BOHR International Journal of Current Research
in Optometry and Ophthalmology
2026, Vol. 5, No. 1, pp. 5–12
DOI: 10.54646/bijcroo.2026.45
www.bohrpub.com

RESEARCH

The impact of cataract surgery on normal ocular surface: an experience from a tertiary center of southern region of Bangladesh

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Received: 29 December 2025; **Accepted:** 22 January 2026; **Published:** 15 February 2026

Background: Ocular surface homeostasis and tear film stability can be compromised after cataract surgery, leading to dry eye disease (DED), whose incidence may vary widely and is often ignored as-a knowledge gap in Bangladesh.

Objective: To determine the frequency, severity, and predictors of tear film instability (DED) following age-related cataract surgery in a tertiary hospital in Bangladesh.

Methods: A prospective observational study was conducted at Chittagong Medical College Hospital (CMCH) from January 2022 to June 2023 among 113 patients aged $\geq$40 years undergoing small-incision cataract surgery or phacoemulsification. Patients with pre-existing DED or ocular surface disease were excluded. Tear Film Break-Up Time (TBUT) and Schirmer's Test-1 (ST-1) were assessed before surgery and at 1 week, 1 month, and 3 months after surgery. Statistical analysis was performed using SPSS v25.0.

Results: Postoperative tear film instability peaked on day 7 (62.8%), declined to 39.8% on day 30, and was 12.4% on day 90 ($p < 0.001$). Mean TBUT and ST-1 values decreased significantly postoperatively but remained below baseline at 3 months. Incision length ($p = 0.048$) and longer microscope light exposure ($p = 0.022$) were independent predictors of tear film stability, while age, sex, surgical type, and cumulative dissipated energy (CDE) were not.

Conclusion: Cataract surgery causes a significant, but largely transient, reduction in tear film stability leading to DED, which peaks in the first postoperative week, with partial recovery by 3 months. Minimizing incision size and light exposure may reduce risk.

Keywords: Bangladesh, cataract surgery, dry eye disease, Schirmer's test, tear film, tear film break-up time.

Introduction

The emergence of visually symptomatic cataracts is prevalent, and it is the leading cause of treatable blindness worldwide (1). Despite scientific advances in cataract surgery that have enhanced the quality of life (QOL) of millions of individuals worldwide over the last half-century, there are possible challenges that can be both sight- and non-sight-threatening (2, 3). While the majority of scientific, clinical, and technical advancements are aimed at preventing vision-threatening conditions, it is crucial not to overlook the avoidance and mitigation of non-sight-threatening side effects, which can have a significant impact on patient QOL. One such example is dry eye disease (DED) (4, 5). A utility assessment study was carried out to measure the effect of DED on QOL and discovered that utility scores in DED were equal to those of angina patients or people who regularly receive dialysis (6).

In addition to the conventional risk factors for DED, it has been observed that several surgical procedures involving the anterior segment, such as cataract surgery, can either result in DED or exacerbate existing symptoms of tear film instability or dry eye. Factors that are responsible for the development of tear film instability or dry eye after cataract surgeries include immediate preoperative use of povidone iodine and topical anesthetics, the type of surgery, the site of the incision, incision length, repeated intraoperative ocular surface drying and irrigation, phototoxicity by the operating microscope, and postoperative prolonged use of antibiotic-steroid eye drops (7–10). Surgical procedures like cataract surgery cause denervation of the cornea, which results in impaired epithelial wound healing, increased epithelial permeability, decreased epithelial metabolic activity, and loss of cytoskeletal structures associated with cellular adhesion (11).

The incidence of dry eye after cataract surgery without preexisting DED has been reported to vary widely, from 9.8% to 91.7% (4, 12). Potential reasons for this are, differences in patient populations, varying diagnostic criteria for dry eye, or different surgical techniques and technologies used. A systematic review and meta-analysis found that among 775 patients without preexisting DED in nine identified studies, 206 (26.6%) individuals developed DED after cataract surgery, with a prevalence rate of 37.4% (13).

With the blessings of restoring sight and a smile to patients, modern cataract surgery has proven to be an effective tool. While the primary goal is clear vision, a comprehensive approach to patient care must also account for a patient's overall ocular comfort and surface health. However, the follow-up of tear film instability or dry eye symptoms after cataract surgery and analysis of correlating risk factors has not been undertaken adequately in Bangladesh. To fill this knowledge gap, the study was carried out with an aim to assess the frequency and severity of tear film instability, or DED, and its determinants and risk factors among patients undergoing cataract surgery at a tertiary care hospital in Bangladesh.

Methodology

This was a prospective observational study conducted at the Department of Ophthalmology of Chittagong Medical College Hospital (CMCH), the oldest and major tertiary referral center in the southern region of Bangladesh, from January 2022 to June 2023.

The study population included patients aged 40 years and older who were admitted for age-related cataract surgery and were consecutively enrolled after being screened for eligibility. Patients were excluded for pre-existing DED, use of certain topical or systemic medications known to cause dry eye, concurrent ocular pathologies affecting the surface, a history of ocular surgery on the operative eye within the previous 6 months, other ocular pathologies besides age-related cataract in the operative eye, and a history of specific systemic diseases associated with dry eye. Patients who experienced intraoperative or postoperative complications or refused to participate were also excluded from the study.

Data were collected via a structured questionnaire after obtaining informed written consent. A key part of the preoperative assessment was to screen for pre-existing DED using the Tear Film Break-Up Time (TBUT) and the Schirmer's Test-1 (ST-1). TBUT was measured by timing the tear film's stability after applying fluorescein, with an average of three readings used; a result of $\leq$10 seconds indicated DED. The ST-1, performed once, measured the wetting length of a Whatman No. 41 filter paper (5 mm $\times$ 35 mm) after 5 minutes, with a reading of $\leq$10 mm also indicating DED (14). All surgeries, either small incision cataract surgery (SICS) or phacoemulsification, were performed according to the patients' and surgeon's choice by multiple experienced surgeons. Postoperatively, dry eye assessments were repeated at 1 week, 1 month, and 3 months. The severity of DED was categorized as mild, moderate, or severe based on a combination of TBUT and ST-1 results (12). Mild DED was indicated by a TBUT between 6.1 and 10 seconds and an ST-1 reading of 5–10 mm. Moderate DED was defined by TBUT values of 3.1–6 seconds and ST-1 readings of 3–4 mm. Severe DED was diagnosed with TBUT values of 0–3 seconds and ST-1 readings of 0–2 mm.

Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean $\pm$ SD, and categorical variables as frequency and percentage. Group comparisons used the chi-square or Fisher's exact test for categorical data and the independent sample t-test for continuous data. A paired sample t-test was used to determine the significant mean difference between preoperative and postoperative values, respectively. A p-value < 0.05 was considered significant.

All study protocols were performed in accordance with the ethical guidelines of the Declaration of Helsinki, and ethical approval was taken before starting the study from the Ethical Review Committee of CMCH (Memo No. CMC/PG/2022/819 Dated 10/02/2022).

Results

The study included 113 patients with an average age of 57.7 ± 9.0 years (range 41–80). The gender distribution was nearly equal, with 52.2% male and 47.8% female patients. Most of participants were composed of housewives (46.9%) and farmers (23.0%), with service holders (12.4%), businessmen (9.7%), and retired service holders (8.0%) making up the remainder. Smokers were 52.2% and betel nut chewers 40.7% in the study population. The majority of patients (64.6%) reported no systemic morbidity, but hypertension (15.9%) was the most common pre-existing condition, followed by chronic respiratory disease (11.5%) and chronic kidney disease (9.7%) (**Table 1**).

The frequency of DED is highest on Day 7 after cataract surgery, affecting 62.8% of patients. This prevalence decreases over time, dropping to 39.8% by Day 30 and significantly to 12.4% by Day 90. Conversely, the number of patients without DED increases from 37.2% on Day 7 to 87.6% on Day 90 (**Figure 1**).

TBUT and ST-1 values declined significantly postoperatively, lowest at Day 30, with partial recovery by Day 90 (all $p < 0.001$) (**Figure 2**).

TABLE 1 | Demographic profile of study population (n = 113).

Variables		Frequency	Percentage
Age	Mean ± SD years	57.7 ± 9.0 years	
	Range	41–80 years	
Gender	Male	59	52.2
	Female	54	47.8
Occupation	Housewife	53	46.9
	Farmer	26	23.0
	Businessman	11	9.7
	Service holder	14	12.4
	Retired service holder	9	8.0
Smoking status	Non-smoker	54	47.8
	Smoker	59	52.2
Habits	Betel nut	46	40.7
	None	67	59.3
Systemic morbidities	Hypertension	18	15.9
	Chronic respiratory disease	13	11.5
	Chronic kidney disease	11	9.7
	None	73	64.6

Data were expressed as frequency and percent if not mentioned otherwise.
SD, Standard deviation.

Incision length correlated with postoperative DED ($p = 0.048$), highest in the 7.1–8.0 mm group (30.1%). Microscope light exposure was longer in the DED group (21.8 ± 3.6 minutes vs. 20.1 ± 3.5 minutes; $p = 0.022$). Age, sex, surgical type, and cumulative dissipated energy (CDE) were not significant predictors (**Table 2**).

Table 3 shows correlations between dry eye parameters and various patient and surgical variables. Among surgical factors, incision length and microscope light exposure time demonstrated a significant negative correlation with both tear film parameters. Age, sex, type of surgery, and CDE did not show significant associations.

On Day 7, the majority of DED cases are categorized as "mild" (31.9%) or "moderate" (27.4%). "Severe" cases are minimal at 3.5%. By Day 90, the prevalence of DED is low, with mild cases at 9.7% and moderate cases at 2.7%, and severe cases are not present on the graph (**Figure 3**).

Discussion

Although this study described postoperative "dry eye" changes, it is important to recognize that DED is a multifactorial condition involving tear film instability, Meibomian gland dysfunction, goblet cell loss, corneal nerve alteration, environmental influences, and hormonal factors. Our assessment was limited to tear film stability (TBUT) and tear secretion (ST-I), which represent only part of the complex DED spectrum. Therefore, the findings of this study more precisely reflect transient tear film instability following cataract surgery rather than the full diagnosis of DED.

A total of 225 patients were initially screened for eligibility in the study. Among them, 129 met the inclusion and exclusion criteria and were included in the study. Throughout the study period, the majority of patients admitted with age-related cataracts had a history of diabetes. As a result, the size of my sample was limited. Due to surgery-related complications, 8 patients were excluded from this study. Out of 121 operated cases of cataract patients, follow-up was done to evaluate tear film instability or DEDs. One patient at day 30 and 7 patients at day 90 were lost to follow-up. Hence, the study analysis was done on 113 patients.

The mean age of study participants was 57.7±9.0 years (range 41–80) (**Table 1**). The mean age of the DED group was slightly higher than the non-DED group (58.8 ± 8.8 vs. 56.1 ± 9.1 years; $p = 0.131$), but not significantly so (**Table 2**). The Beaver Dam eye research found a higher frequency of dry eyes and a connection with advancing age (15). The study population's sex distribution was male 59 (52.21%) and female 54 (47.79%), with a ratio of 1.09:1. Females had a higher rate of postoperative DED (54.5%) than males (45.5%), although this difference was not statistically significant ($p = 0.113$). The link between female sex and dry eye is extensively documented (16, 17). Sex hormones, particularly androgens, have been related to a high prevalence

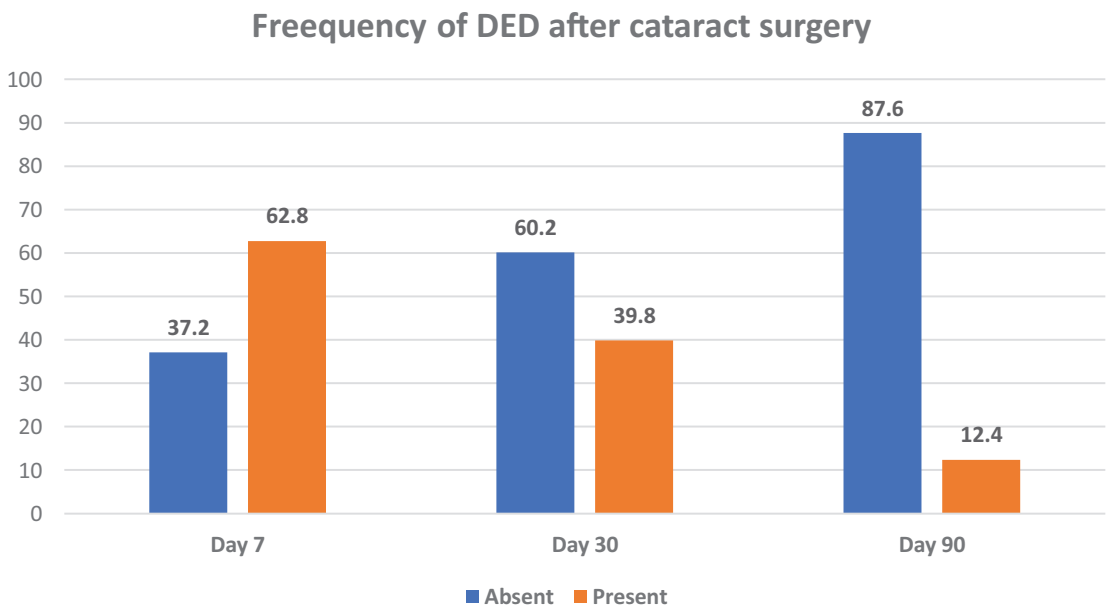

FIGURE 1 | Frequency of dry eye disease (DED) after cataract surgery.

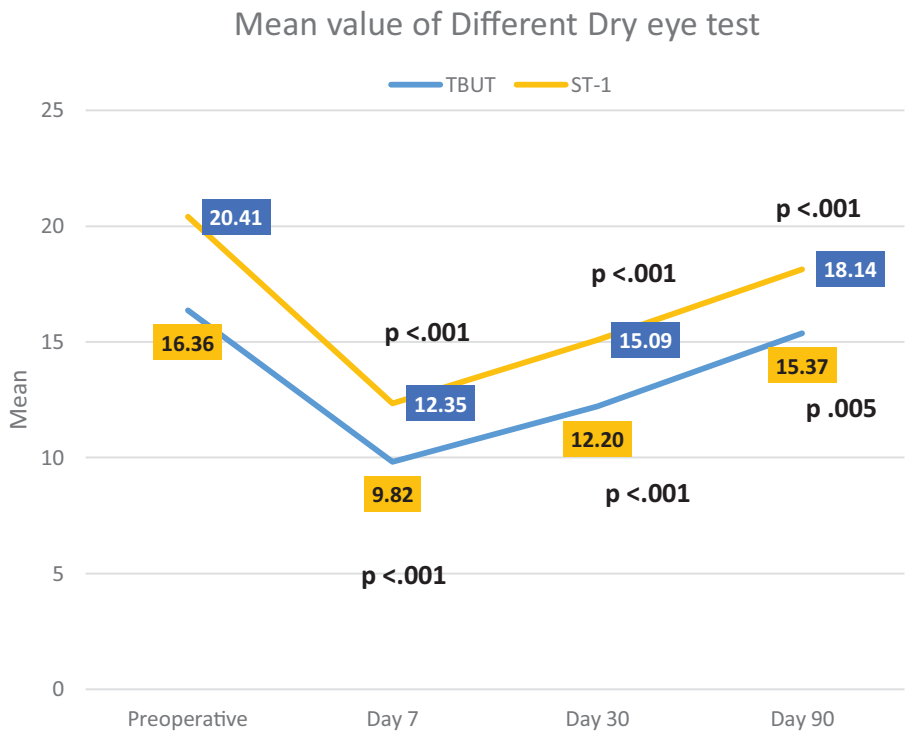

FIGURE 2 | Pattern of changes of dry eye test values following cataract surgery.

of dry eye symptoms in females, possibly due to hormonal impacts (18, 19).

The frequency of DED was highest in the immediate postoperative period and progressively decreased over time (**Figure 1**). On Day 7, DED was present in 62.8% of patients. This proportion decreased significantly to 39.8% by Day 30 and later to 12.4% by Day 90. Conversely, the percentage of patients without DED increased from 37.2% on Day 7 to 87.6% on Day 90, indicating a clear trend of ocular surface recovery in the three months following surgery. The lack of a gold standard test presents a challenge in determining dry eye (20). The report of dry eye occurring after cataract surgery in patients without DED has been documented to be highly varied, ranging between 9.8% and 91.7% (4, 12).

The objective measures support this trend, as mean TBUT and ST-1 scores have a statistically significant lower value on

TABLE 2 | Association of dry eye with demographic and surgical parameters in this study.

Variables		Dry Eye		p-value
		Absent (n = 42)	Present (n = 71)	
Age (in years)		56.1 ± 9.1	58.8 ± 8.8	0.131
Sex	Male	26 (61.9)	33 (46.5)	0.113*
	Female	16 (38.1)	38 (54.5)	
Type of surgery	SICS	25 (59.5)	53 (74.6)	0.093*
	Phacoemulsificaion	17 (40.5)	18 (25.4)	
Incision length (mm)	2.8	17 (30.9)	18 (25.4)	**0.048***
	6.0–7.0	20 (45.5)	31 (43.7)	
	7.1-8.0	5 (11.9)	22 (30.1)	
Microscopic light exposure time (minute)		20.1 ± 3.5	21.8 ± 3.6	**0.022****
CDE (%)		17.7 ± 3.8	19.7 ± 5.1	0.200**

*Chi-Square test; **Independent sample t test.
SICS, Small incision cataract surgery; CDE, Cumulative dissipated energy.

TABLE 3 | Correlation between dry eye parameters with demographic and surgical factors.

Variables		Mean TBUT (sec)	p-value	Mean Schirmer's (mm)	p-value
Age (years)		r = −0.182	0.056	r = −0.144	0.089
Sex	Male	15.9 ± 2.3	0.112	19.6 ± 2.7	0.097
	Female	15.3 ± 2.4		18.7 ± 3.0	
Type of surgery	SICS	15.1 ± 2.4	0.082	18.6 ± 3.0	0.090
	Phacoemulsification	15.8 ± 2.2		19.5 ± 2.9	
Incision length (mm)		r = −0.216	0.023*	r = −0.204	0.031*
Microscope light exposure (minute)		r = −0.238	0.018*	r = −0.221	0.022*
CDE, %		r = −0.121	0.184	r = −0.109	0.214

*Independent sample t-test categorical variables; Pearson correlation for continuous variables.

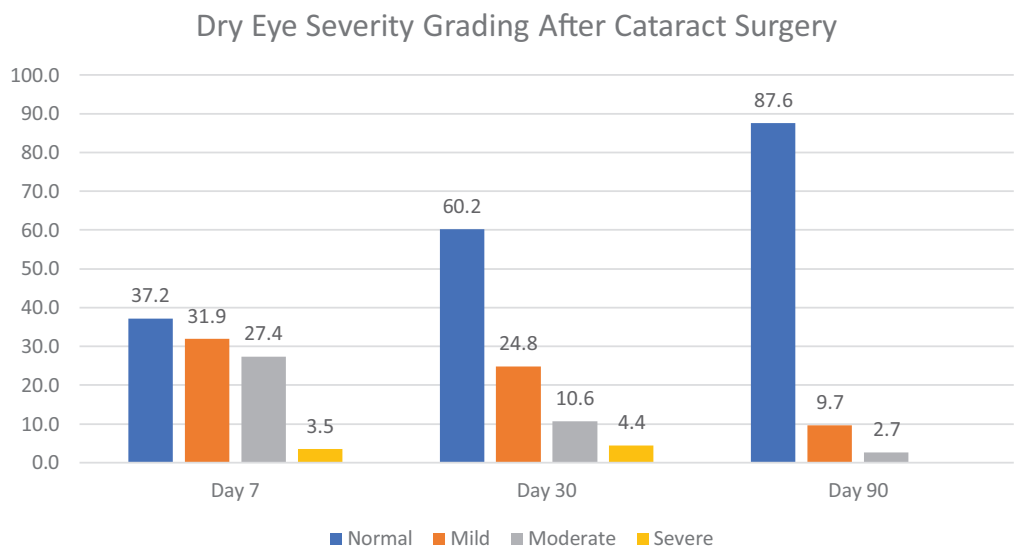

FIGURE 3 | Dry eye severity grading after cataract surgery.

Day 7 than on preoperative baselines ($p < 0.001$) (**Figure 2**). Despite this recovery, the mean values at Day 90 (15.37 sec. for TBUT and 18.14 mm for ST-1) remained below their preoperative levels (16.36 seconds and 20.41 mm, respectively), suggesting a partial but incomplete recovery of the tear film by 3 months. Additionally, on the basis of dry

eye severity, 64.8% of patients exhibited some degree of dry eye, with a distribution of 31.9% mild, 27.4% moderate, and 3.5% severe on day 7 (**Figure 3**). By Day 30, a progressive improvement was noted, as the proportion of patients with normal tear film increased to 60.2%, while the prevalence of mild, moderate, and severe dry eye decreased. This trend continued to Day 90, at which point 87.6% of patients had a normal dry eye grading, and the number of moderate and severe cases was drastically reduced to 2.7% and 0%, respectively. Similarly, most previous studies also reported a predominance of mild dry eye (53.32% by Venugopal and Krishnaraj; 85.8% by Kasetsuwan et al.; 27% by Ishrat et al.) (4, 5, 21). However, Jayashree et al. reported a predominance of severe dry eye (61.72%) (22). Several studies showed varying persistence of DED and ocular surface abnormalities ranging from 1 week to 12 months after cataract surgery (4, 23–25).

This transient nature of tear film instability or DED can be attributed to several factors. The first is the transection of corneal nerves, which happens when creating the corneoscleral tunnel and usually heals with time (26). Second, the surgery's infliction of ocular trauma—including cutting the conjunctiva, scraping the sclera, and fixing the limbus with toothed forceps—may prompt the release of inflammatory mediators that might hasten and exacerbate the development of dry eye (21). These inflammatory mediators tend to subside over time. Thirdly, topical medications like steroids with inherent preservatives are used at a much higher dosage in the first week of surgery and tapered over the following weeks (7). The observed improvement over time likely reflects the gradual healing of corneal nerves and the resolution of the inflammatory response.

Table 2 explores the relationship between postoperative DED and key surgical parameters. SICS was more common overall, performed in 69% of cases. Among those who developed DED, 53 patients (69%) underwent SICS and 18 (31%) underwent phacoemulsification. In the non-DED group, 25 (69.1%) had SICS and 17 (30.1%) had phacoemulsification. The difference in DED incidence between SICS and phacoemulsification was not statistically significant ($p = 0.093$). In a previous study, DED was noted in both types of surgeries (89.1% in SICS and 92.2% in phacoemulsification at day 7) (12). Incision length showed a significant association ($p = 0.048$): DED was most frequent with 6.0–7.0 mm (43.7%) incision length. Microscopic light exposure time was longer in the DED group (21.8 ± 3.6 minutes) than in the non-DED group (20.1 ± 3.5 minutes; $p = 0.022$). CDE was slightly higher in the DED group (19.7 ± 5.1%) than in those without DED (17.7 ± 3.8%), but not significant ($p = 0.200$). A key finding of our study is the statistically significant association between DED and two specific surgical parameters: incision length and microscopic light exposure time. In contrast, patient demographics (age, sex) and surgical modality (SICS vs. phacoemulsification) were not independent predictors, suggesting that surgical technique and intraoperative factors may outweigh baseline patient characteristics in influencing early postoperative DED risk. Although CDE trended higher in the DED group, the lack of significance indicates that ultrasound energy alone may not meaningfully contribute when modern phaco settings are used. These findings indicate that avoidance of surgical trauma, through adoption of smaller incision methods and optimization of surgical efficiency, may be a way of reducing postoperative DED.

The main advantage of this study is that it is prospective, with several postoperative evaluations, which allows examining the changes in tear film instability or DED in detail. It fills an important gap in regional knowledge and provides a basis on how to enhance the outcome of cataract surgery with regard to ocular surface health in Bangladesh. The clinical results indicate a significant yet transient decrease in the stability of the tear film and tear secretion in the first days of the postoperative phase of the cataract surgery. This is a highlight of the necessity of patient preoperative counseling and preventive management of the symptoms of dry eye, especially in the first week to month after surgery.

Limitation

A significant drawback was the limited sample size, which was mainly caused by high prevalence of diabetes among hospitalized patients with age-related cataract. The study was single-centered and multiple surgeons performed the surgeries. Moreover, patient-reported symptom scores were omitted and these might help to gain more knowledge on subjective outcomes.

Conclusion

A cataract surgery is known to be very effective in restoring vision, although there are cases where patients might develop symptoms of tear film instability, which might continue to hamper their daily lives for months after surgery. The reason is that surgery leads to a considerable, but mostly reversible decrease in the stability of the tear film. The results highlight the idea that surgical methods that reduce the trauma, including smaller incision approaches and improved operational effectiveness, can be employed to reduce the occurrence of postoperative DED.

Recommendation

Smaller incision techniques and minimizing microscope light exposure time during cataract surgery should be adopted to

reduce postoperative DED risk. Routine dry eye screening and management protocols are essential especially during the first postoperative month. Future research could explore additional determinants and risk factors for postoperative DED, particularly focusing on the specific inflammatory and nerve regeneration processes that contribute to the transient nature of DED, and investigate the effectiveness of targeted interventions to accelerate ocular surface recovery.

Data availability statement

The data that support the findings of this study are available upon request from the authors.

Author contributions

MSA: Conception and design of study, Acquisition of data, Drafting the manuscript, Critical review. KNM: Conception and design of study, Acquisition of data. SSM: Acquisition of data, Data analysis. PM: Data analysis, Drafting the manuscript. NER: Drafting the manuscript, Critical review. SFTF: Drafting the manuscript, Critical review.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Acknowledgments

All the authors expressed their heartfelt gratitude to all surgeons and stuff working in Ophthalmology Department of CMCH.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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