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Comparison of Endothelial Cell Density Post- Phacoemulsification between Diabetic and Non- Diabetic Patients

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ABSTRACT

Objective: To compare corneal endothelial cell density (CED) after phacoemulsification cataract surgery between patients with type II diabetes mellitus and non-diabetic patients.

Methodology: This comparative cross-sectional study was conducted at the Sindh Institute of Ophthalmology and Visual Sciences, Hyderabad, from August 2021 to January 2022. Patients aged 35 to 60 years of both genders who presented with cataract of any duration and underwent uneventful phacoemulsification cataract surgery were included. One day before surgery, CED was measured using a Topcon SP-3000P specular microscope. During surgery, total operative time was recorded. Preoperative and postoperative CED were measured. Patients were reviewed postoperatively, and CED was reassessed one week after surgery using a pre-designed proforma.

Results: A total of 279 patients were enrolled in the study. The mean preoperative corneal endothelial cell density was 2522.22 ± 181.59 cells/mm², which significantly decreased postoperatively to 1702.00 ± 73.56 cells/mm² (p = 0.001). Importantly, the mean postoperative CED was significantly lower among diabetic patients (1671.96 ± 48.64 cells/mm²) compared to non-diabetic patients (1840.09 ± 81.91 cells/mm²) (p = 0.001), indicating significantly greater endothelial cell loss after surgery in diabetic patients.

Conclusion: Diabetic patients experienced significantly greater CED loss following phacoemulsification compared to non-diabetic patients. This may be attributed to prolonged structural and metabolic alterations in the corneal endothelium resulting from chronic hyperglycemia.

Keywords: CED, Cataract, Phacoemulsification, DM.

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Introduction

Cataract, characterized by the development of opacity in the natural crystalline lens of the eye, is a leading cause of blindness and visual impairment worldwide. It significantly impacts public health, with an estimated 20 million individuals affected by bilateral blindness globally. In developing countries, cataract accounts for approximately 50% to 90% of all cases of vision loss.[1,2] Phacoemulsification with intraocular lens implantation is one of the most widely practiced contemporary surgical procedures for cataract management and has demonstrated high efficacy in cataract removal with significantly improved visual outcomes.[3] Advances in phacoemulsification and its widespread application have made it a preferred procedure to remove cataract due to its safety, small incision size, and rapid recovery. Despite noticeably validated safety and advances in

phacoemulsification, corneal transparency can still be compromised in complicated cases because of decreased endothelial cell density (ECD) resulting from intraoperative damage occurring to endothelial layer. [3,4]

The corneal endothelium maintains corneal deturgescence, and due to its very limited regenerative capacity, significant intraoperative loss of corneal endothelial cells may lead to deterioration of vision through permanent alteration in corneal structure and function.[5,6] Although, contemporary phacoemulsification techniques have reduced risks of intraoperative trauma, intraoperative corneal damage can still result from several factors, such as irrigation turbulence, corneal distortion, duration of surgery, surgical instrument-related mechanical trauma, contact with intraocular lens, nuclear fragments, and reactive oxygen species.[2] Endothelial cell loss is further accelerated in the presence of comorbidities like glaucoma, prior eye trauma, and diabetes.[7]

Diabetes mellitus, a chronic metabolic disorder, has a well-documented association with ocular complications, including glaucoma, cataract formation, diabetic retinopathy, and corneal abnormalities, which significantly contribute to the blindness around the world. These diabetes-associated complications pose extensively adverse impact on the healthy vision. Although, diabetic retinopathy has gained a considerable attention, damage to the corneal epithelial cells and nerves remain the key contributor to cataracts beside other ocular conditions.[8,9]

The corneal morphological and physiological changes, referred to as diabetic keratopathy, are frequently noted among diabetic patients. Diabetic keratopathy manifests as reduced corneal sensation, epithelial defects, and impaired wound healing, which can progress to corneal scarring and ulceration, ultimately causing corneal opacities and permanent visual loss in advanced cases.[10,11]These corneal changes may reduce endothelial cell reserve, compromising the ability to withstand intraoperative trauma to cornea, and greater endothelial cell loss during cataract surgery among diabetic patients compared to non-diabetic individuals.[12] The Phacoemulsification, while the gold standard for the extraction of cataract extraction, predictably reasons corneal endothelial cell loss an interest of specific significance in patients with diabetes mellitus, whose corneal endothelium is already compromised structurally by chronic hyperglycemia induced fluctuations including reduced density of cell, polymegethism, and impaired cellular integrity. Pakistan is ranking among the top ten countries internationally for prevalence of diabetes, diabetic patients constitute a substantial and growing proportion of cataract surgical candidates. Though, robust local evidence directly associating post-phacoemulsification ECD among diabetic and non-diabetic patients remains limited, limiting the applicability of international findings to the local clinical context. However present study was done to address this critical evidence gap, with the aim of providing population-specific data to guide the uncomplicated surgical practice and informed pre- and post-operative management of diabetic cataract patients in out population.

Methodology

This was a comparative cross-sectional study, conducted at Sindh Institute of Ophthalmology and Visual Sciences, Hyderabad. This study was conducted during a period of six months from 1st August 2021 to 31st January 2022. A sample size of 279 was calculated using WHO sample size calculator, using the estimating mean with specified absolute precision test as; α = 5% Mean ± SD= 2250.37 ± 426.68 with margin of error as 5%. Non-probability consecutive sampling technique was employed. According to the inclusion criteria, the patients aged between 35 and 60 years, both genders, presented with cataract of any duration and undergoing uneventful phacoemulsification cataract surgery were included. However, the patients with any ocular disease likely to affect endothelial count: corneal disease, glaucoma, pseudo exfoliation and uveitis, patients with history of previous ocular surgery, history of previous ocular trauma and patients with complicated phacoemulsification cataract surgery were excluded. Informed consent was obtained from all participants after explaining the study objective and purpose. Before enrolment in the study, all patients underwent a thorough history and clinical examination, random plasma glucose level and CED in all patients was evaluated preoperatively (by Topcon SP 3000P Specular Microscope). All patients were then undergoing phacoemulsification cataract surgery by an experienced surgeon who was a classified ophthalmologist with a minimum of five years 'experience using the same phaco machine (Oertli Machine) and total operative time was noted. Patients were reviewed postoperatively to measure CED at 1 week. All the relevant information including demographic information, pre- operative CED and post-operative CED at 0 days and then at 1 week through a pre-designed questionnaire. Subsequently the data was analyzed using SPSS version 26. Mean and standard deviation was calculated for quantitative variables, while the qualitative variables were expressed as frequency and percentages. Independent samples t-test was applied to compare pre-operative CED and post-operative CED at 0 days and 1 week between diabetics and non-diabetics, and a p-value ≤ 0.05 was considered significant.

Results

A total of 145 patients were included in the final analysis after meeting the inclusion and exclusion criteria. The overall mean age was 54.04 ± 8.82 years, and males constituted a higher proportion of participants compared with females 91(62.82%) vs. 54(37.28%). Most participants were married 144(99.30%), resided in urban areas 83(57.20%) and belonged to a lower socioeconomic stratum 76(52.40%). Nearly three-quarters of the patients had a normal body mass index (BMI) 105(72.38%),with a mean BMI of 23.62 ± 2.50 kg/m².

The most common occupations were laborers 45(31.03%) and housewives 45(31.03%). Thirty patients (20.59%) were current smokers. A greater proportion of patients presented with non-ST-segment elevation myocardial infarction (NSTEMI) 96(66.21%) and typical chest pain was the most frequent presenting symptom 107(73.79%). The most common comorbid conditions were hypertension 85(58.62%) and diabetes mellitus 59(40.68%), as shown in Table I.

Table l: Demographic and clinical characteristics. (n=279)

Gender	Male	149 (53%)
	Female	130 (47%)
Residence	Urban	123 (44%)
	Rural	156 (56%)
Laterality of eye	Right	158 (57%)
	Left	121 (43%)
Mean age		49.42±7.92 years
Cataract duration		2.41±1.45 years
Mean RBS		168.46±23.83
Mean duration of diabetes		7.41+3.16 years

As per main objective of the study, the large proportion of patient admitted with acute MI had deviated sleep pattern (40.69%, n = 59) while 59.31% (n = 86) had almost normal sleep pattern.

Furthermore, patients were also evaluated for associated factor causing sleep deviation among patients admitted with AMI. Males, married patients, residents of urban area, housewives, middle social class, patients with normal BMI, non-smokers, patients with typical chest pain, and patients with NSTEMI had higher prevalence of sleep deviation but did not have significant association, p value >0.05. (Table II)

There was no significant association found of sleep pattern with diabetes, hypertension, dyslipidemia, or anxiety (p = >0.05), while depression showed a statistically significant association with deviated sleep pattern (p = 0.03) as shown in table III.

Table II: Mean CED pre-operatively versus post-operatively and diabase versus non-diabetes patients with cataract.

Corneal endothelial cell density (CED)	Mean ± SD	P-value
Pre-operative CED (cells/mm²)	2522.22 ± 181.59	0.0001*
Post-operative CED (cells/mm²)	1702.00 ± 73.56	
Mean post-operative CED in diabetics (cells/mm²)	1671.96 ± 48.64	0.001
Mean post-operative CED in non-diabetics (cells/mm²)	1840.09 ± 81.91	0.001

Discussion

Cataract remains the leading cause of reversible blindness worldwide, and phacoemulsification is considered the gold-standard surgical treatment. However, this procedure poses a substantial risk to the corneal endothelium, as endothelial cell regeneration is largely irreversible once cells are lost. This risk is considerably higher in diabetic patients, whose corneal endothelium is already compromised due to chronic hyperglycemia. This concern is particularly relevant in Pakistan, where the prevalence of diabetes is high.

The present study enrolled 279 patients to compare corneal endothelial cell density (CED) after phacoemulsification between type II diabetic and non-diabetic patients. The overall mean age of participants was 49.41 ± 7.92 years. The majority were male (53%) and residents of rural areas (56%). Additionally, the overall mean duration of cataract development and diabetes was 2.40 ± 1.45 years and 7.40 ± 3.16 years, respectively.

These findings are comparable to those reported by Khalid M et al.[13], who evaluated endothelial cell density changes following phacoemulsification and observed male predominance (57.5%). However, the mean age in their

Table III: Mean pre and post-operative CED comparison with respect to effect modifiers among patients with cataract.

Variables		Pre- operative (CED) (cells/mm²)	Post- operative (CED) (cells/mm²)	Mean change	P-value
Diabetes	**Yes**	2669.94 ± 62.41	1671.96 ± 48.64	997.98± 6.33	0.0001
	No	2334.86 ± 83.06	1840.09 ± 81.91	694.77± 10.51	0.0001
Gender	**Male**	2516.88 ± 180.97	1705.10 ± 74.74	811.78 ±16.04	0.0001
	Female	2528.33 ± 182.79	1698.44 ± 72.31	829.89 ±17.24	0.0001
Age groups (years)	**35-45**	2535.27 ± 18.66	1695.24 ± 74.92	840.03±21.18	0.0001
	46-60	2516.40 ± 18.72	1705.01 ± 72.94	811.30±14.09	0.0001

study (61.4 ± 6.8 years) was higher than that observed in our cohort. Similarly, Chaurasia RK et al.[14] reported a mean age of 57.9 ± 6.6 years among non-diabetic patients and 58.5 ± 6.3 years among diabetic patients, with male predominance (54%) in both groups. They also noted greater involvement of the right eye compared to the left eye. Furthermore, they reported a lower mean random blood sugar level (131.18 ± 17.75 mg/dL) and a shorter mean duration of diabetes (3.06 ± 1.54 years) compared to our study population.

In the present study, cataract grading was performed using slit-lamp examination. Grade II cataract was observed in 40% of patients, grade III in 47%, and grade IV in 12%. These findings are consistent with those reported by Chaurasia RK et al.[14], where the majority of diabetic and non-diabetic patients had grade III cataract (41% vs. 51%, respectively) and grade II cataract (45% vs. 35%, respectively). Similarly, Khalid M et al.[13] included both diabetic and non-diabetic eyes with grades II and III cataracts on slit-lamp examination.

According to the current study, mean corneal endothelial cell density (CED) pre- operatively was noted as 2522.22 ± 181.59 cells/mm^2, which significantly decreased post-operatively at 7th day to 1702.00 ± 73.56 cells/mm^2 (p=0.001). In aligns to these findings, the study carried out by Aslam A et al[15] reported a statistically significant decrease in endothelial cell density (cells/mm^2) from 2753.0 ± 126.9 pre-operatively to 2451.2 ± 160.9 post-operatively at day 14 ($p < 0.0001$). Consistently, in the study by Khalid M et al[13] endothelial cell density (Cells/mm^2) significantly reduced among diabetic and non-diabetic patients 2 months after phacoemulsification, with a mean change of 323.7±283.1 Cells/mm^2 ($p < 0.05$).

Importantly in our study cohorts, the mean post-operative CED was significantly lower among diabetes patients (1671.96 ± 48.64 cells/mm²) with cataract compared to non-diabetics (1840.09 ± 81.91 cells/mm²), (p = 0.001), indicating significantly more endothelial cell loss among diabetic patients after surgery. Consistent with these findings, in the study by Ciorba AL et al[16] significantly more endothelial cells loss (cells/mm²) was observed among diabetic patients (473 ± 369) compared to non-diabetic patients (166 ± 215) at 1 week postoperatively (p <0.0001). Consistently, a more recent study conducted by Sharma S et al.[17] mean postoperative endothelial cell density (ECD) values (cells/mm²) were lower in diabetic (right eye; 2598 ± 325 and left eye; 2636 ± 342) compared with non-diabetics (right eye; 2709 ± 241 and left eye; 2652 ± 260). In current study, a significant reduction was found in mean CED from pre-operative to post-operative values across all effect modifiers, as it decreases significantly among diabetics and non-diabetics (p = 0.0001), in both males and females (p = 0.0001), and in both age groups 35–45 years and 46–60 years respectively (p = 0.0001). The parallel findings were documented in the study conducted by Khalid M et al.,13 who reported that diabetic and non-diabetic patients experienced statistically significant declines in endothelial cell density after phacoemulsification ($p < 0.05$), with significant CED change from pre-operative (2639.89±331.99 vs. 2657.87±361.16) to post-operative (2250.37±426.68 vs. 2399.97±451.08) within each group respectively. In agreement, Yadav RS et al[18] also reported that mean ECD loss were higher in diabetic patients at 4 weeks (198.30±32.72) and at 12 weeks (232.68±33.69) than those in non-diabetic groups at 4 weeks (136.95±22.21) and at 12 weeks (169.90±21.40), with significant differences in post-phacoemulsification endothelial cell measurements between groups ($p<0.0001$). On the other hand, Mazhar et al[19] conducted a cross-sectional study at Layton Rahmatullah Benevolent Trust Free Eye and Cancer Hospital on 355 patients with type 2 diabetes, where higher endothelial cell loss was observed after phacoemulsification among poor control of diabetes versus patients with good control. However, according to the study by Yang Y et al[20] where compared corneal endothelial outcomes in diabetic patients and non-diabetic patients after phacoemulsification, observed higher endothelial cell loss in the diabetic group compared to non-diabetic group, indicating a significantly greater loss in diabetic patients like this study.

Overall, the findings of this study, consistent with both national and international literature, confirm that diabetic patients experience significantly greater corneal endothelial cell loss following phacoemulsification compared to non-diabetic patients. Poor glycemic control and prolonged duration of diabetes were identified as key contributing factors.

However, this study has several limitations, including a relatively small sample size and a single-center design, which may limit the generalizability of the findings. Additionally, the absence of HbA1c data to categorize patients as having controlled or uncontrolled diabetes restricts a more comprehensive interpretation of the results.

It is therefore recommended that preoperative specular microscopy and optimal glycemic control be adopted as routine clinical practice in diabetic patients undergoing cataract surgery, along with the implementation of endothelium-protective intraoperative techniques. Furthermore, large-scale, multicenter prospective studies are warranted to validate these findings and to establish

standardized surgical guidelines for this high-risk population, particularly at the local level.

Conclusion

Study revealed a significant reduction in corneal ECD postoperatively among diabetic patients compared to non-diabetic patients at one week following the phacoemulsification. Overall findings underscore the importance of routine pre-operative specular microscopy for the evaluation of endothelium among all patients of diabetes mellitus, scheduled for intraocular surgery. Additionally, the endothelium-protective intraoperative approaches are recommended to lessen the surgical influence to the corneal endothelium in the diabetes population.

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