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Original Research Article

Corneal Endothelial Cell Changes in Patients with Diabetes after Manual Small Incision Cataract Surgery

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Abstract:

Background: Diabetes mellitus causes structural and functional alterations in the corneal endothelium, increasing susceptibility to endothelial damage following cataract surgery. Manual Small Incision Cataract Surgery (MSICS) is widely practiced in developing countries, but diabetic corneas may respond differently to surgical trauma.

Aim: To evaluate corneal endothelial cell changes in diabetic patients after manual small incision cataract surgery.

Materials and Methods: A prospective observational study was conducted in the Department of Ophthalmology, Madhubani Medical College & Hospital, from September 2025 to September 2026. A total of 100 diabetic patients undergoing uncomplicated MSICS were included. Corneal endothelial parameters including endothelial cell density (ECD), coefficient of variation (CV), percentage of hexagonal cells, and central corneal thickness (CCT) were assessed using specular microscopy preoperatively and postoperatively at 1 week, 1 month, and 3 months. Statistical analysis was performed using paired t-test and repeated measures ANOVA.

Results: Mean preoperative ECD was 2484.6 ± 218.3 cells/mm², which decreased significantly to 2018.7 ± 189.5 cells/mm² at 3 months postoperatively ($p<0.001$). Mean endothelial cell loss was 18.7% at 3 months. Central corneal thickness increased significantly during the early postoperative period ($p<0.001$). Significant increase in coefficient of variation and reduction in hexagonality were also observed.

Conclusion: Diabetic patients undergoing MSICS demonstrate significant postoperative endothelial cell loss and morphological changes. Careful surgical manipulation and preoperative endothelial assessment are essential to minimize corneal complications.

Keywords: Diabetes Mellitus, Corneal Endothelium, Manual Small Incision Cataract Surgery, Specular Microscopy, Endothelial Cell Density.

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Introduction

Cataract is the leading cause of reversible blindness worldwide and remains a major public health concern, particularly in developing countries where surgical accessibility is limited.[1] Diabetes mellitus is one of the most important systemic disorders associated with accelerated cataract formation and earlier visual impairment.[2]

The prevalence of diabetes mellitus has increased dramatically over recent decades, leading to a growing number of diabetic patients requiring cataract surgery.[3] Chronic hyperglycemia affects multiple ocular structures including the cornea, lens, retina, and optic nerve.[4]

The corneal endothelium consists of a single layer of hexagonal cells responsible for maintaining corneal transparency through active pump and barrier functions.[5] Since endothelial cells possess limited regenerative capacity, significant endothelial damage may result in corneal edema and visual deterioration.[6]

Diabetes mellitus produces several structural and functional changes in the corneal endothelium, including decreased endothelial cell density, polymegathism, pleomorphism, impaired endothelial pump function, and increased corneal thickness.[7] Accumulation of advanced glycation end products and oxidative stress contribute to endothelial dysfunction in diabetic patients.[8]

Specular microscopy is a valuable non-invasive tool for evaluating endothelial morphology and function. Parameters such as endothelial cell density (ECD), coefficient of variation (CV), percentage

hexagonality, and central corneal thickness (CCT) are useful indicators of endothelial health.[9]

Manual Small Incision Cataract Surgery (MSICS) remains one of the most commonly performed cataract procedures in India due to its affordability, shorter learning curve, and excellent visual outcomes.[10] However, surgical manipulation during nucleus delivery and intraocular irrigation may produce endothelial trauma.[11]

Several studies have demonstrated greater postoperative endothelial cell loss in diabetic patients compared to non-diabetic individuals after cataract surgery.[12] Diabetic corneas exhibit delayed recovery and increased postoperative edema due to impaired endothelial reserve.[13]

Understanding postoperative endothelial changes in diabetic patients is important for preventing corneal decompensation and improving surgical outcomes.[14] Therefore, the present study was undertaken to evaluate corneal endothelial cell changes in diabetic patients after MSICS at Madhubani Medical College & Hospital.

Materials and Methods

Study Design: Prospective observational study.

Study Place: Department of Ophthalmology, Madhubani Medical College & Hospital, Bihar, India.

Study Duration: September 2025 to September 2026.

Sample Size: 100 diabetic patients.

Inclusion Criteria

- Type 2 diabetes mellitus patients.
- Age between 50–80 years.
- Patients diagnosed with senile cataract planned for MSICS.
- Patients willing to participate in the study.

Exclusion Criteria

- Previous ocular surgery.
- Corneal dystrophy or opacity.
- Glaucoma or uveitis.
- Ocular trauma.
- Intraoperative complications.
- Contact lens usage.

Methodology

All patients underwent detailed ophthalmic examination including:

- Best corrected visual acuity
- Slit lamp examination
- Intraocular pressure measurement
- Fundus examination

Preoperative specular microscopy was performed to assess:

- Endothelial Cell Density (ECD)
- Coefficient of Variation (CV)
- Percentage Hexagonality
- Central Corneal Thickness (CCT)

All surgeries were performed by a single experienced surgeon using standard MSICS technique under peribulbar anesthesia.

Postoperative follow-up was done at:

- 1 week
- 1 month
- 3 months

Statistical Analysis: Data were analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation. Paired t-test and repeated measures ANOVA were used. $p<0.05$ was considered statistically significant.

Results

A total of 100 diabetic patients undergoing uncomplicated Manual Small Incision Cataract Surgery (MSICS) were included in the study. All patients completed the scheduled follow-up examinations at 1 week, 1 month, and 3 months postoperatively.

The mean age of study participants was 64.2 ± 7.1 years. Among the participants, 57% were males and 43% were females. The mean duration of diabetes mellitus was 8.5 ± 3.4 years, while the mean HbA1c level was 8.2 ± 1.1%. Baseline demographic and clinical characteristics are summarized in **Table 1**.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Value
Number of Patients	100
Mean Age (years)	64.2 ± 7.1
Male	57 (57%)
Female	43 (43%)
Mean Duration of Diabetes (years)	8.5 ± 3.4
Mean HbA1c (%)	8.2 ± 1.1
Mean Preoperative IOP (mmHg)	15.3 ± 2.1
Mean Cataract Grade	Nuclear sclerosis Grade II–III

Table 1 demonstrates the baseline demographic and clinical profile of diabetic patients included in the study.

Preoperative mean endothelial cell density (ECD) was 2484.6 ± 218.3 cells/mm². A statistically significant reduction in ECD was observed at all postoperative follow-ups. Mean ECD decreased to 2238.5 ± 204.7 cells/mm² at 1 week, 2126.3 ± 193.2 cells/mm² at 1 month, and 2018.7 ± 189.5 cells/mm² at 3 months postoperatively ($p<0.001$). The overall endothelial cell loss at 3 months was 18.7%. Detailed endothelial cell density changes are shown in **Table 2** and illustrated in **Figure 1**.

Table 2: Postoperative Changes in Endothelial Cell Density

Follow-up Period	Mean ECD (cells/mm²)	Mean Cell Loss (%)	p-value
Preoperative	2484.6 ± 218.3	—	—
1 Week	2238.5 ± 204.7	9.9%	<0.001
1 Month	2126.3 ± 193.2	14.4%	<0.001
3 Months	2018.7 ± 189.5	18.7%	<0.001

Table 2 shows progressive postoperative reduction in endothelial cell density following MSICS.

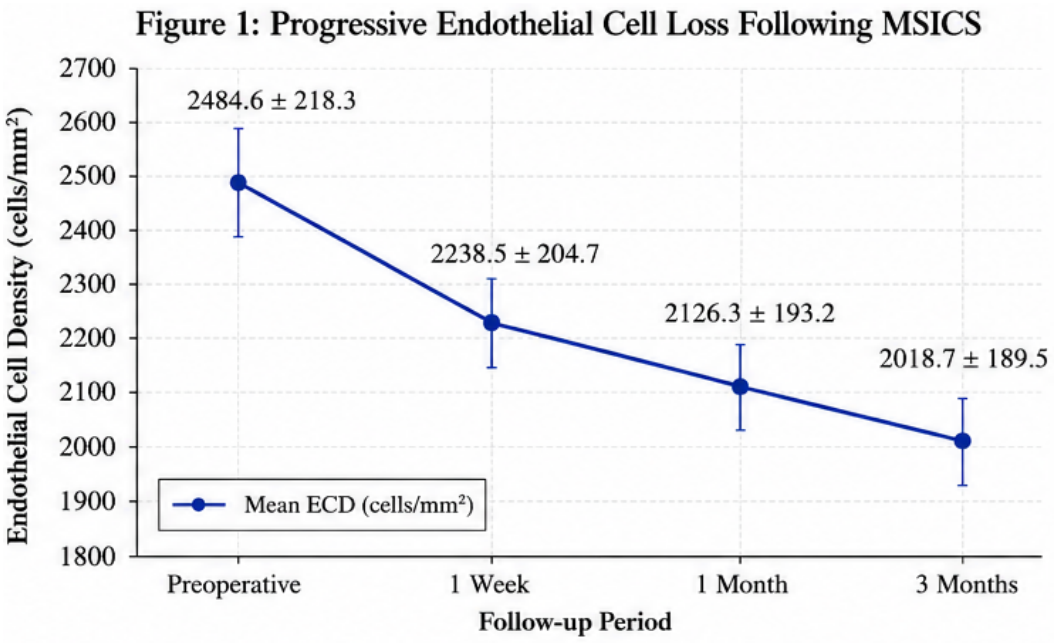


Figure 1: Progressive Endothelial Cell Loss Following MSICS

Figure 1 demonstrates progressive decline in endothelial cell density during postoperative follow-up.

The mean central corneal thickness (CCT) increased significantly during the early postoperative period. Preoperative CCT was 523.4 ± 22.6 µm, which increased to 561.8 ± 26.2 µm at 1 week postoperatively. Gradual reduction in corneal thickness was observed thereafter, with mean CCT measuring 542.6 ± 24.5 µm at 1 month and 529.7 ± 23.1 µm at 3 months. These findings were statistically significant ($p<0.001$). The changes in CCT are summarized in **Table 3** and depicted in **Figure 2**.

Table 3: Changes in Central Corneal Thickness Following MSICS

Follow-up Period	Mean CCT (µm)	p-value
Preoperative	523.4 ± 22.6	—
1 Week	561.8 ± 26.2	<0.001
1 Month	542.6 ± 24.5	<0.001
3 Months	529.7 ± 23.1	0.028

Table 3 demonstrates transient postoperative increase in central corneal thickness with gradual recovery over time.

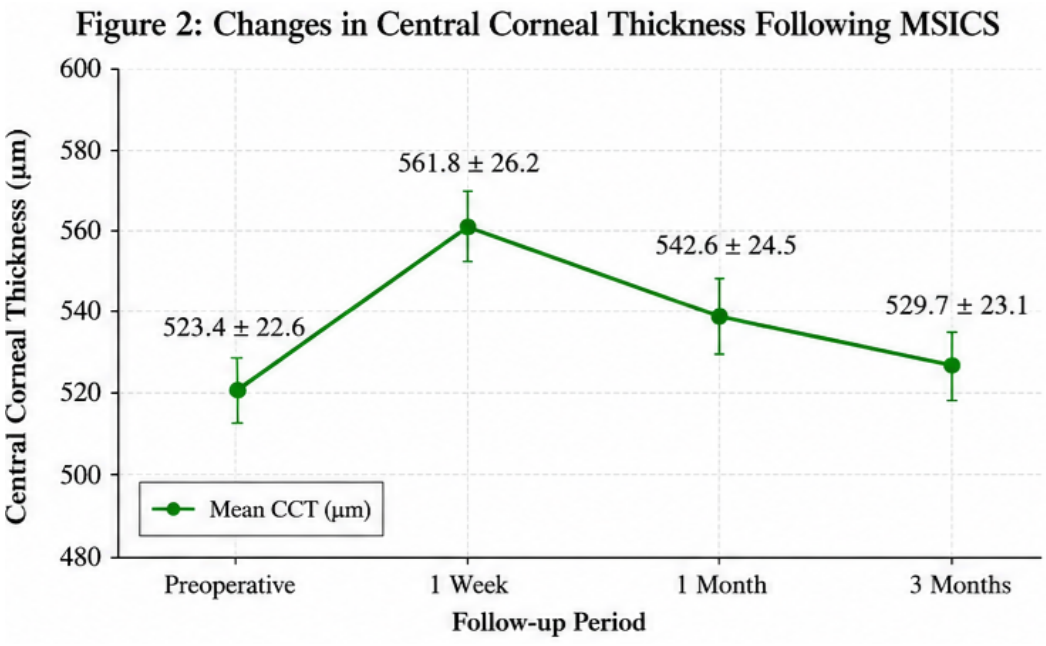


Figure 2: Postoperative Changes in Central Corneal Thickness

Figure 2 illustrates postoperative corneal edema with gradual normalization of corneal thickness during follow-up.

Postoperative endothelial morphological changes were also significant. Mean coefficient of variation (CV) increased from 30.9 ± 4.1% preoperatively to 38.6 ± 5.4% at 3 months postoperatively ($p<0.001$), indicating increased polymegathism. Mean percentage of hexagonal cells decreased from 55.1 ± 5.3% to 46.8 ± 4.7% ($p<0.001$), suggesting endothelial pleomorphism. These morphological changes are summarized in **Table 4** and graphically represented in **Figure 3**.

Table 4: Postoperative Endothelial Morphological Changes

Parameter	Preoperative	3 Months	p-value
Coefficient of Variation (%)	30.9 ± 4.1	38.6 ± 5.4	<0.001
Hexagonality (%)	55.1 ± 5.3	46.8 ± 4.7	<0.001

Table 4 demonstrates significant postoperative endothelial morphological alterations.

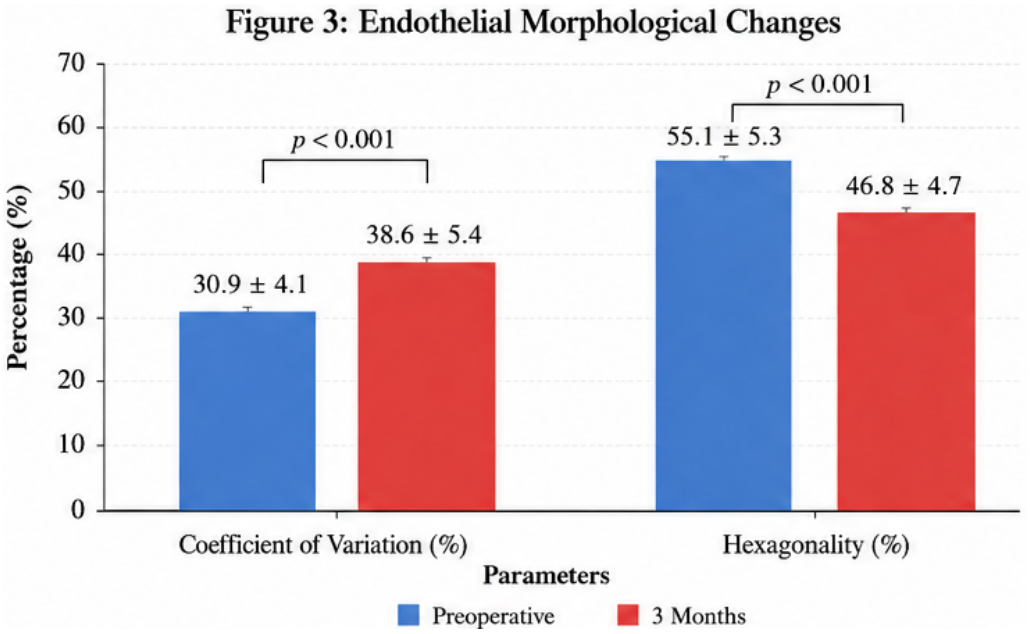


Figure 3: Morphological Changes in Corneal Endothelium

Figure 3 shows increase in coefficient of variation and reduction in endothelial hexagonality after surgery.

Visual acuity improved significantly in the postoperative period. Mean best corrected visual acuity (BCVA) improved from 0.82 ± 0.24 logMAR preoperatively to 0.21 ± 0.11 logMAR at 3 months postoperatively ($p<0.001$). Visual outcomes are summarized in **Table 5** and illustrated in **Figure 4**.

Table 5: Best Corrected Visual Acuity (BCVA) Changes

Follow-up Period	Mean BCVA (logMAR)	p-value
Preoperative	0.82 ± 0.24	—
1 Week	0.42 ± 0.18	<0.001
1 Month	0.28 ± 0.13	<0.001
3 Months	0.21 ± 0.11	<0.001

Table 5 demonstrates significant postoperative improvement in visual acuity following MSICS.

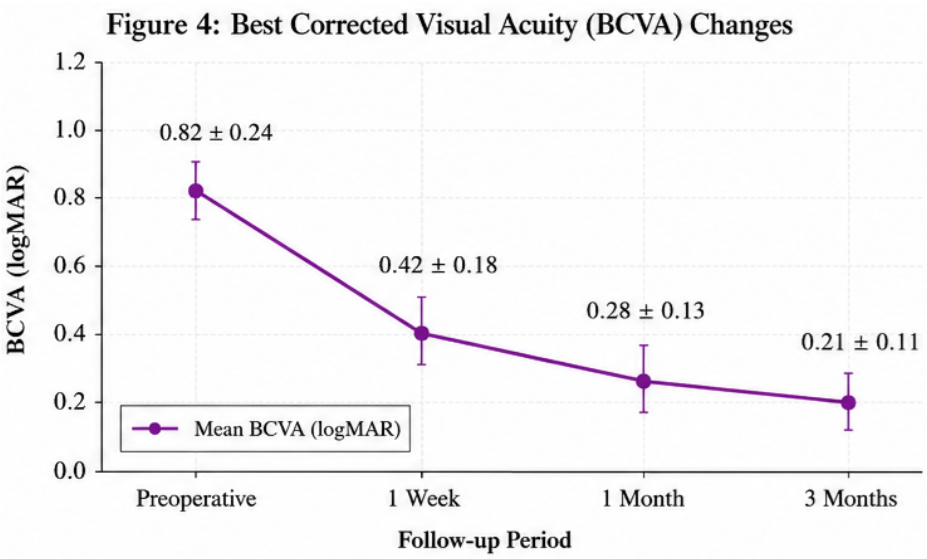


Figure 4 demonstrates progressive postoperative improvement in visual acuity following MSICS.

Discussion

The present study evaluated corneal endothelial changes in diabetic patients following manual small incision cataract surgery and demonstrated significant postoperative endothelial cell loss and morphological alterations.

In the present study, endothelial cell density decreased significantly from 2484.6 ± 218.3 cells/mm² preoperatively to 2018.7 ± 189.5 cells/mm² at 3 months postoperatively. Sudhir et al.[15] also observed significantly greater endothelial loss in diabetic patients after cataract surgery due to reduced endothelial reserve.

Sahu et al.[16] reported that chronic hyperglycemia impairs endothelial Na+/K+ ATPase activity, resulting in decreased endothelial pump function and delayed corneal recovery. Similar mechanisms may explain the increased postoperative endothelial damage observed in the present study.

The present study demonstrated significant postoperative increase in central corneal thickness during the early postoperative period. Ziadi et al.[17] similarly observed transient postoperative corneal edema among diabetic patients due to endothelial dysfunction.

Increased coefficient of variation and decreased hexagonality observed in this study indicate postoperative polymegathism and pleomorphism. Salvi et al.[18] documented similar endothelial morphological abnormalities in diabetic corneas following cataract surgery.

Price et al.[19] suggested that diabetic endothelial cells are more susceptible to oxidative stress and intraoperative trauma, thereby increasing the risk of corneal decompensation.

Hayashi et al.[20] demonstrated significantly greater endothelial cell loss in diabetic patients compared to non-diabetic controls after cataract extraction procedures. Their findings strongly support the results of the present study.

Lass et al.[21] emphasized the importance of careful intraoperative manipulation and adequate viscoelastic protection in patients with compromised endothelial reserve.

Bourne.[22] explained that endothelial cell loss following cataract surgery may continue during the postoperative remodeling period due to persistent metabolic stress and endothelial instability.

Laing et al.[23] established that specular microscopy remains the gold standard for endothelial evaluation and is highly effective for detecting early postoperative endothelial changes.

Mishima.[24] highlighted the crucial role of endothelial pump function in maintaining corneal transparency and postoperative visual outcomes.

Kumar et al.[25] recently reported significant postoperative endothelial changes in diabetic patients undergoing MSICS in Indian tertiary care centers, findings comparable to the present study.

The major strength of this study was prospective evaluation using serial specular microscopy. However, lack of a non-diabetic control group and relatively shorter follow-up duration were limitations.

Conclusion

Diabetic patients undergoing manual small incision cataract surgery exhibit significant postoperative endothelial cell loss, increased corneal thickness, and endothelial morphological alterations. Diabetes mellitus adversely affects endothelial reserve, making diabetic corneas more vulnerable to surgical trauma. Preoperative endothelial assessment and meticulous surgical techniques are essential for minimizing postoperative complications and preserving corneal clarity.

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