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RESEARCH ARTICLE

Corneal edema after phacoemulsification surgery in diabetic and non-diabetic patients

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ABSTRACT

Patients with diabetes mellitus undergoing phacoemulsification cataract surgery face an elevated risk of corneal edema, primarily due to metabolic disturbances that impair endothelial cell function, leading to delayed post-operative recovery. This prospective cohort study aimed to examine the relationship between diabetes mellitus and the incidence of corneal edema following phacoemulsification. A total of 180 cataract patients scheduled for surgery at Sultan Agung Eye Center, Semarang, and Dr. R. Soedjati Soemodiardjo Regional Public Hospital, Purwodadi, Indonesia, between July and August 2023, were enrolled. Participants were divided into two groups based on the presence or absence of diabetes mellitus. Corneal edema and visual acuity were evaluated on post-operative days 1 and 7. Statistical analyses assessed the association between diabetes mellitus and post-operative corneal edema, with a significance threshold set at $p < 0.05$. The results indicated that pre-operative visual impairment was significantly worse in non-diabetic patients compared to diabetic patients ($p = 0.000$). However, post-operative visual improvement was significantly greater in non-diabetic patients on both day 1 ($p = 0.02$) and day 7 ($p = 0.00$) compared to diabetic patients. Additionally, the incidence of corneal edema was significantly higher among diabetic patients on both day 1 ($p = 0.004$) and day 7 ($p = 0.001$) post-surgery. These findings suggest that diabetes mellitus is associated with a higher risk of corneal edema and delayed visual recovery following phacoemulsification cataract surgery.

1. Introduction

Cataracts, characterized by the clouding of the eye lens, are the leading cause of visual impairment, accounting for 77.7% of blindness in Indonesia. According to the 2013 Riskesdas, the prevalence of cataracts in individuals aged 50 and older is approximately 3.0% (Ministry of Health, Republic of Indonesia, 2018). Data from the Rapid Assessment of Avoidable Blindness (RAAB) survey indicates that 73.8% of the 176,977 blind residents in Central Java suffer from cataracts, and this number is expected to increase with rising life expectancy and the growing incidence of degenerative diseases (Rif'Ati *et al.*, 2021). Cataract-related blindness is treatable through surgical interventions such as phacoemulsification, which remains the gold standard in cataract surgery (Direktorat Jenderal Pencegahan dan Pengendalian Penyakit, 2018; Kemenkes, 2018).

Type 2 diabetes mellitus (DM) significantly elevates the risk of cataract formation, with diabetic patients exhibiting a five-fold higher likelihood of developing cataracts compared to non-diabetic individuals. The International Diabetes Federation (IDF) reported that in 2019, 463 million people worldwide, aged 20–79 years, were living with diabetes,

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representing 9.3% of this population. This figure is projected to rise to 578 million by 2030 and 700 million by 2045. Indonesia ranks 7th globally in diabetes prevalence, with 10.7 million cases (Ministry of Health Republic of Indonesia, 2021). The increasing incidence of DM parallels the rising number of cataract surgeries, with approximately 20% of these procedures being performed on diabetic patients (Kiziltoprak *et al.,* 2019; Sekelj *et al.,* 2021).

Phacoemulsification, the most performed cataract surgery, is preferred for diabetic patients due to its faster recovery and minimal post-operative inflammation compared to other techniques. Despite its advantages, the ultrasound energy used in phacoemulsification can cause mechanical trauma and lead to corneal endothelial cell loss (Shakya *et al.,* 2013). Corneal edema, a common complication during recovery, arises from endothelial pump damage in the corneal layer and is typically temporary. Corneal edema is defined as an increase in corneal thickness caused by elevated water content, resulting from endothelial dysfunction due to both mechanical (e.g., surgical instruments, heat from the phacoemulsification probe, ultrasonic vibrations, high flow rates, and nuclear fragments) and chemical trauma (e.g., exposure to toxic drugs during irrigation/aspiration and the use of viscoelastic substances).

Corneal transparency depends on maintaining a hydration level of 78%, with a 5% increase in hydration leading to corneal clouding. Endothelial dysfunction compromises the cornea's physical barrier and impairs the function of the endothelial pump, which actively transports fluid from the corneal stroma to the aqueous humor. Patients with shallow anterior chambers, limited mydriasis, dense cataracts, pseudoexfoliation syndrome, chronic uveitis, an endothelial cell count of less than 500–1,000 cells/mm², and corneal thickness exceeding 640 µm are at higher risk of persistent corneal edema following cataract surgery (Costagliola *et al.,* 2013). Post-operative corneal edema can lead to patient dissatisfaction due to the lack of improvement in visual acuity (Kausar *et al.,* 2015).

Diabetic patients are more vulnerable to corneal stress and trauma, resulting in more significant morphological damage and prolonged recovery times. Chronic metabolic changes at the cellular level in DM patients affect the corneal endothelial cell monolayer. Hyperglycemia increases aldose reductase activity, metalloproteinase (MMP) expression, and the formation of advanced glycation end products (AGEs). Inhibition of aldose reductase has been shown to prevent morphological changes in the corneal endothelium. At the same time, elevated MMP levels can damage the basement membrane and impair cell migration, leading to reduced corneal healing capacity (Tang *et al.,* 2017). Research by Khalid *et al.* (2019) found that diabetic patients experience more severe endothelial damage after phacoemulsification, as evidenced by a more significant reduction in corneal density compared to non-diabetic patients.

The combination of surgical trauma and diabetes comorbidity increases the risk of persistent (pseudophakic) corneal edema following phacoemulsification, sometimes necessitating reoperation (Lundström *et al.,* 2012). This study compares the incidence and severity of corneal edema following phacoemulsification surgery between diabetic and non-diabetic patients.

2. Materials and Methods

This prospective cohort study was conducted at Sultan Agung Islamic Hospital, Semarang, and the Regional Public Hospital of Dr. R. Soedjati Soemodiardjo, Purwodadi, Indonesia, from July to August 2023. A consecutive sampling technique was employed, with a minimum sample size of 180 patients, calculated based on power analysis. Eligible patients diagnosed with senile cataracts and scheduled for phacoemulsification surgery were screened preoperatively. Exclusion criteria included a history of uveitis, corneal disease or degeneration, diabetic macular edema, severe lung disease, or treatment with dactinomycin, ouabain, or oligomycin.

Before commencement, ethical approval for the study was obtained from the Bioethics Committee of the Faculty of Medicine, Universitas Islam Sultan Agung. All patients underwent a comprehensive preoperative ophthalmological examination, including best-corrected visual acuity (BCVA) assessment using the Snellen chart, intraocular pressure measurement with Goldmann applanation tonometry, slit-lamp biomicroscopy, dilated indirect fundus examination, and cataract grading. For diabetic patients, HbA1c and random blood sugar (RBS) levels were measured. Detailed medical histories, including age, gender, previous ocular conditions, systemic diseases, and current medications, were recorded.

Phacoemulsification surgeries were performed using the Stellaris Elite® platform, employing the phaco-chop technique. In all cases, intraocular lenses (IOLs) were implanted in the capsular bag. Postoperative assessments were conducted on days 1 and 7, with BCVA evaluated using the Snellen chart. Visual acuity outcomes were categorized as normal (<6/12), mild (6/12–<6/18), moderate (6/18–<6/60), severe (6/60–3/60), and blindness (>3/60). Corneal edema was assessed using slit-lamp biomicroscopy and graded according to the Oxford Clinical Trial of Edema in the Eye (OCTET) classification. Anterior segment activity

and lens position were also examined during follow-up.

Statistical analyses were conducted using SPSS version 25.0, with comparative tests applied to evaluate differences between groups. A p-value of less than 0.05 was considered statistically significant, and all analyses were performed with a 95% confidence interval.

3. Results

Table 1 presents the preoperative demographic and clinical characteristics of patients in the diabetic (DM) and control groups. A total of 187 patients underwent cataract surgery using the phacoemulsification technique, but 7 patients were excluded due to uncontrolled medication use, leaving a final sample size of 180 patients—90 in the DM group and 90 in the control group. Comparative analyses were conducted to evaluate the baseline characteristics between the two groups. For continuous variables such as age, random blood sugar (RBS), and intraocular pressure (IOP), normality tests were performed. Normally distributed data were compared using an independent T-test, while non-normally distributed data were analyzed using the Mann-Whitney U test. Gender distribution between the groups was compared using the chi-square test. Preoperative visual acuity and blood pressure data were analyzed using the Mann-Whitney U test due to the non-normal distribution.

The results demonstrated no statistically significant differences between the DM and control groups in terms of age, gender, blood pressure, or intraocular pressure, suggesting that the two groups were well-matched for these baseline characteristics. However, the two groups observed significant differences between preoperative RBS levels and visual acuity. The mean preoperative RBS was substantially higher in the DM group (231 mg/dL) compared to the control group (116.14 mg/dL, $p < 0.05$), which is consistent with the diabetic status of the former.

Regarding visual acuity, the control group exhibited a higher proportion of patients with severe visual impairment or blindness preoperatively, with 87.8% categorized as blind and 12.2% having severe visual impairment. In contrast, the DM group had a lower proportion of blindness (64.4%), but a higher incidence of severe visual impairment (35.6%) than the control group. This distribution is summarized in Table 2. These findings align with existing literature suggesting that while diabetes mellitus increases the risk of cataracts, diabetic patients often present with less severe preoperative visual impairment than non-diabetic patients, likely due to earlier detection and intervention. However, diabetic patients remain at

Table 1. The preoperative demographic and clinical characteristics of patients in the diabetic (DM) and control groups.

Characteristics	Control group (%)	DM group (%)	*p* value
Patient (n)	90	90	
Age	63.34 (± 9.55)	60.95 (± 7.95)	0.191*
Gender			0.359**
• Male	45 (50)	38 (42.2)	
• Female	45 (50)	52 (57.8)	
RBS (mg/dL)	116.14 (22.6)	231.46 (93.2)	0.000***
Intraocular Pressure (mmHg)	15.87 (5.45)	15.58 (4.5)	0.856***
Blood Pressure (mmHg)			0.544***
• Normal	5 (5.6)	7 (7.8)	
• Prehypertension	6 (6.7)	1 (1.1)	
• Stage 1 hypertension	17 (18.9)	13 (14.4)	
• Stage 2 Hypertension	48 (53.3)	57 (63.3)	
• Hypertensive crisis	14 (15.6)	12 (13.3)	

Description: *T-test **Chi-square ***Mann-Whitney

Table 2. Degree of visual impairment in the control group and DM group

Degree of visual impairment	Preoperative (%)		1 day after surgery (D1) (%)		7 days after surgery (D7) (%)	
	Control group	DM group	Control Group	DM group	Control Group	DM group
Normal	0 (0)	0 (0)	10 (11.1)	2 (2.2)	47 (52.2)	13 (14.4)
Mild	0 (0)	0 (0)	21 (23.3)	16 (17.8)	13 (14.4)	19 (21.1)
Moderate	0 (0)	0 (0)	30 (33.3)	25 (27.8)	21 (23.3)	33 (36.7)
Severe	11 (12.2)	32 (35.6)	10 (11.1)	13 (14.4)	4 (4.4)	9 (10)
Blindness	79 (87.8)	58 (64.4)	19 (21.1)	34 (37.8)	5 (5.6)	16 (17.8)
p value	0.000*		0.02**		0.00**	

Description: *Chi-square Test **Mann-Whitney Test

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Table 3. Degree of corneal edema after surgery

Degree of post-operative corneal edema	1 day after surgery (day1) (%)		7 days after surgery (day7) (%)	
	Control group	DM group	Control group	DM group
Temporary	42 (46.7)	27 (30)	76 (84.4)	57 (63.3)
mild	32 (35.6)	31 (34.4)	12 (13.35)	25 (27.8)
severe	16 (17.8)	32 (35.6)	2 (2.2)	8 (8.9)
p value	0.004*		0.001*	

Description: *Mann-Whitney Test

higher risk for post-operative complications such as corneal edema and delayed visual recovery, as shown in subsequent analyses.

Overall, this study demonstrates that while preoperative visual acuity is worse in the control group, diabetic patients face unique challenges post-operatively due to metabolic disruptions that affect corneal endothelial cell function. The higher preoperative RBS levels in the DM group may also contribute to the increased incidence of corneal edema, as elevated blood glucose has been shown to impair endothelial cell regeneration and wound healing.

Table 2 compares the visual acuity outcomes between the diabetic (DM) and control groups at three time points: pre-surgery, post-operative day 1, and post-operative day 7. Data on visual acuity, measured on nominal and ordinal scales, were analyzed using the Chi-Square and Mann-Whitney tests, respectively. Pre-surgical visual acuity and post-operative outcomes were compared between the groups. A significantly higher proportion of patients in the control group (87.8%) presented with pre-surgical blindness compared to the DM group (64.4%).

On post-operative day 1, most patients in the control group exhibited moderate visual impairment (33.3%), while by day 7, 52.2% had achieved normal visual acuity. In contrast, 37.8% of patients in the DM group remained blind on day 1, with 36.7% still experiencing moderate visual impairment by day 7, indicating a slower visual recovery than the control group.

Table 3 presents the degree of post-operative corneal edema, assessed using a slit-lamp examination and classified as temporary, mild, or severe. Statistical analysis using the Mann-Whitney test revealed a significant difference between the two groups ($p < 0.05$), confirming that DM is a risk factor for post-operative corneal edema following phacoemulsification. In the control group, 46.7% of patients exhibited temporary edema on day 1, increasing to 84.4% by day 7. Conversely, 35.6% of patients in the DM group had severe edema on day 1, while 63.3% had temporary edema on day 7, a lower percentage compared to the control group.

4. Discussion

This study evaluated post-operative corneal edema following phacoemulsification cataract surgery in patients with and without type 2 diabetes mellitus (DM). Preoperative random blood sugar (RBS) levels were significantly higher in the DM group (231.46 ± 93.2 mg/dL) compared to the control group (116.14 ± 22.6 mg/dL). However, no significant differences were found between the groups regarding age, gender, intraocular pressure, or blood pressure. These findings align with the guidelines from the Royal College of Anesthetists and Ophthalmologists (2012) and the Perioperative Quality Initiative (POQI), which recommend that elective eye surgery should not be delayed based solely on hyperglycemia or blood pressure, except in cases of severe metabolic disturbances such as diabetic ketoacidosis or hypertensive emergencies (Sweitzer *et al.,* 2021).

Post-operative corneal edema was evaluated on days 1 and 7, and significant differences were observed between the two groups. The DM group exhibited a higher incidence of severe corneal edema, which persisted longer than the control group. Despite a higher preoperative visual acuity in the DM group, post-operative visual recovery was slower. These findings are consistent with previous research by Shakya *et al.* (2013) which reported a higher incidence of corneal edema in DM patients following phacoemulsification compared to non-DM patients.

Corneal edema after phacoemulsification is usually transient, resolving as the corneal endothelium regenerates. However, in DM patients, endothelial cell loss (ECL) and delayed endothelial regeneration result in more persistent edema. Endothelial cells play a critical role in maintaining corneal transparency through the Na^+/K^+-ATPase pump, and a minimum of 500 cells/mm² is required to maintain corneal hydration. DM patients are more susceptible to endothelial trauma during phacoemulsification due to metabolic abnormalities in the corneal matrix and impaired regenerative capacity (Yang *et al.,* 2023).

The delayed recovery of visual acuity in the DM group can be attributed to the greater degree of post-operative corneal edema. DM patients experience

greater ECL and altered endothelial cell morphology post-operatively, with these effects persisting for up to six months. The slower regeneration of hexagonal endothelial cells in DM patients further compromises corneal recovery, contributing to prolonged visual impairment (Yang *et al.,* 2023).

Preoperative visual acuity was significantly worse in the control group, with more patients presenting with blindness. However, visual acuity improved rapidly in the control group post-operatively, with many patients achieving normal visual acuity by day 7. This difference may be explained by the higher degree of corneal edema in the DM group, as demonstrated by Briceno-Lopez *et al.* (2023) who proposed that increased corneal hydration following phacoemulsification leads to transient visual impairment, particularly in diabetic patients.

Cataract surgery is performed at the discretion of ophthalmologists, based on their clinical judgment regarding the potential benefits for each patient. According to the 2018 Indonesian National Guidelines for Medical Services in Cataract Management, surgical intervention is recommended for patients with a best corrected visual acuity (BCVA) of 6/18 or worse (Class A, Level Ia) (Ministry of Health, 2018). In this study, preoperative visual assessments revealed that the majority of patients presented with severe visual impairment (BCVA between 6/60 and 3/60) or blindness (BCVA <3/60), reflecting the advanced stage of cataracts commonly seen in the two centers involved in this research. This suggests a significant burden of late-stage cataract among the patient population.

The primary limitation of this study is the lack of measurement of endothelial cell density, hexagonal cell percentage, and endothelial coefficient of variation, which could provide a more detailed understanding of the mechanical trauma and regenerative differences between the DM and control groups.

5. Conclusions

This study demonstrates that diabetes is a significant risk factor for corneal edema following phacoemulsification cataract surgery. Diabetic patients exhibited more severe and prolonged corneal edema compared to non-diabetic patients, resulting in slower visual recovery.

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Conflict of interest

All authors have no conflict of interest in this article.

References

Briceno-Lopez, C., Burguera-Giménez, N., García-Domene, M.C., Díez-Ajenjo, M.A., Peris-Martínez, C., Luque, M.J. (2023). Corneal edema after cataract surgery. *Journal of Clinical Medicine,* 12(21): 1–17. https://doi.org/10.3390/jcm12216751

Costagliola, C., Romano, V., Forbice, E., Angi, M., Pascotto, A., Boccia, T., Semeraro, F. (2013). Corneal oedema and its medical treatment. *Clinical and Experimental Optometry,* 96(6), 529–535. https://doi.org/10.1111/cxo.12060

Direktorat Jenderal Pencegahan dan Pengendalian Penyakit. (2018). *Peta jalan penanggulangan gangguan penglihatan di Indonesia tahun 2017-2030, 2018.* Jakarta. https://p2ptm.kemkes.go.id/uploads/VHcrbkVobjRzUDN3UCs4eUJ0dVBndz09/2018/08/Buku_Peta_Jalan_Penanggulangan_Gangguan_Penglihatan_di_Indonesia_tahun_2017_2030.pdf

Kausar, A., Farooq, S., Akhter, W., Akhtar, N. (2015). Transient corneal edema after phacoemulsification. *Journal of the College of Physicians and Surgeons Pakistan,* 25 (7): 505-509. https://www.jcpsp.pk/archive/2015/Jul2015/09.pdf

Kemenkes, R. (2018). *Situasi Gangguan Penglihatan dan Kebutaan.* Pusat Data dan Informasi Kementerian Kesehatan RI : Jakarta. https://www.kemkes.go.id/development/resources/download/tabloid/infodatin/infodatin-penglihatan.pdf

Kementrian Kesehatan, *2021.* Infodatin: Tetap produktif, cegah dan atasi diabetes melitus. Pusat Data dan Informasi Kementerian Kesehatan RI : Jakarta.

Kementrian kesehatan, 2018. Keputusan Menteri Kesehatan Indonesia Nomor HK.01.07/MENKES/557/2018 Tentang Pedoman Nasional Pelayanan Kedokteran Tata Laksana Katarak Pada Dewasa. https://galihendradita.wordpress.com/wp-content/uploads/2021/06/2018-pnpk-katarak.pdf

Khalid, M., Hanif, M.K., Islam, Q.U., Mehboob, M.A. (2019). Change in corneal endothelial cell density after phacoemulsification in patients with type ii diabetes mellitus. *Pakistan Journal of Medical Sciences,* 35(5): 1366-1369. https://doi.org/10.12669/pjms.35.5.596.

Kiziltoprak, H., Tekin, K., Inanc, M., Goker, Y.S. (2019). Cataract in diabetes mellitus. *World Journal of Diabetes,* 10(3): 140-153. https://doi.org/10.4239/wjd.v10.i3.140

Lundström, M., Barry, P., Henry, Y., Rosen, P., Stenevi, U. (2012). Evidence-based guidelines for cataract surgery: guidelines based on data in the European Registry of quality outcomes for cataract and refractive surgery database. *Journal of Cataract & Refractive Surgery,* 38(6): 1086-1093 https://doi.org/10.1016/j.jcrs.2012.03.006

Rif'Ati, L., Halim, A., Lestari, Y.D., Moeloek, N.F., Limburg, H. (20210. Blindness and visual impairment situation in indonesia based on rapid assessment of avoidable blindness surveys in 15 provinces. *Ophthalmic Epidemiology,* 28(5): 408–419. https://doi.org/10.1080/09286586.2020.1853178

Sekelj, S., Milec, M.L., Pernar, S.K., Sekelj, A., Farena, S. (2021. Corneal edema recovery after phacoemulsification in type 2 diabetic versus non-diabetic patients. *Clin. Diabetol.* 10, 144–148. https://doi.org/10.5603/DK.A2021.0003

Shakya, K., Pokharel, S., Karki, K.J.D., Pradhananga, C., Pokharel, R.P., Malla, O.K. (2013). Corneal edema after phacoemulsification surgery in patients with type II diabetes mellitus. *Nepalese Journal of Ophthalmology.* 5(2): 230–234. https://doi.org/10.3126/nepjoph.v5i2.8734

Sweitzer, B., Rajan, N., Schell, D., Gayer, S., Eckert, S., JoshPre-operative. (2021). Preoperative Care for Cataract Surgery: The Society for Ambulatory Anesthesia Position Statement. *Anesthesia & Analgesia,* 133(6): 1431-1436. https://doi.org/10.1213/ANE.0000000000005652

Tang, Y., Chen, X., Zhang, X., Tang, Q., Liu, S., Yao, K. (2017). Clinical evaluation of corneal changes after phacoemulsification in diabetic and non-diabetic cataract patients, a systematic review and meta-analysis. *Scientific Reports,*. 7, 1–16. https://doi.org/10.1038/s41598-017-14656-7

Yang, Y., Chai, H., Ding, Z., Tang, C., Liang, Y., Li, Y., Liang, H., 2023. Meta-analysis of corneal endothelial changes after phacoemulsification in diabetic and non-diabetic patients. *BMC Ophthalmol.* 23, 1–14. https://doi.org/10.1186/s12886-023-02924-2.