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A Comparative Longitudinal Study On Changes In Corneal Endothelial Cell Count And Central Corneal Thickness In Patients With And Without Diabetes Mellitus After Manual Small Incision Cataract Surgery In A Tertiary Care Centre In Mandya

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A B S T R A C T

Background: Diabetes mellitus may affect corneal endothelial health, potentially impacting outcomes of cataract surgery.***Objective***: To compare changes in corneal endothelial cell count and central corneal thickness (CCT) after manual small incision cataract surgery (SICS) in patients with and without diabetes.***Methods***: This prospective study included 50 diabetic and 50 non-diabetic patients undergoing manual SICS. Corneal endothelial cell density and CCT were measured preoperatively and at day 1, week 1, and month 1 postoperatively. ***Results****:* At one month post-surgery, diabetic patients showed significantly greater endothelial cell loss (14.6% vs. 10.3%, p=0.003) and CCT increase (2.2% vs. 1.1%, p=0.025) compared to non-diabetic patients. Age (β=-5.2, p=0.004), presence of diabetes (β=-78.3, p=0.002), and HbA1c levels (β=-28.7, p=0.012) were significant predictors of endothelial cell loss. Visual acuity outcomes were similar between groups (0.18 ± 0.12 vs. 0.15 ± 0.10 logMAR, p=0.161), but diabetic patients showed a trend towards more complications. ***Conclusion***: Diabetic patients experience greater corneal endothelial cell loss and increased CCT following manual SICS compared to non-diabetic patients. These findings highlight the need for careful consideration of diabetes in preoperative assessment and postoperative management of cataract surgery patients.

Keywords: Diabetes mellitus, cataract surgery, corneal endothelium, central corneal thickness, small incision cataract surgery.

INTRODUCTION

Cataract, a clouding of the normally clear lens of the eye, is a leading cause of visual impairment and blindness worldwide [1]. The global prevalence of cataract is estimated to increase from 95 million in 2014 to 125 million by 2050 [2]. Cataract surgery, involving the removal of the opaque lens and implantation of an artificial intraocular lens (IOL), is the most effective treatment for cataract-related visual impairment [3]. Manual small incision cataract surgery (MSICS) is a widely practiced surgical technique, particularly in developing countries, due to its cost-effectiveness and comparable outcomes to phacoemulsification [4].

The corneal endothelium, a single layer of hexagonal cells on the posterior surface of the cornea, plays a crucial role in maintaining corneal transparency by regulating corneal hydration [5]. These cells have limited regenerative capacity, and their loss or damage can lead to corneal edema and loss of visual acuity [6]. Cataract surgery can cause corneal endothelial cell loss due to various factors such as surgical trauma, ultrasound energy, irrigating solutions, and mechanical contact with instruments [7]. Therefore, assessing corneal endothelial cell density (ECD) and central corneal thickness (CCT) is essential for evaluating the impact of cataract surgery on corneal health and visual outcomes.

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both [8]. DM is a significant risk factor for cataract development and progression, with diabetic patients having a higher prevalence and earlier onset of cataract compared to non-diabetic individuals [9]. Moreover, DM can cause morphological and functional changes in the corneal endothelium, such as polymegathism (cell size variability), pleomorphism (cell shape variation), and increased CCT [10]. These alterations may render the corneal endothelium more susceptible to surgical stress and affect postoperative corneal recovery in diabetic patients undergoing cataract surgery.

Several studies have investigated the impact of cataract surgery on corneal endothelial parameters in diabetic and non-diabetic patients. A prospective study by Hugod*et al.*, found that diabetic patients had a significantly higher endothelial cell loss compared to non-diabetic controls at 3 months after phacoemulsification cataract surgery (10.8% vs. 7.2%, p=0.032) [11]. Similarly, Morikubo*et al.*, reported a greater decrease in ECD and increase in CCT in diabetic patients compared to non-diabetic patients at 1 month after cataract surgery [12]. However, conflicting results have been reported by other studies. For instance, a retrospective study by Wang *et al.*, found no significant difference in ECD loss between diabetic and non-diabetic patients at 1 month (9.0% vs. 6.9%, p=0.164) and 3 months (11.7% vs. 9.4%, p=0.213) after phacoemulsification [13].

While previous studies have provided valuable insights into the impact of cataract surgery on corneal endothelium in diabetic patients, there is limited literature comparing the longitudinal changes in ECD and CCT between diabetic and non-diabetic patients undergoing MSICS. Moreover, the existing studies have reported inconsistent findings, warranting further investigation. Therefore, this study aims to compare the changes in ECD and CCT in patients with and without DM after MSICS in a tertiary care center in Mandya, India. The findings of this study may help in understanding the differential impact of MSICS on corneal endothelium in diabetic and non-diabetic patients, guiding preoperative risk assessment, surgical planning, and postoperative management.

Aims and Objectives

The primary aim of this study was to assess and compare the changes in corneal endothelial cell count and central corneal thickness (CCT) after manual small incision cataract surgery (SICS) in patients with and without diabetes mellitus. Specifically, the researchers sought to evaluate the endothelial cell loss and alterations in CCT following SICS in diabetic patients compared to age-matched non-diabetic patients. The study aimed to provide insights into the stability and vulnerability of the corneal endothelium in these two patient groups, with the ultimate goal of avoiding postoperative corneal damage and reducing corneal edema to maintain normal corneal function.

Materials and Methods

Study Design and Setting This was a descriptive longitudinal study conducted from September 2022 to January 2023 at the Department of Ophthalmology in a tertiary care center in Mandya, India. The study population consisted of cataract patients visiting the outpatient department who met the inclusion criteria.

Sample Size and Sampling

The sample size was calculated based on a previous study that found a significant change in CCT in the diabetic group. Using the formula N = (Z^2 σ^2)/d^2, where Z = 1.96, σ (standard deviation of CCT) = 33.6, and d (absolute error) = 10%, the calculated sample size was 44, which was rounded up to 50 per group. Thus, a total of 100 patients were included in the study: 50 cataract patients with diabetes and 50 age-matched cataract patients without diabetes.

Inclusion and Exclusion Criteria

The study included patients over 50 years of age with immature cataracts who consented to participate. Both diabetic and non-diabetic patients were included. Exclusion criteria encompassed anterior segment eye diseases (e.g., anterior uveitis, glaucoma, high myopia, or spontaneous lens subluxation/dislocation), history of trauma leading to traumatic cataract or lens displacement, corneal abnormalities (e.g., opacity, degeneration, dystrophies, or scarring), posterior segment eye diseases except diabetic retinopathy, and poor fixation or lack of cooperation during examination.

Data Collection and Examination Procedures

All patients underwent a comprehensive preoperative ophthalmic examination, including visual acuity assessment, slit lamp biomicroscopy, fundus examination by indirect ophthalmoscopy, intraocular pressure measurement using non-contact tonometry, and biometry for intraocular lens power calculation. Blood glucose tests were performed on all patients to identify undetected diabetes, and glycosylated hemoglobin tests were conducted for diabetic patients to assess glycemic control.

The key outcome measures - corneal endothelial cell count and central corneal thickness - were assessed using non-contrast specular microscopy. These measurements were taken preoperatively and postoperatively at day 1, week 1, and 1 month after surgery.

Data Analysis

The collected data was entered into Microsoft Excel sheets and analyzed using the trial version of SPSS software. Descriptive statistics, including frequency and percentage, were used to summarize the data. Quantitative data was represented as mean ± standard deviation. The unpaired t-test was employed to compare quantitative data between the two groups (diabetic and non-diabetic patients).

RESULTS

The study included 100 patients undergoing manual small incision cataract surgery, equally divided between diabetic (n=50) and non-diabetic (n=50) groups. As shown in Table 1, there were no significant differences in baseline characteristics between the two groups, including age (65.3 ± 7.2 vs. 64.8 ± 6.9 years, p=0.721), sex distribution (27/23 vs. 25/25 male/female, p=0.689), preoperative visual acuity (0.82 ± 0.24 vs. 0.79 ± 0.22 logMAR, p=0.513), and preoperative intraocular pressure (14.7 ± 2.8 vs. 14.3 ± 2.5 mmHg, p=0.458). The mean HbA1c level in the diabetic group was 7.2 ± 0.9%, with an average diabetes duration of 8.4 ± 4.7 years.

Preoperative corneal measurements (Table 2) revealed no statistically significant differences between the diabetic and non-diabetic groups in terms of endothelial cell density (2456 ± 241 vs. 2512 ± 228 cells/mm², p=0.231) or central corneal thickness (542 ± 28 vs. 535 ± 26 µm, p=0.194).

Postoperative corneal endothelial cell density changes (Table 3) showed a more pronounced decrease in the diabetic group compared to the non-diabetic group at all time points. The difference was statistically significant at day 1 (2187 ± 263 vs. 2298 ± 245 cells/mm², p=0.029), week 1 (2134 ± 278 vs. 2276 ± 251 cells/mm², p=0.008), and month 1 (2098 ± 285 vs. 2254 ± 257 cells/mm², p=0.003). The percentage of endothelial cell loss at one month was higher in the diabetic group (14.6%) compared to the non-diabetic group (10.3%).

Central corneal thickness changes (Table 4) also demonstrated significant differences between the two groups. The diabetic group experienced greater corneal thickening at all postoperative time points: day 1 (583 ± 35 vs. 561 ± 31 µm, p=0.001), week 1 (568 ± 32 vs. 549 ± 29 µm, p=0.002), and month 1 (554 ± 30 vs. 541 ± 27 µm, p=0.025). The percentage increase in central corneal thickness at one month was 2.2% in the diabetic group compared to 1.1% in the non-diabetic group.

Correlation analysis (Table 5) revealed significant associations between preoperative factors and endothelial cell loss at one month. Age (r=-0.32, p=0.001), diabetes duration (r=-0.41, p<0.001), and HbA1c levels (r=-0.37, p=0.008) all showed negative correlations with endothelial cell density, indicating that older age, longer duration of diabetes, and poorer glycemic control were associated with greater endothelial cell loss.

Multiple regression analysis (Table 6) further confirmed the influence of these factors on endothelial cell loss. Age (β=-5.2, p=0.004), presence of diabetes (β=-78.3, p=0.002), and HbA1c levels (β=-28.7, p=0.012) were all significant predictors of endothelial cell loss at one month post-surgery.

Regarding complications and visual outcomes (Table 7), there was no statistically significant difference in postoperative visual acuity between the diabetic and non-diabetic groups (0.18 ± 0.12 vs. 0.15 ± 0.10 logMAR, p=0.161). However, there was a trend towards more complications in the diabetic group, with 8% experiencing corneal edema lasting more than one week compared to 2% in the non-diabetic group, although this difference did not reach statistical significance (p=0.169). The incidence of posterior capsule opacification was similar between the groups (6% vs. 4%, p=0.646).

In summary, these results demonstrate that patients with diabetes experienced significantly greater corneal endothelial cell loss and increased central corneal thickness following manual small incision cataract surgery compared to non-diabetic patients. The presence of diabetes, along with age and glycemic control, were identified as significant factors influencing postoperative corneal changes. While visual outcomes were comparable between the groups, there was a trend towards more postoperative complications in diabetic patients, albeit not statistically significant.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Diabetic Group (n=50)	Non-Diabetic Group (n=50)	p-value
Age (years)	65.3 ± 7.2	64.8 ± 6.9	0.721
Sex (Male/Female)	27/23	25/25	0.689
Preop VA (logMAR)	0.82 ± 0.24	0.79 ± 0.22	0.513
Preop IOP (mmHg)	14.7 ± 2.8	14.3 ± 2.5	0.458
HbA1c (%)	7.2 ± 0.9	N/A	N/A
Diabetes duration (years)	8.4 ± 4.7	N/A	N/A

Table 2: Preoperative Corneal Measurements

Measurement	Diabetic Group (n=50)	Non-Diabetic Group (n=50)	p-value
Endothelial cell density (cells/mm²)	2456 ± 241	2512 ± 228	0.231
Central corneal thickness (μm)	542 ± 28	535 ± 26	0.194

Table 3: Postoperative Corneal Endothelial Cell Density Changes

Time Point	Diabetic Group (n=50)	Non-Diabetic Group (n=50)	p-value
Day 1	2187 ± 263 (-10.9%)	2298 ± 245 (-8.5%)	0.029*
Week 1	2134 ± 278 (-13.1%)	2276 ± 251 (-9.4%)	0.008**
Month 1	2098 ± 285 (-14.6%)	2254 ± 257 (-10.3%)	0.003**

Values are presented as mean ± SD (percentage change from baseline) *p<0.05, **p<0.01

Table 4: Postoperative Central Corneal Thickness Changes

Time Point	Diabetic Group (n=50)	Non-Diabetic Group (n=50)	p-value
Day 1	583 ± 35 (+7.6%)	561 ± 31 (+4.9%)	0.001**
Week 1	568 ± 32 (+4.8%)	549 ± 29 (+2.6%)	0.002**
Month 1	554 ± 30 (+2.2%)	541 ± 27 (+1.1%)	0.025*

Values are presented as mean ± SD (percentage change from baseline) *p<0.05, **p<0.01

Table 5: Correlation Analysis of Preoperative Factors with Endothelial Cell Loss at 1 Month

Factor	Correlation Coefficient (r)	p-value
Age	-0.32	0.001**
Diabetes duration	-0.41	<0.001**
HbA1c	-0.37	0.008**

**p<0.01

Table 6: Multiple Regression Analysis for Factors Influencing Endothelial Cell Loss at 1 Month

Factor	Beta Coefficient	Standard Error	p-value
Age	-5.2	1.8	0.004**
Diabetes (Yes/No)	-78.3	24.6	0.002**
HbA1c	-28.7	11.3	0.012*

*p<0.05, **p<0.01

Table 7: Complications and Visual Outcomes

Outcome	Diabetic Group (n=50)	Non-Diabetic Group (n=50)	p-value
Postop VA (logMAR)	0.18 ± 0.12	0.15 ± 0.10	0.161
Corneal edema> 1 week	4 (8%)	1 (2%)	0.169
Posterior capsule opacification	3 (6%)	2 (4%)	0.646

DISCUSSION

The present study aimed to compare the changes in corneal endothelial cell count and central corneal thickness (CCT) following manual small incision cataract surgery (SICS) in patients with and without diabetes mellitus. Our findings revealed significant differences between the two groups, with diabetic patients experiencing greater endothelial cell loss and increased CCT postoperatively.

The preoperative endothelial cell density and CCT were comparable between diabetic and non-diabetic patients in our study. This is consistent with findings by Sudhir*et al.*, who reported no significant difference in baseline endothelial cell density between diabetic and non-diabetic individuals in a large population-based study [11]. However, some studies have found lower preoperative endothelial cell counts in diabetic patients [12], suggesting that the impact of diabetes on corneal endothelium may vary across populations.

Postoperatively, we observed a more pronounced decrease in endothelial cell density in the diabetic group compared to the non-diabetic group at all time points. At one month post-surgery, the percentage of endothelial cell loss was 14.6% in the diabetic group versus 10.3% in the non-diabetic group (p=0.003). These findings align with a study by Hugod*et al*., who reported a mean endothelial cell loss of 9.2% in diabetic patients compared to 7.2% in non-diabetic patients three months after phacoemulsification (p<0.001) [13]. The slightly higher cell loss percentages in our study may be attributed to the use of manual SICS technique as opposed to phacoemulsification.

Central corneal thickness changes also demonstrated significant differences between the two groups in our study. The diabetic group experienced greater corneal thickening at all postoperative time points, with a 2.2% increase in CCT at one month compared to 1.1% in the non-diabetic group (p=0.025). These findings are supported by a study by Morikubo*et al*., who found that diabetic patients had significantly greater increases in CCT following cataract surgery, which persisted for up to three months postoperatively [14].

Our correlation and regression analyses identified age, diabetes duration, and HbA1c levels as significant factors influencing endothelial cell loss. These results are consistent with a study by Goktas*et al*., who found that age and diabetes duration were negatively correlated with endothelial cell density (r=-0.28, p<0.001 and r=-0.24, p<0.001, respectively) [15]. The influence of glycemic control on corneal endothelial health is further supported by Lee et al., who demonstrated that poor glycemic control (HbA1c >7%) was associated with lower endothelial cell density and greater polymegathism [16].

While we did not find statistically significant differences in postoperative visual acuity between the diabetic and non-diabetic groups, there was a trend towards more complications in the diabetic group. This is in line with findings from a large retrospective study by Takamura*et al*., which reported a higher incidence of postoperative complications in diabetic patients undergoing cataract surgery, including prolonged corneal edema (OR 1.67, 95% CI 1.12-2.49) [17].

The mechanisms underlying the increased vulnerability of diabetic corneas to surgical trauma are not fully understood. However, several theories have been proposed. Diabetes is known to affect the Na+/K+-ATPase pump function of endothelial cells, which may impair their ability to maintain corneal deturgescence [18]. Additionally, advanced glycation end-products accumulate in diabetic corneas, potentially altering their biomechanical properties and increasing susceptibility to surgical stress [19].

In conclusion, our study demonstrates that patients with diabetes experience significantly greater corneal endothelial cell loss and increased central corneal thickness following manual SICS compared to non-diabetic patients. These findings highlight the importance of careful preoperative assessment and tailored surgical approaches for diabetic patients undergoing cataract surgery. Future studies should focus on optimizing surgical techniques and postoperative management strategies to minimize corneal endothelial damage in this vulnerable population.

CONCLUSION

This study provides compelling evidence that patients with diabetes mellitus experience significantly greater corneal endothelial cell loss and increased central corneal thickness following manual small incision cataract surgery compared to non-diabetic patients. The findings underscore the vulnerability of the diabetic cornea to surgical trauma and highlight the need for tailored approaches in managing cataract surgery for this patient population.

The observed differences in endothelial cell loss (14.6% in diabetic vs. 10.3% in non-diabetic patients at one month, p=0.003) and central corneal thickness changes (2.2% increase vs. 1.1% at one month, p=0.025) suggest that diabetic patients may require more careful intraoperative and postoperative management to minimize corneal complications. The identification of age, diabetes duration, and glycemic control as significant factors influencing endothelial cell loss provides valuable insights for preoperative risk assessment and patient counseling.

While visual outcomes were comparable between the groups, the trend towards increased postoperative complications in diabetic patients, though not statistically significant, warrants attention. Surgeons should be vigilant in monitoring diabetic patients for prolonged corneal edema and other potential complications in the early postoperative period.

Future research should focus on optimizing surgical techniques and developing targeted interventions to protect the corneal endothelium in diabetic patients undergoing cataract surgery. Additionally, long-term follow-up studies are needed to assess the impact of these early postoperative changes on corneal health and visual outcomes over time.

In conclusion, this study emphasizes the importance of considering diabetes as a significant risk factor for corneal endothelial damage during cataract surgery. By recognizing and addressing these risks, ophthalmologists can work towards improving surgical outcomes and preserving corneal health in this vulnerable patient population.

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