	Controlled DM (n = 25)	Uncontrolled DM (n = 25)	p-value
Age (years), mean ± SD	60.1 ± 7.1	61.5 ± 7.9	0.48
Male sex, n (%)	11 (44%)	12 (48%)	0.77
Type 1 DM, n (%)	6 (24%)	7 (28%)	0.74
Type 2 DM, n (%)	19 (76%)	18 (72%)	0.74
Duration of DM (years), mean ± SD	10.9 ± 4.5	11.9 ± 5.3	0.47
HbA1c (%), mean ± SD	6.5 ± 0.3	9.1 ± 1.0	<0.001*

*****Statistically significant**.**

Corneal Tomographic Parameters (Scheimpflug-Based Tomography)

The comparison of corneal tomographic parameters between the controlled and uncontrolled diabetes groups is presented in Table 2. Flat keratometry (K1) was found to be significantly steeper in the uncontrolled diabetes group when compared to the controlled group (45.98 ± 1.72 D vs 44.06 ± 1.44 D; p = 0.003). The extent of this difference was moderate-to-large (Cohen's d = 1.22), suggesting potential clinical significance despite the relatively small sample size. Refer to Figure 1A & Figure 1B. No statistically significant differences were noted for steep keratometry, mean keratometry, central corneal thickness (CCT), anterior chamber depth (ACD), or corneal volume (all p > 0.05). Nevertheless, a greater variability in values, indicated by higher standard deviations, was consistently noted in the uncontrolled diabetes group, especially concerning CCT and corneal volume. See Figure 2A & Figure 2B. Additionally, refer to Figure 3A & Figure 3B. Variability differences were observed descriptively and were not formally assessed for variance equality. With the exception of flat keratometry, the tomographic parameters did not show significant differences between the groups. The combination of non-significant p-values, moderate effect sizes, and increased variability indicates potential subclinical heterogeneity that requires validation in larger, adequately powered studies, rather than indicating definitive structural changes.

Table 2. Corneal tomographic parameters (right eye) in controlled vs uncontrolled diabetes

Parameter	Controlled DM Mean ± SD	Uncontrolled DM Mean ± SD	p-value	Cohen's d
Flat K (D)	44.06 ± 1.44	45.98 ± 1.72	0.003*	1.22
Steep K (D)	45.63 ± 1.72	45.35 ± 2.49	0.48	0.13
Mean K (D)	44.51 ± 1.37	45.49 ± 1.57	0.08	0.66
CCT (µm)	540.48 ± 34.15	534.48 ± 49.13	0.52	0.14
ACD (mm)	3.31 ± 0.44	3.36 ± 0.34	0.69	0.13
Corneal Volume (mm³)	56.32 ± 3.08	56.44 ± 3.66	0.88	0.04

*Statistically significant.

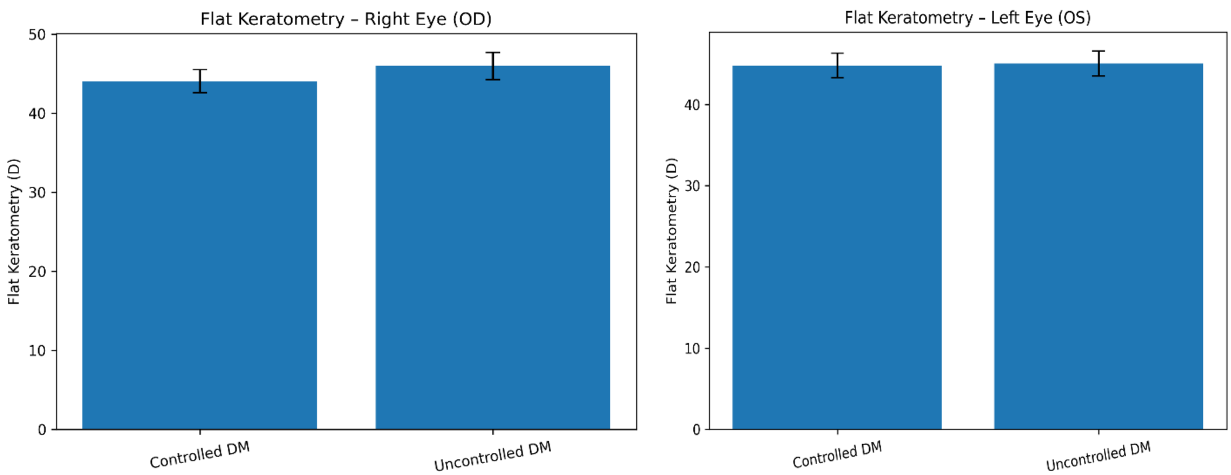

Figure 1A. A comparison of flat keratometry (K1) measurements in the right eye of patients with controlled versus uncontrolled diabetes. The results indicate that uncontrolled diabetes is associated with a significantly steeper corneal curvature ($p = 0.003$). The error bars illustrate the standard deviation.

Figure 1B. The flat keratometry measurements in the left eye reveal similar trends for both controlled and uncontrolled diabetes, although no statistically significant difference was observed.

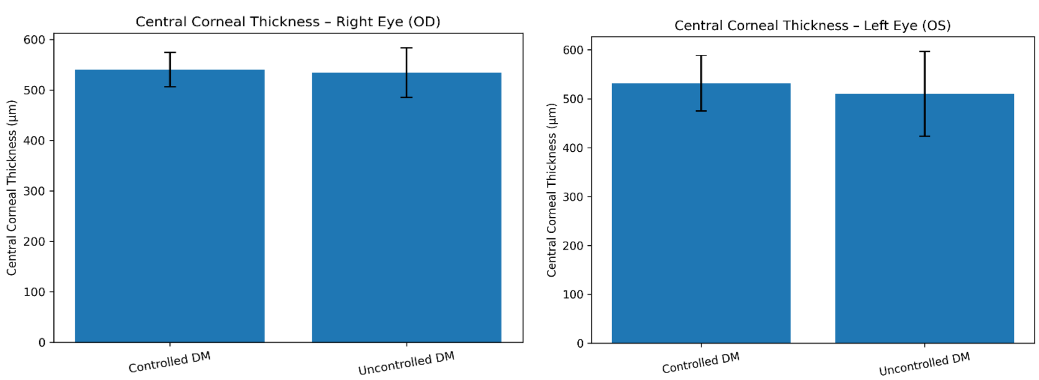

Figure 2A. The central corneal thickness in the right eye of both controlled and uncontrolled diabetic patients is presented. While the differences were not statistically significant, a higher degree of variability was noted in cases of uncontrolled diabetes.

Figure 2B. The central corneal thickness in the left eye shows a greater dispersion in uncontrolled diabetes when compared to controlled diabetes.

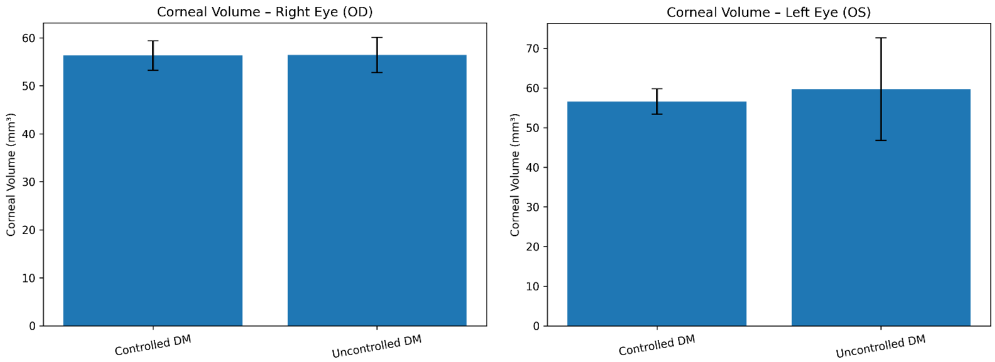

Figure 3A. Measurements of corneal volume in the right eye indicated no significant difference between controlled and uncontrolled diabetes.

Figure 3B. The corneal volume in the left eye exhibits considerable variability in cases of uncontrolled diabetes, implying heightened stromal heterogeneity.

Corneal Endothelial Parameters (Specular Microscopy)

Corneal endothelial parameters are detailed in Table 3. The endothelial cell density (ECD) was found to be numerically greater in the uncontrolled diabetes group compared to the controlled group (2601.96 ± 389.34 vs 2403.56 ± 218.83 cells/mm²); however, this difference did not achieve statistical significance ($p = 0.07$). The associated effect size was moderate (Cohen's d = −0.62), indicating a considerable overlap between the groups as shown in Figure 4A & Figure 4B. The higher ECD noted in the uncontrolled diabetes group should be interpreted with caution, as it likely indicates increased measurement variability, regional endothelial redistribution, or survivor bias rather than a genuine endothelial gain. No statistically significant differences were found in endothelial morphology indices, including the coefficient of variation, percentage of hexagonal cells, or mean cell area (all $p > 0.05$). Although endothelial morphology seemed to be preserved across glycemic groups, the combination of moderate effect size and increased variability in ECD suggests heterogeneous endothelial stress, which supports a hypothesis-generating rather than confirmatory interpretation.

Table 3. Corneal endothelial parameters (right eye) in controlled vs uncontrolled diabetes

Parameter	Controlled DM Mean ± SD	Uncontrolled DM Mean ± SD	p-value	Cohen's d
ECD (cells/mm²)	2403.56 ± 218.83	2601.96 ± 389.34	0.07	−0.62
Coefficient of variation (%)	32.1 ± 4.8	33.4 ± 5.1	0.33	0.26
Hexagonal cells (%)	56.8 ± 7.2	55.1 ± 6.8	0.28	0.24
Mean cell area (µm²)	418.2 ± 37.5	404.8 ± 39.6	0.19	0.35

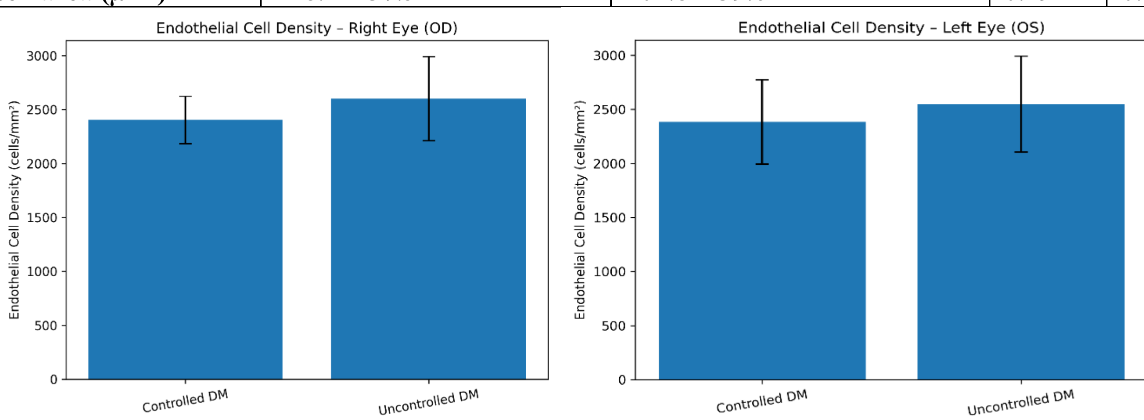

Figure 4A. The density of endothelial cells in the right eye of both controlled and uncontrolled diabetic patients. Although statistical significance was not achieved, a moderate effect size along with heightened variability was observed in cases of uncontrolled diabetes.

Figure 4B. The endothelial cell density in the left eye exhibits comparable directional trends across the groups, with distributions that overlap.

Correlation Analysis

Correlation analysis revealed weak negative correlations between HbA1c and endothelial cell density (r = −0.18, p = 0.21), as well as between HbA1c and central corneal thickness (r = −0.11, p = 0.44). The duration of diabetes also exhibited a weak negative correlation with endothelial cell density (r = −0.23, p = 0.10). However, none of these correlations achieved statistical significance (Table 4) (Figure 5). These results suggest that isolated glycemic status, indicated by HbA1c, may not independently influence corneal structural parameters and may rather reflect cumulative metabolic exposure.

Table 4. Correlation of glycemic control and diabetes duration with corneal parameters

Correlation	r	p-value
HbA1c vs ECD	−0.18	0.21
HbA1c vs CCT	−0.11	0.44
Duration of DM vs ECD	−0.23	0.10

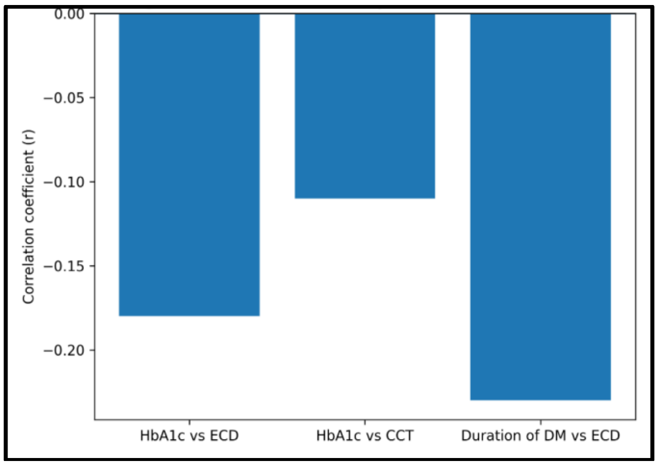

Figure 5. A summary of correlations depicting the relationship between glycemic control (HbA1c) and corneal parameters. Weak negative correlations were noted between HbA1c and endothelial cell density (r = −0.18, p = 0.21), as well as between HbA1c and central corneal thickness (r = −0.11, p = 0.44). Individual data points are omitted.

Multivariable Regression Analysis

Multivariable linear regression analysis, which adjusted for age, sex, and duration of diabetes, revealed that HbA1c was not an independent predictor of endothelial cell density (β = −12.6 cells/mm² for each 1% increase in HbA1c; 95% CI −33.5 to +8.2; p = 0.23). This effect is significantly lower than the threshold deemed clinically significant for endothelial impairment. After considering key demographic and disease-related variables, glycemic control did not exhibit a clinically or statistically significant independent relationship with endothelial cell density.

Discussion

This hospital-based cross-sectional study assessed corneal tomographic and endothelial parameters in diabetic patients categorized by glycemic control, employing a predefined single-eye analytical method and effect size reporting to improve methodological rigor. The results suggest that uncontrolled glycemia correlates with subtle and heterogeneous corneal changes, primarily manifested as alterations in corneal curvature and heightened structural variability, rather than consistent or overt anatomical differences. These findings lend support to a hypothesis-generating interpretation of corneal involvement related to diabetes, rather than indicating definitive structural compromise.

Corneal Curvature and Tomographic Parameters

The primary discovery of the current study was the notably steeper flat keratometry (K1) found in patients suffering from uncontrolled diabetes when compared to those with regulated glycemic levels. This variation was associated with a moderate-to-large effect size, indicating possible clinical significance despite the limited sample size. These results align with earlier studies that suggest chronic hyperglycemia may affect corneal stromal structure and biomechanical characteristics through non-enzymatic glycation of collagen fibers and the buildup of advanced glycation end products, resulting in changes to corneal curvature (Beato et al., 2020; Çolak et al., 2021). Conversely, steep keratometry, average keratometry, central corneal thickness, anterior chamber depth, and corneal volume did not show significant differences between the glycemic groups. Nevertheless, a greater variability in these parameters was consistently noted in patients with uncontrolled diabetes. This trend indicates a subclinical heterogeneity in the corneal response to chronic metabolic stress, rather than a uniform remodeling, and is consistent with previous Scheimpflug-based research that reported increased variability without consistent differences in mean values (Papadakou et al., 2020; Kadri et al., 2021; Pandey et al., 2024). It is crucial to note that these differences in variability were observed descriptively and were not formally assessed for equality of variance, thus they should be interpreted with caution.

Central Corneal Thickness

The central corneal thickness did not show a significant difference between diabetic patients with controlled and uncontrolled conditions, exhibiting only a minor effect size. These results align with previous research that has indicated inconsistent or weak correlations between glycemic control and corneal thickness (Su et al., 2008; Chowdhury et al., 2021; Storr-Paulsen et al., 2014). The lack of a significant relationship between HbA1c levels and central corneal thickness in this study further implies that corneal thickness may be indicative of cumulative metabolic exposure, endothelial functional reserve, and stromal hydration dynamics, rather than merely reflecting short-term glycemic status (El-Agamy & Alsubaie, 2017). Therefore, changes in central corneal thickness in diabetic patients should not be viewed as a direct indicator of current glycemic control.

Corneal Endothelial Parameters

The density of endothelial cells was found to be numerically greater in the group with uncontrolled diabetes; however, this difference did not achieve statistical significance. Analysis of effect size revealed a moderate degree of difference, accompanied by increased variability. This unexpected result should be interpreted with caution, as it likely indicates measurement variability, regional endothelial redistribution, or survivor bias rather than an actual increase in endothelial cells. Previous studies have reported similar heterogeneity in endothelial findings, despite an overarching trend indicating endothelial compromise in diabetes (Taşlı et al., 2020; Kim & Kim, 2021; Storr-Paulsen et al., 2014). Importantly, indices of endothelial morphology—including the coefficient of variation and hexagonality—did not show significant differences between the groups, implying a relative preservation of endothelial morphology across different glycemic levels. This finding corroborates earlier evidence suggesting that early or moderate metabolic dysregulation may preferentially impact corneal structure and function prior to presenting as consistent endothelial cell loss or pleomorphism (Beato et al., 2020; Papadakou et al., 2020).

Relationship Between Glycemic Control and Corneal Parameters

Correlation and multivariable regression analyses revealed no significant independent relationship between HbA1c and endothelial cell density or central corneal thickness after controlling for age, sex, and duration of diabetes. These results align with previous studies that have indicated weak or nonexistent correlations between HbA1c and corneal structural parameters (Çolak et al., 2021; Papadakou et al., 2020; Pandey et al., 2024). Notably, the regression coefficient observed for endothelial cell density was significantly lower than the thresholds deemed clinically relevant for endothelial impairment, indicating that the absence of statistical significance does not obscure a clinically relevant effect. In summary, these results reinforce the notion that corneal alterations related to diabetes are multifactorial and cumulative, shaped by the duration of the disease, metabolic memory, and individual susceptibility, rather than solely by isolated assessments of glycemic control.

Clinical Implications

The current findings highlight the significance of evaluating the anterior segment in diabetic patients, especially in those with inadequate glycemic control. Even minor changes in corneal curvature and heightened structural variability can affect the precision of intraocular pressure readings, refractive stability, contact lens compatibility, and preoperative evaluations for cataract or refractive surgery (Jha et al., 2022; Opala et al., 2025). Thus, integrating corneal tomography and endothelial assessments into standard diabetic eye care may assist in risk stratification and personalized clinical decision-making, particularly in surgical contexts.

Strengths and Limitations

The key strengths of this study encompass the utilization of advanced imaging techniques, standardized acquisition protocols, predefined management of inter-eye correlation, and the reporting of effect sizes in conjunction with traditional statistical testing. Nevertheless, it is important to recognize several limitations. These limitations consist of a relatively small sample size, a single-centre design, a cross-sectional approach, the inclusion of both type 1 and type 2 diabetes without a stratified analysis, and the lack of a non-diabetic control group. Although these factors restrict causal inference and generalizability, they do not undermine the internal consistency or methodological transparency of the associations observed.

Future Directions

Future longitudinal research involving larger and sufficiently powered cohorts is necessary to elucidate the temporal relationship between glycemic control and changes in corneal structure. The inclusion of non-diabetic control groups, assessments of corneal biomechanics, and stratification based on diabetes type and the severity of retinopathy may provide further insights into the mechanisms that contribute to corneal involvement in diabetes, as well as assist in establishing clinically significant thresholds for corneal changes.

Conclusion

In this cross-sectional study, it was found that uncontrolled diabetes mellitus correlated with subtle changes in corneal tomographic parameters, notably steeper flat keratometry, and exhibited greater structural variability when compared to controlled diabetes. Conversely, central corneal thickness and endothelial cell parameters did not show statistically significant differences across glycemic groups, and glycemic control (HbA1c) was not identified as an independent predictor of corneal thickness or endothelial cell density. These results indicate that corneal involvement related to diabetes may represent heterogeneous and subclinical structural variability instead of a uniform anatomical compromise, highlighting the multifactorial and cumulative aspects of corneal changes in diabetes. The lack of clinically significant associations between HbA1c and endothelial parameters further reinforces the need for careful interpretation of corneal findings concerning short-term glycemic status. Although the changes observed are modest, they could hold potential importance in certain clinical scenarios, such as intraocular pressure evaluation and preoperative planning for cataract or refractive surgery. There is a need for larger, longitudinal studies that include non-diabetic controls and advanced biomechanical assessments to elucidate the clinical significance and temporal progression of corneal changes associated with diabetes.

Acknowledgement

The authors express their heartfelt gratitude to all participants for their cooperation and readiness to contribute to this research. We also recognize the significant support provided by the clinical and technical staff at the Department of Ophthalmology, Shree C.H. Nagri Hospital, for their help with data collection and imaging procedures. This study did not receive any external funding. Conducted between April 2019 and February 2020, this hospital-based cross-sectional comparative study aimed to assess the differences in corneal tomographic and endothelial parameters between diabetic patients with controlled and uncontrolled glycemic status.

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Critical revision of manuscript: Dr. Helly Thakkar, Dr. Ankit Sanjay Varshney, Optom. Shraddha Gupta
Final approval of manuscript: All authors

Funding

No funding.

Conflict of interest

The author states that there are no conflicts of interest. The manuscript has not been submitted for publication in any other journal.

Ethics approval

Not applicable.

AI tool usage declaration

The authors not used any AI and related tools to write this manuscript.

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