Original Article

Comparison of Central Corneal Thickness Changes After Phacoemulsification in Diabetic and Non-Diabetic Patients

Shammee Tasmia[1], Tanjin Huda[2], Zakia Sultana[3], Jannatul Ferdous[4], Mujtahid Mohammad Hossain[5], Md. Abdur Rashid[6], Subarna Roy[7]

Abstract

Introduction: This prospective observational study investigates the impact of diabetes mellitus (DM) on central corneal thickness (CCT) after phacoemulsification cataract surgery. Cataract remains the principal cause of blindness, particularly in the developing world, and phacoemulsification is a widely practiced method for cataract surgery. The clarity of the cornea post-surgery is of great interest, as increased CCT can affect this clarity due to endothelial cell loss. **Methodology:** The study was conducted on 100 cataract patients undergoing phacoemulsification cataract surgery at the National Institute of Ophthalmology & Hospital, Dhaka, from July 2018 to January 2019. The patients were equally divided into diabetic and nondiabetic groups. Data on patients' ocular examination, endothelial cell count (ECC), and CCT were collected preoperatively and postoperatively on the 1st day, 7th day, and 1 month after surgery. The analysis was conducted using SPSS version 25, and the results were presented in tables and graphs. **Results:** The study revealed significant differences in CCT changes between the two groups. Diabetic patients exhibited greater CCT compared to nondiabetic patients postoperatively, indicating that hyperglycemia has a significant impact on corneal health. Specifically, the pre-operative mean CCT for diabetic patients was 528.80±2.08 µm, which increased to 540.16±5.53 µm on the 1st POD, 537.74±7.11 µm on the 7th POD, and 537.30±6.18µm after 1 month. In contrast, nondiabetic patients had a pre-operative mean CCT of528.98±9.45 µm, which changed to 541.64±15.56 µm on the 1st POD, 535.00±14.37 µm on the7th POD, and 534.42±13.45 µm after 1 month. **Conclusion:** The findings suggest that corneal changes in diabetic patients should be evaluated preoperatively to prevent postoperative corneal edema and maintain corneal clarity. This emphasizes the need for careful monitoring and management of diabetic patients undergoing phacoemulsification cataract surgery to ensure optimal postoperative outcomes.

Keywords: Diabetes mellitus (DM), endothelial cell count (ECC), central corneal thickness (CCT), visual acuity (V/A), intraocular pressure (IOP)

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1. Junior Consultant (ophthalmology), Rajshahi Medical College Hospital
2. Junior Consultant (ophthalmology), Gopalganj Eye Hospital & Training Institute
3. Assistant Professor, National Institute of Ophthalmology & Hospital, Dhaka.
4. Junior Consultant, Shaheed Suhrawardy Medical College & Hospital
5. Professor (Community Ophthalmology) & Director (Planning & Development), Directorate General of Medical Education
6. Junior Consultant, National Institute of Ophthalmology & Hospital, Dhaka.
7. Epidemiologist, National Institute of Ophthalmology & Hospital, Dhaka.

Address of correspondence:
Dr. Shammee Tasmia
Junior Consultant (Ophthalmology),
Rajshahi Medical College Hospital
Email: shammeetasmia@gmail.com
Phone: 01757 290669

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Introduction

Cataract is the leading cause of avoidable blindness worldwide, particularly in developing countries where it accounts for nearly three-quarters of blindness cases [1,2]. In developed nations, phacoemulsification has become the standard technique for cataract surgery, and its adoption is steadily increasing in less developed regions.

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion or action, influenced by both genetic and environmental factors. Globally, the prevalence of diabetes among individuals aged 20–79 years is approximately 8% and is projected to rise to 10% by 2030 [3]. In Bangladesh, the prevalence is currently around 7.4% and is expected to increase to 13% by 2030. Diabetes predisposes patients to a range of complications, including an earlier onset and

more rapid progression of cataract formation [4,5,6.] Hyperglycemia leads to elevated glucose levels in the aqueous humor, which diffuses into the lens and is metabolized by aldose reductase into sorbitol. The accumulation of sorbitol results in osmotic stress and overhydration of the lens, thereby accelerating cataract development [7,8]. In addition, increased glycation associated with hyperglycemia contributes to basement membrane collagen accumulation and increased membrane permeability.

The cornea, a transparent and avascular tissue, is also adversely affected by hyperglycemia. Normally, the corneal endothelial cell density is about 3000 cells/mm², and the central corneal thickness (CCT) is approximately 0.523 mm [9]. When endothelial cell counts fall below 500 cells/mm², endothelial decompensation can occur, impairing the corneal pump function and leading to edema. In diabetic patients, the cornea tends to be thicker and exhibits greater pleomorphism and polymegathism [10,11]. Several studies have reported that central corneal thickness is increased in diabetic patients, highlighting the importance of a thorough preoperative corneal evaluation.

Phacoemulsification, while effective, is associated with some degree of endothelial cell loss, which can contribute to postoperative corneal edema if excessive. Although some studies report no significant difference in CCT changes between diabetic and non-diabetic patients after surgery, other research indicates that diabetic corneas are more prone to morphological abnormalities and edema [12,13].
In light of these findings, the purpose of this study is to investigate the differences in central corneal thickness between diabetic and non-diabetic patients following phacoemulsification with intraocular lens implantation. Specifically, the study examines CCT on the first postoperative day, the seventh postoperative day, and one month after surgery, aiming to identify strategies to prevent corneal edema and ensure optimal postoperative outcomes in diabetic patients.

Methods

This prospective observational study was conducted at the Cataract Clinic of the National Institute of Ophthalmology & Hospital, Dhaka, over a period of six months (from July 2018 to December 2018) following protocol approval. One hundred patients scheduled for cataract surgery were enrolled and divided equally into two groups based on diabetic status using purposive sampling.

A provisional diagnosis was established through detailed history-taking and clinical examination, and all necessary investigations were performed prior to the surgical intervention. Informed written consent was obtained from each patient.
A total of 100 eyes with a similar grade of lenticular opacity were included in the study and evaluated both preoperatively and postoperatively. All eyes were selected at the same center, and all surgeries were performed by a single surgeon. Specular bio microscopy was used to measure endothelial cell counts, and anterior segment OCT was utilized to assess central corneal thickness (CCT) in both groups. Patients were followed up at 24 hours, one week, and one month after surgery for evaluation of CCT.

Results

This study was conducted to evaluate the changes in corneal endothelial cell count and central corneal thickness in diabetic and non-diabetic patients after phacoemulsification surgery. An equal number of diabetic and non-diabetic patients were selected, and they were followed pre-operatively, on the 1st postoperative day (POD), the 7th POD, and 1 month after the operation. Visual acuity (measured in LogMAR units), intraocular pressure (IOP), central corneal thickness (CCT), and endothelial cell count were evaluated for each patient. The mean values of all the aforementioned variables were compared with the pre-operative values within each group and also between the groups.

Out of 100 patients, the mean age in group 1 was 52.48±6.95 (SD) years, and in group 2 it was 56.18±7.86 (SD) years. In group 1, 72% of the patients were male and 28% were female, whereas in group 2, 62% were male and 38% were female.

In group 1, the mean random blood sugar (RBS) was 9.05±0.54 (SD) mmol/L and HbA1C was

6.15±0.60 (SD)%, while in group 2, the mean RBS was 6.15±0.60 (SD) mmol/L and HbA1C was 5.34±0.30 (SD)%.

In group 1, the mean IOP was 13.58±1.64 (SD) mm Hg pre-operatively, 16.26±1.46 (SD) mm Hg on the 1st POD, 14.52±1.53 (SD) mm Hg on the 7th POD, and 14.28±1.18 (SD) mm Hg at 1 month after the operation. In group 2, the corresponding values were 13.88±1.76 (SD) mm Hg, 15.10±1.88 (SD) mm Hg, 11.78±1.20 (SD) mm Hg, and 11.26±0.85 (SD) mm Hg, respectively.

In group 1, the mean visual acuity was 0.83±0.16 (SD) LogMAR units pre-operatively, 0.30±0.29 (SD) LogMAR units on the 1st POD, 0.22±0.245 (SD) LogMAR units on the 7th POD, and 0.19±0.199 (SD) LogMAR units at 1 month after the operation. In group 2, the values were 0.84±0.17 (SD) LogMAR units, 0.17±0.20 (SD) LogMAR units, 0.06±0.10 (SD) LogMAR units, and 0.03±0.07 (SD) LogMAR units at the respective time points.

In group 1, the mean endothelial cell count was 2348.86±87.88 (SD) cells/mm² pre-operatively, 2191.88±98.83 (SD) cells/mm² on the 1st POD, 2157.54±109.29 (SD) cells/mm² on the 7th POD, and 2114.44±63.79 (SD) cells/mm² at 1 month after the operation. In group 2, the mean endothelial cell counts were 2353.68±59.72 (SD) cells/mm², 2345.84±60.73 (SD) cells/mm², 2331.28±60.51 (SD) cells/mm², and 2289.08±88.92 (SD) cells/mm² at the corresponding time points.

In group 1, the mean central corneal thickness was 528.80±2.08 (SD) µm pre-operatively, 540.16±5.53 (SD) µm on the 1st POD, 537.74±7.11 (SD) µm on the 7th POD, and 537.30±6.18 (SD) µm at 1 month after the operation. In group 2, the values were 528.98±9.45 (SD) µm, 541.64±15.56 (SD) µm, 535.00±14.37 (SD) µm, and 534.42±13.45 (SD) µm at the respective time points.

Age distribution

Age group	Group A	Group B	t value / p value
34-39 years	1	1	
39-44 years	3	1	
44-49 years	13	7	
49-54 years	9	9	
54-59 years	16	13	2.483/0.390
59-64 years	5	8	
64-69 years	2	9	
69+ years	1	2	
Total	**50**	**50**	
Mean±SD	**52.48±6.95**	**56.18±7.86**	

ns= non-significant

Gender distribution

Gender	Group-1	Group-2	2 value/ p value
Male	36	31	
Female	14	19	1.131/0.288[ns]
Total	50	50	

ns= non-significant

Distribution of RBS and HbA1C level of the study subjects

Parameters	Group-1	Group-2	t value/p value
Mean RBS (m. mol/L)	9.05±0.54 (SD)	6.15± 0.60 (SD)	25.376/0.497[ns]
Mean Hb A_1C (%)	6.86±0.51 (SD)	5.34± 0.30 (SD)	18.371/0.000[s]

ns= non-significant, s=significant

Distribution of IOP in different follow-up periods

Assessment periods	Group-1 (mm of Hg)	Group-2 (mm of Hg)	t value/p value
Pre-operative	13.58±1.64 (SD)	13.88±1.76 (SD)	0.89/0.42[ns]
1st POD	16.26±1.46 (SD)	15.10±1.88 (SD)	3.455/0.122[ns]
7th POD	14.52±1.53 (SD)	11.78±1.20 (SD)	9.97/0.024[s]
1 month after operation	14.28±1.18 (SD)	11.26±0.85 (SD)	14.679/0.047[s]

ns= non-significant, s=significant

Distribution of comparison of mean IOP within the group

Groups	Base-line mean IOP (mm of Hg)	Mean IOP in 1st POD	t value /p value	Mean IOP in 7th POD	t value /p value	Mean IOP 1 month after operation	t value /p value
Group-1	13.58±1.64	16.26±1.46	26.596/ 0.000s	14.52±1.53	5.87/ 0.000s	14.24±1.18	4.127 / 0.000s
Group-2	13.88±1.76	88	7.292 / 0.000s	11.78±1.20	9.63/ 0.000s	85	10.458/ 0.000s

ns= non-significant, paired t test

Distribution of visual acuity in different follow-up periods

Assessment periods	Group-1 (Log MAR unit)	Group-2 (Log MAR unit)	t value/p value
Pre-operative	0.83±0.16 (SD)	0.84±0.17 (SD)	2.33/0.727ns
1st POD	0.30±0.29 (SD)	0.17±0.20 (SD)	2.62/0.008s
7th POD	0.22±.245 (SD)	0.06±0.10 (SD)	4.06/0.002s
1 month after operation	0.19±0.199 (SD)	0.03±0.07 (SD)	5.14/0.002s

ns= non-significant, s=significant

Distribution of comparison of mean visual acuity (Log MAR unit) within the groups

Groups	Base-line mean V/A (Log MAR)	Mean V/A in 1st POD	t value/ p value	Mean V/A in 7th POD	t value/ p value	Mean V/A 1 month after operation	t value/ p value
Group-1	0.83±0.16	0.31±0.30	12.585/ 0.000s	0.22±0.24	14.488/ 0.000s	0.19±0.2	16.93/ 0.000ns
Group-2	0.84±0.17	0.17±0.21	20.625/ 0.000ns	0.06±0.11	27.358/ 0.000s	0.03±0.07	32.04/ 0.000ns

ns= non-significant, paired t test

Distribution of Endothelial Cell Count in different follow-up periods

Assessment periods	Group-1 (mm^2)	Group-2 (mm^2)	t value/p value
Pre-operative	2348.86±87.88 (SD)	2353.68±59.72 (SD)	0.21/0.32^{ns}
1st POD	2191.88±98.83 (SD)	2345.84±60.73 (SD)	9.38/0.002^{s}
7th POD	2157.54±109.29 (SD)	2331.28±60.51 (SD)	9.83/0.001^{s}
1 month after operation	2114.44±63.79 (SD)	2289.08±88.92 (SD)	11.28/0.045^{s}

ns= non-significant, s=significant

Distribution of comparison of mean endothelial cell count within the group

Assessment periods	Group 1		Group 2	
	Value	t value/p value	Value	t value/p value
Base-line mean ECC (mm^2)	2348.86±87.88	----------	2353.68±59.72	
Mean ECC in 1st POD	2191.88±98.83	8.675/ 0.000^{ns}	2345.84±60.73	0.844/ 0.403^{ns}
Mean ECC in 7th POD	2157.54±109.29	9.45/ 0.000^{s}	2331.28±60.51	2.38/ 0.021^{s}
Mean ECC 1 month after operation	2114.44±63.79	14.57/ 0.000^{s}	2289.08±88.92	4.77/ 0.000^{s}

ns= non-significant, paired t test

Distribution of Central Corneal Thickness in different follow-up periods

Assessment periods	Group-1 (µm)	Group-2 (µm)	t value/p value
Pre-operative	528.80±2.08 (SD)	528.98±9.45 (SD)	0.94/0.772^{ns}
1st POD	540.16±5.53 (SD)	541.64±15.56 (SD)	0.634/0.000^{s}
7th POD	537.74±7.11 (SD)	535.00±14.37 (SD)	1.20/0.002^{s}
1 month after operation	537.30±6.18(SD)	534.42±13.45(SD)	1.376/0.000^{s}

ns= non-significant, s=significant

Distribution of comparison of mean central corneal thickness within the group

Groups	Base-line mean CCT (µm)	Mean CCT in 1st POD	t value/p value	Mean CCT in 7th POD	t value /p value	Mean CCT 1 month after operation	t value /p value
Group-1	528.80± 2.08	540.16± 5.53	15.084/0.000s	537.74± 7.11	4.323/ 0.000s	537.30± 6.18	9.802/ 0.000s
Group-2	528.98± 9.45	541.64± 15.56	4.323/0.028s	535.00± 14.37	2.574/ 0.000s	534.42± 13.45	2.5101/ 0.015s

ns= non-significant, paired t test

Discussion

Endothelial cell loss is inevitable following phacoemulsification. When the loss remains within a certain range, it is usually uneventful; however, excessive loss often manifests as corneal edema due to endothelial decompensation. Another mechanism contributing to postoperative corneal edema is a defective endothelial fluid pump. Older patients and those with systemic diseases, such as diabetes mellitus, tend to experience greater endothelial cell loss during intraocular surgery. Evidence also suggests that patients with diabetes mellitus exhibit increased polymorphism and polymegathism of the endothelium. Given that age-related cataract is the most common type and diabetes is considered a disease of aging, it is important to document endothelial cell loss and stromal edema reflected by increased central corneal thickness to create awareness among phacoemulsification surgeons and encourage extra precautions when operating on diabetic patients.

Analysis of age distribution in this study revealed that the mean age in group A was 52.4 years, and in group B it was 56.18 years, although this difference was not statistically significant (P = 0.390). Most patients in both groups belonged to the 54–59-year age range. Lee JS et al. (2006) reported a mean age of 57.5±8.5 years, which is consistent with our findings.

A study by Yasemin Ozdamar et al. (2010) on the correlation between diabetes mellitus and central corneal thickness showed that among participants, 51% were male and 49% were female. In our study, group A comprised 36 males (72%) and 14 females (28%), while group B included 31 males (62%) and 19 females (38%). The higher proportion of male participants may be attributed to the cultural perspective in Bangladesh, where males are more likely to seek medical attention, while female patients are often neglected.

In the current study, in group-1 the mean RBS was 9.05±0.54 (SD) mmol/L and HbA1C was 6.15±0.60 (SD)%, while in group-2 the mean RBS was 6.15±0.60 (SD) mmol/L and HbA1C was 5.34±0.30 (SD)%. The random blood sugar level and HbA1C in both groups were within normal limits, as these values were estimated pre-operatively and phacoemulsification was performed only on patients with fully controlled glycemic status.

Ozdamar, Y et al. (2010)15 showed that the mean IOP was significantly higher in the study group (15.1±2.9 mm Hg) compared with the control group (11.6±2.2 mm Hg) (P = 0.001), which is consistent with our study findings. Comparable postoperative IOPs were noted in both groups, possibly due to blockage of the trabecular meshwork by viscoelastic substances. The mean

IOP in group A increased more than in group B, possibly due to clogging of the trabecular meshwork by inflammatory cells, which may be less effectively controlled in diabetic patients. However, after one month, the IOP in both groups became similar, yielding no significant difference, likely due to the absorption of the viscoelastics.

In this study, the analysis of visual acuity in group-1 showed mean values of 0.83±0.16 (SD) LogMAR pre-operatively, 0.30±0.29 (SD) LogMAR on the 1st POD, 0.22±0.245 (SD) LogMAR on the 7th POD, and 0.19±0.199 (SD) LogMAR at one month postoperatively. In group-2, the corresponding values were 0.84±0.17 (SD) LogMAR pre-operatively, 0.17±0.20 (SD) LogMAR on the 1st POD, 0.06±0.10 (SD) LogMAR on the 7th POD, and 0.03±0.07 (SD) LogMAR at one month postoperatively.

Endothelial cell count decreased during postoperative follow-up in both groups, as some degree of cell loss occurs during phacoemulsification due to fluid turbulence—a loss that is more pronounced in diabetic patients. Jagjit S et al. (1996)5 demonstrated significantly lower corneal endothelial function in patients with non-insulin-dependent diabetes mellitus, suggesting a higher potential for decompensation following deleterious stress. Shenoy, R. et al. (2008)11 showed that the mean corneal endothelial cell density was –175 cells/mm² (95% CI –317 to –33 cells/mm²) lower in the eyes of diabetic patients, and that the number of endothelial cells exhibiting polymegathism was significantly greater among these eyes. Lundberg, B. et al. (2005)16 also reported endothelial cell loss after phacoemulsification surgery.

Central corneal thickness (CCT) increased on the first postoperative day in both groups due to corneal edema. Su, D.H. et al. (2008)10 reported that CCT is associated with higher IOP, longer axial length, a greater radius of corneal curvature, and factors such as higher BMI and metabolic syndromes like DM and CKD. Lundberg, B. et al. (2005) further showed that central corneal swelling on postoperative day 1 strongly correlates with central corneal endothelial cell loss of 3 months. Mathew, P.T. et al. (2011)18 studied 153 diabetic patients and 163 non-diabetic patients undergoing manual SICS and found that postoperative endothelial cell density, with percentage losses of 9.26±9.55 and 19.24±11.57 at 6 weeks and 3 months respectively in diabetic patients, and 7.67±9.2 and 16.58±12.9 respectively in controls, differed significantly between the groups ($P < 0.023$). In both groups, an initial increase in CCT was observed until the second postoperative week, followed by a reduction in the sixth week and a further decrease at the 3-month follow-up. The change in CCT between the second and sixth weeks was significantly higher in the diabetic group ($P = 0.045$). These studies, along with our findings, indicate that central corneal thickness increases postoperatively after ocular surgeries such as phacoemulsification.

A clear cornea is the most desired postoperative outcome for ophthalmologists, as it ensures optimal vision for patients after phacoemulsification. The corneal endothelium and central corneal thickness play key roles in achieving this outcome. Damage to corneal endothelial cells may occur during phacoemulsification, and the thickness of the central cornea is strongly related to the endothelial cell count, morphology, the effectiveness of the endothelial fluid pump, and intraocular pressure (IOP). Although some degree of endothelial cell loss during phacoemulsification is inevitable and usually has little effect on postoperative corneal clarity, diabetes mellitus is a significant contributing factor to increased endothelial cell loss.

Conclusion

Central corneal thickness increased following phacoemulsification surgery due to intraoperative endothelial cell loss, a commonly encountered phenomenon among practicing surgeons. Statistical analysis of the mean endothelial cell counts between the diabetic and non-diabetic groups in this study shows that there is a significant loss of endothelial cells, which in turn leads to an increase in central corneal thickness in diabetic patients during phacoemulsification. Additional precautions during phacoemulsification can be taken to ensure postoperative corneal clarity and improved visual outcomes.

Conflict of interest

None

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