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Comparison of Corneal Endothelial Cell Parameters between Diabetic and Non-Diabetic Patients after Phacoemulsification Cataract Surgery

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ABSTRACT

Background: Diabetes mellitus is associated with structural and functional alterations of the corneal endothelium, potentially increasing the risk of endothelial damage following cataract surgery. Phacoemulsification, although widely performed and considered safe, may result in significant endothelial cell loss, particularly in diabetic patients. **Objective:** To assess and compare corneal endothelial cell changes after phacoemulsification cataract surgery in diabetic and age-matched non-diabetic patients. **Methods:** The study was a prospective descriptive cross-sectional study that was carried out at Al-Shifa Trust Eye Hospital, Rawalpindi, during a period of six months (from August 2024 to February, 2025). There were 94 patients (47 diabetics and 47 non-diabetics) who were undergoing uneventful phacoemulsification. The parameters of preoperative and postoperative endothelial corneal parameters were evaluated through specular microscopy of endothelial cell density (ECD), hexagonality, coefficient of variation (CV) and central corneal thickness (CCT) in the preoperative, 1 and 4 weeks postoperative assessments. The SPSS version 23 was used to analyze data. In places where it was suitable, independent samples t-test and chi-square test were used. The p-value of less than 0.05 was taken as statistically significant. **Results:** Preoperatively, diabetic patients had significantly lower ECD and hexagonality, along with higher CV and CCT compared to non-diabetics ($p < 0.05$). Postoperatively, endothelial cell density was significantly lower in diabetic patients at both 1 week and 4 weeks ($p = 0.001$). Percentage endothelial cell loss was significantly greater in diabetics at both time points. **Conclusion:** Diabetic patients exhibit greater endothelial vulnerability following phacoemulsification cataract surgery, even with good glycemic control. Careful surgical planning and close postoperative monitoring are recommended in this population.

INTRODUCTION

Cataract is among the most common causes of reversible blindness in the global world and still poses a massive burden on the population in the form of poor health, especially in developing nations. Phacoemulsification cataract surgery has now become the standard surgery method because of its safety profile, faster visual recovery and low postoperative complications. Endothelial cell loss is however a concern after surgery since there is a limited regenerative potential of endothelial cells [1-3].

The endothelium of the cornea is important in ensuring the transparency of the cornea by balancing the hydration of the stroma by its pumping and barrier roles. A major loss in the density of endothelial cells (ECD) can cause loss of corneal transparency resulting in postoperative edema or decompensation. Endothelial damage is caused by surgical trauma, ultrasonic energy, mechanical stress, and turbulence of fluids during phacoemulsification [4-6].

Diabetes mellitus has been identified to cause corneal endothelium structural and functional modifications. Chronic hyperglycemia is associated with the buildup of advanced glycation end products, oxidative stress, and the inactivation of Na^+/K^-ATPase pump, which cause the loss of endothelial cell density, elevation of polymegathism (coefficient of variation), decreased hexagonality and thickened corneal centrally. These alterations could make the diabetic cornea more vulnerable to surgical affront [7-9].

Phacoemulsification in diabetic patients is regularly undertaken; however, there is a debate over whether diabetes has a significant impact on the postoperative endothelial cell loss. In addition, there is a lack of local information on the Pakistani population on the endothelial alterations after cataract surgery in diabetics. Therefore, this study was conducted to compare corneal endothelial cell parameters before and after phacoemulsification

cataract surgery in diabetic and age-matched non-diabetic patients.

METHODOLOGY

It was a prospective descriptive cross-sectional study at Al-Shifa Trust-Eye Hospital, Rawalpindi, between August 2024 and February 2025. The study was initiated following approval of the research topic by the Research Evaluation Unit via Ref No: CPSP/REU/OPL-2023-114-2632. All the participants had signed the informed consent before enrolling into the study and the confidentiality of patient information was strictly ensured during the study. A total sample size of 94 patients was calculated using Cochran's formula for sample size estimation at a 95% confidence level (Z = 1.96), anticipated standard deviation of corneal cell thickness of 24.68, and an absolute precision of 5%, resulting in a final sample size of 94 patients. The participants were divided into two equal groups: 47 patients with type 2 diabetes mellitus and 47 age-matched non-diabetic patients undergoing phacoemulsification cataract surgery.

The study included patients between the ages of 50 and 90 years that had senile cataract. Only patients who had a maximum duration of disease reach 10 years and good glycemic control (HbA1c < 7%), were enrolled in the diabetic group. The non-diabetic patients could not be having HbA1c levels < 5.6%. The same experienced surgeon carried out all the surgeries by utilizing a standardized phacoemulsification method to reduce variability in the procedures.

Patients with pathological or traumatic cataract, preoperative endothelial cell density less than 1200 cells/mm^2, or any ocular pathology other than cataract were excluded from the study.

Each participant experienced a full preoperative ophthalmic examination which comprised of best corrected visual acuity (BCVA), slit-lamp biomicroscopic examination, intraocular pressure assessment by use of the Goldmann applanation tonometry, and dilated fundus examination utilizing a 90 D lens. Non-contact endothelial specular microscopy was used to measure the corneal endothelial parameters. The parameters that were recorded were endothelial cell density (ECD), percent hexagonal cell, coefficient of variation (CV) and central corneal thickness (CCT).

Measurement of endothelial parameters was done before the operation, 1 week after operation and 4 weeks after operation. The intraoperative variables such as phacoemulsification time, cumulative dissipated energy (CDE), surgery duration and any intraoperative complications were recorded using a structured proforma. Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 23. Normality of data distribution was assessed using the Shapiro-Wilk test. Quantitative variables were expressed as mean ± standard deviation for normally distributed data and median with interquartile range for non-normally distributed data. Qualitative variables were presented as frequencies and percentages. Independent samples t-test was used for comparison between groups for normally distributed continuous variables, while the Mann–Whitney U test was applied for non-parametric data. Chi-square test was used for comparison of categorical variables. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 94 patients (47 diabetics and 47 non-diabetics) were included. The mean age did not differ significantly between groups (63.38 ± 6.36 vs 64.36 ± 6.23 years, p = 0.453). Gender distribution was comparable (p = 0.097). As expected, HbA1c levels were significantly higher in diabetic patients (6.65 ± 0.18 vs 5.25 ± 0.13, p < 0.001).

Table 1

Comparison of Baseline Demographic and Glycemic Characteristics Between Diabetic and Non-Diabetic Groups

Variable	Non-Diabetic (n=47)	Diabetic (n=47)	p-value
Age (years), Mean ± SD	64.36 ± 6.23	63.38 ± 6.36	0.453
Male, n (%)	22 (46.8%)	30 (63.8%)	0.097
Female, n (%)	25 (53.2%)	17 (36.2%)	—
HbA1c (%), Mean ± SD	5.25 ± 0.13	6.65 ± 0.18	<0.001

Diabetic patients were found to have significantly lower endothelial cell density and hexagonality as well as higher coefficient of variation and central corneal thickness before the operation than non-diabetic patients (p < 0.05).

Table 2

Comparison of Preoperative Corneal Endothelial Cell Parameters Between Diabetic and Non-Diabetic Patients (n=94)

Parameter	Non-Diabetic (n=47)	Diabetic (n=47)	p-value
Endothelial Cell Density (cells/mm^2), Mean ± SD	2575 ± 185	2475 ± 190	0.01
Hexagonality (%), Mean ± SD	51.0 ± 5.5	48.0 ± 5.5	0.02
Coefficient of Variation (CV), Mean ± SD	34.0 ± 3.8	37.0 ± 4.0	0.003
Central Corneal Thickness (µm), Mean ± SD	530 ± 20	540 ± 22	0.03

The density of endothelial cells at 1 week and 4 weeks after surgery was significantly reduced in diabetic patients relative to non-diabetic patients (p = 0.001) shows the extensive loss of endothelial cells among diabetic patients.

Table 3

Comparison of Postoperative Endothelial Cell Density at 1 Week and 4 Weeks Between Diabetic and Non-Diabetic Patients (n = 94)

Time Point	Non-Diabetic (n=47) Mean ± SD	Diabetic (n=47) Mean ± SD	p-value
ECD at 1 Week (cells/mm^2)	2369 ± 175	2214 ± 188	0.001
ECD at 4 Weeks (cells/mm^2)	2332 ± 170	2178 ± 180	0.001

Independent samples t-test was used to compare endothelial cell density between groups at each postoperative time point. A p-value < 0.05 was considered statistically significant.

This difference in endothelial cell loss (percent) was statistically significant between diabetic patients 1 and 4 weeks after surgery (p = 0.001). There was significant absolute endothelial cell loss in diabetic patients than in non-diabetics, which indicates higher endothelial susceptibility after phacoemulsification.

Table 4

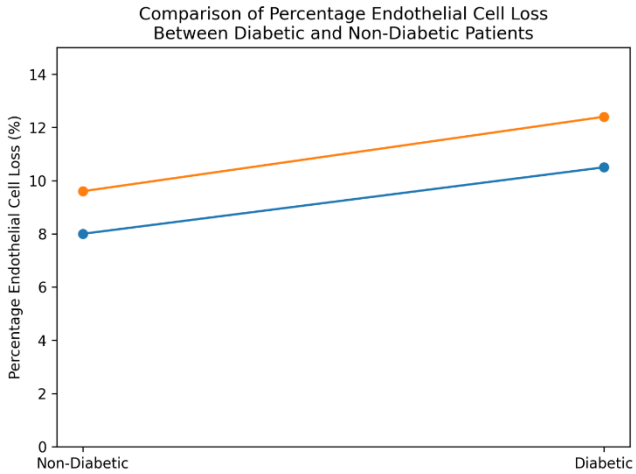
Comparison of Absolute and Percentage Endothelial Cell Loss at 1 Week and 4 Weeks Between Diabetic and Non-Diabetic Patients (n = 94)

Parameter	Non-Diabetic (n=47) Mean ± SD	Diabetic (n=47) Mean ± SD	p-value
Absolute ECD Loss at 1 Week (cells/mm^2)	206 ± 58	261 ± 65	0.001
% ECD Loss at 1 Week	8.0 ± 2.3	10.5 ± 2.6	0.001
Absolute ECD Loss at 4 Weeks (cells/mm^2)	243 ± 61	297 ± 70	0.001
% ECD Loss at 4 Weeks	9.6 ± 2.8	12.4 ± 3.1	0.001

Independent samples t-test was used to compare endothelial cell loss between groups. A p-value < 0.05 was considered statistically significant.

Figure 1

Comparison of percentage endothelial cell loss at 1 week and 4 weeks between diabetic and non-diabetic patients following phacoemulsification cataract surgery. Diabetic patients demonstrated significantly greater endothelial cell loss at both postoperative time points (p = 0.001).



DISCUSSION

The present study aimed to compare corneal endothelial cell changes following phacoemulsification cataract surgery in diabetic and age-matched non-diabetic patients. The results showed that preoperative endothelial cell density (ECD), hexagonality, coefficient of variation (CV) and central corneal thickness (CCT) were significantly lower in diabetic patients than non-diabetic patients. Moreover, endothelial cell loss at the end of the postoperative period was much higher in diabetic patients after 1 and 4 weeks, and this fact denotes that endothelial cells are more vulnerable to diabetic patients [10-13].

Even though age and the distribution of gender between the two populations were similar, which is less of a demographic confounding factor, the glycemic status was significantly different as anticipated. The fact that there is no significant age difference (p = 0.453) is a testament to the correct matching, which increases the internal validity of the comparison [14-16].

Reduced endothelial cell density and disturbed morphological parameters of increased polymegathism (CV) and hexagonality were observed in diabetic patients preoperatively. These results confirm the idea that chronic hyperglycemia provokes subclinical endothelial dysfunction at the preoperative stage of healthcare. It is known that long-term diabetes results in the accumulation of advanced glycation end-products and oxidative stress in the endothelial cells of the cornea that causes dysfunction in the cellular pump and morphological instability. The fact that the central corneal thickness of patients who had diabetes increased is also evidence of the endothelial compromise [17-19].

At a postoperative stage, endothelial cell loss occurred in both groups, which is a anticipatory outcome of a phacoemulsification process because of ultrasonic energy, turbulence of fluids, and mechanical load. The extent of endothelial cell loss was however much greater in diabetics. The diabetic patients reported an increased absolute and percentage ECD loss at 1 week and 4 weeks as opposed to non-diabetics (p = 0.001). This implies that diabetic endothelium lacks functional reserve and the capacity to overcome surgical stress [20].

The fact that the endothelial recovery in diabetics might be slow or incomplete remains in the persistence of the severe cell loss at 4 weeks. Past experimental results indicate that the activity of Na^+/K^+-ATPase pumps is lower in diabetic corneas, which contributes to the poor deturgescence and postoperative edema. This delayed recovery is further manifested by the increased post operating CCT values in diabetic patients [21].

The results of the study have clinical implications. Despite the notion that phacoemulsification is safe, diabetic patients, despite the fact that they have good glycemic control, seem to be more susceptible to endothelial compromising. Hence there should be meticulous surgical planning, low utilization of ultrasound energy, sufficient viscoelastic protection, and careful control of fluidics in diabetic patients.

This study has strengths, such as prospective design, equal group allocation, standardized approach to the surgical procedure by one surgeon, and assessment of various endothelial parameters at two points in time after the operation. There are however some limitations that should be considered. The maximum duration of follow-up was four weeks; a further follow-up would be informative of the long-term endothelial recovery. Also, well-controlled diabetics were only used; the results might be different in poorly-managed and long-term diabetes. Lastly, no use of sophisticated imaging modalities used to evaluate endothelial functional reserve.

CONCLUSION

Diabetic patients demonstrated significantly lower preoperative endothelial cell density and greater postoperative endothelial cell loss following phacoemulsification cataract surgery compared to age-matched non-diabetic patients. Despite good glycemic control, diabetic corneas exhibited increased vulnerability to surgical stress.

These findings highlight the importance of meticulous surgical technique, careful preoperative endothelial assessment, and close postoperative monitoring in diabetic patients undergoing cataract surgery. Further longitudinal studies with extended follow-up are recommended to evaluate long-term endothelial recovery and the impact of glycemic control on surgical outcomes.

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