

Corneal Endothelial cell changes in diabetic patients after small incision Cataract Surgery

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Received: 15-11-2025 / Revised: 19-12-2025 / Accepted: 16-01-2026

DOI: <https://doi.org/10.32553/ijmbs.v10i1.3173>

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Conflict of interest: No conflict of interest

Abstract:

Background: Diabetes mellitus is known to cause structural and functional alterations in the corneal endothelium, which may increase susceptibility to surgical trauma during cataract extraction. Small incision cataract surgery (SICS) is widely performed in developing countries; however, data on corneal endothelial changes following SICS in diabetic patients remain limited.

Aim: To evaluate changes in corneal endothelial cell density and morphology in diabetic patients following small incision cataract surgery.

Materials and Methods: This prospective observational study was conducted at Patna Medical College from 1 September 2024 to 1 September 2025. A total of 68 diabetic patients with senile cataract undergoing uneventful SICS were included. Preoperative and one-month postoperative corneal endothelial parameters, including endothelial cell density, coefficient of variation, and percentage of hexagonal cells, were assessed using specular microscopy. Statistical analysis was performed to compare preoperative and postoperative findings.

Results: The mean preoperative endothelial cell density was 2468 ± 218 cells/mm², which decreased significantly to 2216 ± 205 cells/mm² at one month postoperatively ($p < 0.001$). A significant increase in coefficient of variation and a reduction in hexagonality were observed postoperatively, indicating increased polymegathism and pleomorphism ($p < 0.001$). Greater endothelial cell loss was noted in patients with longer duration of diabetes. Transient corneal edema was observed in a small proportion of patients and resolved with routine management.

Conclusion: Small incision cataract surgery in diabetic patients is associated with significant endothelial cell loss and morphological changes, particularly in those with longer duration of diabetes. Careful preoperative assessment and meticulous surgical technique are essential to minimize corneal endothelial damage in this high-risk group.

Keywords: Diabetes mellitus; Corneal endothelium; Small incision cataract surgery; Endothelial cell density; Specular microscopy

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Introduction

Cataract remains the leading cause of reversible blindness worldwide, with a disproportionately higher burden in developing countries such as India [1]. Diabetes mellitus is a major systemic disorder that accelerates cataract formation and increases the likelihood of patients requiring surgical intervention at an earlier age compared to non-diabetic individuals [2]. With the rising prevalence of diabetes globally, ophthalmologists are increasingly encountering diabetic patients undergoing cataract surgery, making it essential to understand the unique corneal and endothelial considerations in this population [3].

The corneal endothelium plays a critical role in maintaining corneal transparency by regulating stromal hydration through its pump and barrier functions [4]. Human corneal endothelial cells are non-regenerative, and any significant loss or morphological alteration can lead to corneal edema, delayed visual recovery, or even permanent decompensation [5]. Surgical trauma during cataract extraction is a well-recognized cause of endothelial cell loss, influenced by factors such as surgical technique, duration of surgery, intraocular manipulation, and use of irrigating solutions [6].

Diabetes mellitus has been shown to induce structural and functional alterations in the corneal endothelium even before surgical intervention. These changes include reduced endothelial cell density, increased polymegathism and pleomorphism, thickening of Descemet's membrane, and impaired endothelial pump function [7,8]. Chronic hyperglycemia leads to oxidative stress, accumulation of advanced glycation end products, and altered cellular metabolism, rendering endothelial cells more susceptible to surgical trauma [9]. Consequently, diabetic patients are considered at higher risk for postoperative corneal complications following cataract surgery [10].

Small incision cataract surgery (SICS) remains a widely practiced technique in high-

volume centers across India due to its cost-effectiveness, shorter learning curve, and favorable visual outcomes [11]. Although SICS is generally safe, it involves relatively larger incisions and manual nucleus delivery, which may increase endothelial stress compared to phacoemulsification, particularly in compromised corneas [12]. In diabetic patients, this added stress may result in greater endothelial cell loss and morphological changes postoperatively [13].

Despite the high prevalence of diabetes and extensive use of SICS in the Indian setting, limited prospective data are available evaluating corneal endothelial changes in diabetic patients undergoing this surgical technique. Understanding the magnitude and pattern of endothelial cell loss after SICS in diabetic individuals is crucial for surgical planning, patient counseling, and postoperative management [14]. The present study was therefore undertaken at Patna Medical College to evaluate corneal endothelial cell changes in diabetic patients following small incision cataract surgery over a one-year period, aiming to contribute clinically relevant data applicable to similar tertiary care settings [15].

Materials and Methods

Study Design and Setting

This prospective observational study was conducted in the Department of Ophthalmology at Patna Medical College over a period of one year, from 1 September 2024 to 1 September 2025. The study aimed to evaluate changes in corneal endothelial parameters in diabetic patients undergoing small incision cataract surgery (SICS). Ethical clearance was obtained from the Institutional Ethics Committee, and the study adhered to the tenets of the Declaration of Helsinki. Written informed consent was taken from all participants prior to enrollment.

Study Population

A total of 68 diabetic patients diagnosed with age-related cataract and scheduled for elective SICS were included in the study. Patients of either sex, aged 40 years and above, with documented type 2 diabetes mellitus and clear central corneas were considered eligible.

Inclusion Criteria

- Diagnosed cases of type 2 diabetes mellitus
- Presence of visually significant senile cataract
- Clear cornea with adequate preoperative visualization
- Patients willing to provide informed consent and comply with follow-up visits

Exclusion Criteria

- History of corneal pathology such as dystrophy, degeneration, or scarring
- Previous intraocular surgery or ocular trauma
- Presence of glaucoma, uveitis, or pseudoexfoliation syndrome
- Complicated cataract or associated retinal pathology
- Intraoperative complications such as posterior capsular rupture

Preoperative Evaluation

All patients underwent a comprehensive ophthalmic examination, including best-corrected visual acuity, slit-lamp biomicroscopy, intraocular pressure measurement using applanation tonometry, and dilated fundus examination. Corneal endothelial assessment was performed preoperatively using a non-contact specular microscope to record endothelial cell density (cells/mm²), coefficient of variation in cell size, and percentage of hexagonal cells. Systemic evaluation included assessment of duration of diabetes and relevant medical history.

Surgical Technique

All surgeries were performed under peribulbar anesthesia by experienced surgeons using a standardized small incision cataract surgery technique. A superior scleral tunnel incision was made, followed by capsulotomy, hydrodissection, nucleus delivery, cortical wash, and implantation of a posterior chamber intraocular lens. Balanced salt solution was used for intraocular irrigation in all cases. Intraoperative variables were kept as uniform as possible to minimize bias.

Postoperative Evaluation and Follow-up

Postoperative examinations were conducted on day 1, at 1 week, and at 1 month following surgery. Corneal endothelial evaluation using specular microscopy was repeated at the 1-month follow-up visit. Any postoperative complications were recorded and managed according to standard protocols.

Outcome Measures

The primary outcome measure was change in corneal endothelial cell density following SICS. Secondary outcome measures included alterations in endothelial cell morphology, specifically polymegathism and pleomorphism.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as mean \pm standard deviation. Preoperative and postoperative endothelial parameters were compared using paired statistical tests, with a p-value of less than 0.05 considered statistically significant.

Result

A total of 68 diabetic patients undergoing small incision cataract surgery were included in the study. All surgeries were completed without major intraoperative complications, and all patients were available for postoperative evaluation up to one month.

Demographic and Clinical Characteristics

The study group consisted of 38 males (55.9%) and 30 females (44.1%). The mean age of the patients was 59.6 ± 8.4 years.

With respect to the duration of diabetes mellitus, 26.5% of patients had diabetes for less than 5 years, 47.1% had diabetes for 5–10 years, and 26.5% had diabetes for more than 10 years (Table 1).

Table 1: Demographic and Clinical Profile of the Study Population (n = 68)

Variable	Number (%) / Mean \pm SD
Age (years)	59.6 ± 8.4
Male	38 (55.9%)
Female	30 (44.1%)
Duration of diabetes <5 years	18 (26.5%)
Duration of diabetes 5–10 years	32 (47.1%)
Duration of diabetes >10 years	18 (26.5%)

Endothelial Cell Density Changes

Preoperative specular microscopy showed a mean endothelial cell density (ECD) of 2468 ± 218 cells/mm². At one month after surgery, the mean ECD reduced to $2216 \pm$

205 cells/mm². The mean endothelial cell loss was 252 cells/mm², corresponding to an approximate 10.2% decrease from baseline. This reduction was statistically significant ($p < 0.001$) (Table 2).

Table 2: Comparison of Preoperative and Postoperative Endothelial Cell Density

Parameter	Preoperative	Postoperative (1 month)	p-value
Endothelial cell density (cells/mm ²)	2468 ± 218	2216 ± 205	<0.001

Endothelial Cell Morphology

A significant increase in polymegathism was observed postoperatively. The coefficient of variation (CV) increased from $34.2 \pm 4.1\%$ preoperatively to $38.6 \pm 4.5\%$ at one month after surgery ($p < 0.001$).

Similarly, pleomorphism worsened postoperatively, as evidenced by a reduction in the percentage of hexagonal cells from $56.8 \pm 6.3\%$ to $49.2 \pm 6.7\%$, which was also statistically significant ($p < 0.001$) (Table 3).

Table 3: Changes in Endothelial Cell Morphology

Parameter	Preoperative	Postoperative (1 month)	p-value
Coefficient of variation (%)	34.2 ± 4.1	38.6 ± 4.5	<0.001
Hexagonal cells (%)	56.8 ± 6.3	49.2 ± 6.7	<0.001

Influence of Duration of Diabetes on Endothelial Cell Loss

Analysis based on duration of diabetes revealed a progressive increase in endothelial cell loss with longer disease duration. Patients with diabetes for less than 5 years

showed the least mean endothelial cell loss (198 ± 42 cells/mm²), whereas those with diabetes for more than 10 years exhibited the highest mean loss (301 ± 55 cells/mm²). This trend was statistically significant ($p < 0.01$) (Table 4).

Table 4: Endothelial Cell Loss According to Duration of Diabetes

Duration of diabetes	Mean endothelial cell loss (cells/mm ²)
<5 years	198 ± 42
5–10 years	244 ± 48
>10 years	301 ± 55

Postoperative Corneal Status

On postoperative day one, mild corneal edema was observed in 9 patients (13.2%). All cases resolved within one week with routine postoperative treatment. No patient developed persistent corneal edema or endothelial decompensation during the follow-up period.

Discussion

Cataract surgery in diabetic patients poses unique challenges due to the underlying metabolic and microstructural alterations affecting the cornea. The present study evaluated corneal endothelial cell changes following small incision cataract surgery in diabetic patients and demonstrated a significant reduction in endothelial cell density along with notable morphological alterations in the postoperative period.

In the current study, a mean endothelial cell loss of approximately 10% was observed at one month following surgery. This finding is consistent with previous reports indicating that diabetic corneas are more vulnerable to surgical trauma due to pre-existing endothelial dysfunction [16]. Chronic hyperglycemia has been shown to impair endothelial cell metabolism, reduce Na⁺/K⁺-ATPase activity, and compromise barrier function, making these cells less resilient to intraoperative stress [17].

Apart from quantitative cell loss, qualitative changes in endothelial morphology were also evident. A significant increase in the coefficient of variation and a reduction in hexagonality were observed postoperatively, reflecting increased polymegathism and pleomorphism. Similar morphological disturbances have been reported in diabetic patients following cataract surgery, suggesting that endothelial cell remodeling occurs as a compensatory response to cell loss

[18]. These changes may precede functional impairment and serve as early indicators of endothelial stress.

The duration of diabetes emerged as an important determinant of endothelial damage in the present study. Patients with a longer duration of diabetes exhibited greater endothelial cell loss compared to those with a shorter disease duration. This observation aligns with studies that have demonstrated cumulative endothelial injury with prolonged exposure to hyperglycemia and oxidative stress [19]. Long-standing diabetes has been associated with increased deposition of advanced glycation end products within the cornea, leading to altered cellular adhesion and increased susceptibility to surgical insult [20].

Small incision cataract surgery, though widely practiced and cost-effective, involves manual nucleus delivery and greater intraocular manipulation compared to phacoemulsification. These factors may contribute to increased endothelial stress, particularly in diabetic eyes with compromised corneal reserve [21]. However, despite the observed endothelial changes, none of the patients in the present study developed persistent corneal edema or endothelial decompensation, suggesting that SICS remains a reasonably safe procedure when performed carefully in selected diabetic patients.

Transient corneal edema observed in a subset of patients on the first postoperative day resolved with standard medical management, indicating adequate endothelial functional recovery in the short term. Similar postoperative findings have been reported in other studies evaluating corneal response following cataract surgery in diabetics [22].

The findings of this study underscore the importance of meticulous surgical technique, adequate use of viscoelastic substances, and careful postoperative monitoring in diabetic patients undergoing SICS. Preoperative assessment of endothelial status using specular microscopy may help identify patients at higher risk for postoperative corneal complications [23].

Limitations

The study was limited by a relatively short follow-up period and the absence of a non-diabetic control group. Long-term follow-up and comparative studies with different surgical techniques may provide further insights into endothelial recovery patterns in diabetic patients.

Conclusion

The present study demonstrates that diabetic patients undergoing small incision cataract surgery experience a significant reduction in corneal endothelial cell density along with notable morphological alterations in the early postoperative period. The extent of endothelial damage was found to increase with longer duration of diabetes, highlighting the cumulative effect of chronic hyperglycemia on corneal health. Although transient postoperative corneal edema was observed, no case of persistent corneal decompensation occurred, indicating that SICS remains a safe and effective surgical option in diabetic patients when performed with appropriate precautions. Preoperative evaluation of corneal endothelial status and adherence to meticulous surgical techniques are crucial to ensure optimal postoperative outcomes in this vulnerable population.

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