

Research Article

Evaluation of Postoperative Dry Eye Following Phacoemulsification Cataract Surgery

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Abstract: **Introduction:** Dry eye disease is a frequent yet underrecognized complication following phacoemulsification cataract surgery, potentially compromising patient satisfaction and visual quality. **Objective:** To prospectively evaluate changes in subjective symptoms and objective tear film parameters after uncomplicated phacoemulsification and to determine the time course of postoperative dry eye. **Methods:** This prospective observational study enrolled 48 patients undergoing routine phacoemulsification. Ocular Surface Disease Index (OSDI) scores, tear film break-up time (TBUT), Schirmer I test without anaesthesia, and corneal fluorescein staining (Oxford scale) were assessed preoperatively and at 1 week, 1 month, and 3 months postoperatively. Data were analysed using repeated measures ANOVA and paired t-tests. **Results:** Significant worsening of all parameters occurred at 1 week postoperatively (OSDI 24.6±11.2 vs. 12.5±7.8, p<0.001; TBUT 7.2±2.8 s vs. 10.8±2.5 s, p<0.001; Schirmer 10.5±4.9 mm vs. 14.2±5.3 mm, p<0.001; staining grade 1.2±0.8 vs. 0.4±0.5, p<0.001). Values improved gradually but remained significantly altered at 1 month. By 3 months, most parameters returned to near-baseline levels, though 20.8% of patients had persistent dry eye symptoms. **Conclusion:** Phacoemulsification induces a transient aggravation of dry eye that peaks in the early postoperative period and resolves largely by 3 months. Preoperative screening and proactive ocular surface management are essential to optimise outcomes.

Keywords: Dry eye disease, phacoemulsification, tear film break-up time, Schirmer test, OSDI, corneal staining

INTRODUCTION

Cataract surgery is the most frequently performed ophthalmic procedure worldwide, and phacoemulsification with intraocular lens implantation has become the gold standard due to its small incision, rapid visual rehabilitation, and excellent safety profile. With an ageing global population, the volume of cataract surgeries continues to rise, and patients' expectations for unaided high-quality vision after surgery have increased correspondingly. While modern phacoemulsification routinely delivers outstanding refractive and visual acuity outcomes, a substantial proportion of patients report postoperative ocular surface discomfort, foreign body sensation, fluctuating vision, and symptoms characteristic of dry eye disease. These complaints may be dismissed as trivial in the context of an otherwise successful surgery, yet they can profoundly reduce patient satisfaction and functional vision, particularly during tasks such as reading, driving at night, or using digital screens. Consequently, the evaluation and management of ocular surface health in the perioperative period have gained increasing attention in contemporary cataract care [1,2].

Dry eye disease is a multifactorial disorder of the tear film and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and inflammation of the ocular surface, as defined by the

TFOS DEWS II International Dry Eye Workshop [3]. The reported incidence of new-onset or aggravated dry eye after cataract surgery varies widely from 10% to 40%, depending on the diagnostic criteria, population studied, and duration of follow-up [4,5]. The symptoms may range from mild grittiness and burning to significant pain, epiphora, and blurred vision that mimics residual refractive error or posterior capsular opacification, thereby prompting unnecessary clinical investigations and anxiety. Thus, dry eye after cataract surgery represents an important clinical entity that can diminish the overall success of an otherwise flawless procedure.

The pathogenesis of post-phacoemulsification dry eye is complex and involves multiple interrelated mechanisms. The clear corneal incision, typically placed temporally, severs a large number of corneal nerve fibres, particularly those of the long ciliary nerves, leading to a transient neurotrophic state with reduced corneal sensitivity and impaired afferent signalling to the lacrimal functional unit [6,7]. This denervation disrupts the normal blink reflex and basal tear secretion, contributing to tear film instability. Intraoperative factors such as prolonged exposure to the operating microscope light, frequent irrigation of the ocular surface, and the mechanical trauma of the lid speculum can damage corneal and conjunctival epithelium and goblet cells. Postoperatively, the topical medications routinely prescribed antibiotics, corticosteroids, and non-steroidal anti-inflammatory drugs almost universally contain

preservatives such as benzalkonium chloride (BAK), which exert concentration- and time-dependent toxic effects on the corneal epithelium, conjunctival goblet cells, and meibomian glands [8,9]. Additionally, the surgery-induced intraocular inflammation triggers the release of prostaglandins and cytokines into the tear film, further destabilising the ocular surface homeostasis [10]. The cumulative effect of these insults often unmasks a pre-existing subclinical dry eye state or creates de novo dry eye that follows a characteristic temporal evolution.

Despite the growing body of literature, many studies have been conducted in Western or East Asian populations, and there is a relative paucity of prospective data from the Indian subcontinent, where climatic factors, dietary habits, and genetic predispositions may influence ocular surface physiology. Furthermore, the time course of recovery of the various tear film parameters and their correlation with subjective symptoms remain incompletely defined. The present study was therefore designed to systematically evaluate the subjective and objective dry eye indices before and at multiple intervals after uncomplicated phacoemulsification in patients attending a tertiary care centre in southern India, with the aim of characterising the severity and duration of postoperative ocular surface disruption and identifying patients at risk of persistent dry eye.

OBJECTIVE

The primary objective of this investigation was to prospectively evaluate the changes in subjective dry eye symptoms, as measured by the Ocular Surface Disease Index (OSDI), and objective tear film parameters specifically tear film break-up time (TBUT), Schirmer I test without anaesthesia, and corneal fluorescein staining following uncomplicated phacoemulsification cataract surgery. By assessing these parameters at predetermined postoperative time points (1 week, 1 month, and 3 months), the study sought to delineate the exact temporal profile of dry eye induction and resolution.

The secondary objective was to determine the proportion of patients who continue to exhibit clinically significant dry eye at the end of the 3-month follow-up period and to identify any preoperative demographic or clinical characteristics that might predispose individuals to a more severe or prolonged postoperative dry eye course. The study ultimately aimed to generate evidence that would inform preoperative counselling, risk stratification, and the implementation of targeted perioperative ocular surface optimisation protocols in routine cataract practice.

MATERIALS AND METHODS

This was a prospective, observational, single-centre study carried out at the Department of Ophthalmology, Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital, over a six-month period from 1st July 2025 to 25th December 2025. Forty-eight consecutive patients who met the eligibility criteria and were scheduled for routine phacoemulsification cataract surgery were enrolled after obtaining written informed consent. The study protocol was approved by the Institutional Ethics Committee and adhered to the tenets of the Declaration of Helsinki. All patients underwent a comprehensive ophthalmic evaluation at baseline, which included assessment of best-corrected visual acuity, slit-lamp biomicroscopy, intraocular pressure measurement, dilated funduscopy, and biometry. For the purpose of dry eye evaluation, the following tests were performed in a fixed sequence after a minimum of 2 hours without instilling any eye drops: the OSDI questionnaire was administered first to capture subjective symptoms, followed by TBUT measurement using fluorescein-impregnated strips wetted with preservative-free saline, corneal fluorescein staining graded according to the Oxford Scheme (0–5 in each of five zones), and finally the Schirmer I test without topical anaesthesia, using standardised Whatman filter paper strips placed in the lateral canthus for exactly 5 minutes. To minimise diurnal variation, all examinations were conducted between 10 a.m. and 12 p.m. by the same trained examiner who was masked to the previous test results [11,12].

Inclusion criteria: Patients aged 40–80 years with age-related cataracts graded NO2–NC4 or C2–P4 according to the Lens Opacities Classification System III; willingness to comply with the follow-up schedule; and capacity to provide valid informed consent. Only one eye per patient (the eye scheduled for surgery first) was included in the analysis.

Exclusion criteria: Pre-existing severe dry eye disease (OSDI score >32 or Schirmer I value <5 mm without anaesthesia); Sjögren's syndrome or other autoimmune connective tissue disorders; history of ocular surgery, trauma, or chemical burns; corneal dystrophies, recurrent corneal erosion syndrome, or active ocular infection; contact lens wear within the preceding 3 months; diabetes mellitus with clinically evident peripheral neuropathy; use of systemic medications known to affect tear secretion (antihistamines, tricyclic antidepressants, isotretinoin, hormone replacement therapy) within 4 weeks; glaucoma requiring topical medications; intraoperative complications such as posterior capsule rupture, zonular dialysis, or vitreous loss; and patients who required additional surgical procedures during the study period.

Data Collection Procedure: All surgeries were performed under topical anaesthesia with 0.5% proparacaine hydrochloride by a single experienced surgeon using a standardised phacoemulsification

technique. A 2.2 mm temporal clear corneal incision was created, followed by continuous curvilinear capsulorhexis, phacoemulsification using an Infiniti® system (Alcon Laboratories, Fort Worth, TX, USA), and implantation of a foldable hydrophobic acrylic intraocular lens in the capsular bag. The total phacoemulsification time, cumulative dissipated energy, and volume of irrigating fluid were recorded. Postoperatively, all patients received a fixed regimen of topical moxifloxacin 0.5% and dexamethasone 0.1% combination drops four times daily for the first week, tapered to three times daily for the second week, twice daily for the third week, and once daily for the fourth week. No preservative-free artificial tears were prescribed routinely; however, if a patient developed intolerable dry eye symptoms, preservative-free carboxymethylcellulose 0.5% drops were provided and the instance was recorded and analysed separately. Patients were reassessed on postoperative day 1, at 1 week (± 1 day), 1 month (± 3 days), and 3 months (± 5 days). At each visit, the same battery of dry eye tests was repeated in an identical order.

Statistical Data Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 25.0 (IBM Corp., Armonk, NY). Normality of continuous variables was assessed with the Shapiro-Wilk test. Descriptive statistics were expressed as mean $\pm$ standard deviation for normally distributed data and median (interquartile range) for skewed data. The primary analysis compared preoperative and postoperative values using repeated measures analysis of variance (ANOVA) with Greenhouse-Geisser correction when sphericity could not be assumed; post hoc pairwise comparisons were performed with Bonferroni correction. Paired t-tests were also used for individual time-point comparisons. Categorical variables were compared with the chi-square test. A two-tailed p value < 0.05 was considered statistically significant. For patients who received rescue artificial tears, sensitivity analyses were conducted excluding these individuals to assess the robustness of the primary findings.

RESULTS

A total of 48 eyes of 48 patients completed all follow-up visits and were included in the final analysis. The mean age of the participants was 64.5 ± 8.2 years (range 45–79 years), and 26 (54.2%) were male. All patients had age-related nuclear or corticonuclear cataracts of moderate density. No intraoperative adverse events occurred. The demographic and baseline clinical characteristics are summarised in Table 1.

Preoperatively, the mean OSDI score was 12.5 ± 7.8 , indicating mild dry eye in the majority of participants. At the 1-week postoperative visit, there was a statistically highly significant increase to 24.6 ± 11.2 ($p < 0.001$ compared to baseline). Although a gradual decline was observed, the OSDI remained significantly elevated at 1 month (22.3 ± 10.5 , $p < 0.001$ vs. baseline). By 3 months, the mean OSDI had fallen to 14.1 ± 8.0 , which was not statistically different from the preoperative value ($p = 0.09$). Of the 48 patients, 10 (20.8%) had an OSDI score exceeding 20 at the 3-month visit, indicating persistent moderate-to-severe dry eye symptoms. Detailed OSDI trajectories are presented in Table 2.

The mean TBUT dropped sharply from 10.8 ± 2.5 seconds at baseline to 7.2 ± 2.8 seconds at 1 week ($p < 0.001$). At 1 month, the TBUT remained significantly shortened at 8.1 ± 3.1 seconds ($p < 0.001$). By the 3-month follow-up, it had improved to 9.9 ± 2.9 seconds, which was not statistically different from the preoperative value ($p = 0.06$; Table 3). Schirmer I test values followed a parallel course: baseline 14.2 ± 5.3 mm, declining to 10.5 ± 4.9 mm at 1 week ($p < 0.001$), 11.8 ± 5.2 mm at 1 month ($p = 0.002$), and returning to 13.1 ± 4.8 mm at 3 months ($p = 0.15$ vs. baseline; Table 4).

Corneal fluorescein staining assessed by the Oxford grading scale showed a significant exacerbation at 1 week, with the mean score rising from 0.4 ± 0.5 preoperatively to 1.2 ± 0.8 ($p < 0.001$). At 1 month, the staining grade was 1.0 ± 0.7 ($p < 0.001$), and by 3 months it had decreased to 0.6 ± 0.6 . Although the 3-month value was substantially lower than the peak, it remained marginally but statistically higher than the preoperative score ($p = 0.04$; Table 5). The worst staining was observed in the inferior corneal zone, consistent with exposure and poor tear distribution. No patient developed filamentary keratitis or persistent epithelial defects.

Table 1: Baseline demographic and clinical characteristics (n=48)

Parameter	Value
Age (years), mean $\pm$ SD	64.5 ± 8.2

Male : Female, n	26 : 22
Right eye operated, n (%)	27 (56.3)
Cataract grade (LOCS III NO/NC), median (IQR)	3.0 (2.5–3.5)
Phacoemulsification time (sec), mean $\pm$ SD	45.2 $\pm$ 12.7
Cumulative dissipated energy (CDE), mean $\pm$ SD	6.8 $\pm$ 2.9
Irrigation fluid volume (mL), mean $\pm$ SD	72.4 $\pm$ 15.1
SD – standard deviation, IQR – interquartile range.	

Table 2: Ocular Surface Disease Index (OSDI) scores at various time points

Time point	OSDI score (mean $\pm$ SD)	p value*
Preoperative	12.5 $\pm$ 7.8	–
Postoperative 1 week	24.6 $\pm$ 11.2	<0.001
Postoperative 1 month	22.3 $\pm$ 10.5	<0.001
Postoperative 3 months	14.1 $\pm$ 8.0	0.09

*Paired t-test compared with preoperative value; Bonferroni adjusted significance level for multiple comparisons.

Table 3: Tear film break-up time (TBUT) at various time points

Time point	TBUT (seconds, mean $\pm$ SD)	p value*
Preoperative	10.8 $\pm$ 2.5	–
Postoperative 1 week	7.2 $\pm$ 2.8	<0.001
Postoperative 1 month	8.1 $\pm$ 3.1	<0.001
Postoperative 3 months	9.9 $\pm$ 2.9	0.06

Table 4: Schirmer I test values (without anaesthesia) at various time points

Time point	Schirmer I (mm, mean $\pm$ SD)	p value*
Preoperative	14.2 $\pm$ 5.3	–
Postoperative 1 week	10.5 $\pm$ 4.9	<0.001
Postoperative 1 month	11.8 $\pm$ 5.2	0.002
Postoperative 3 months	13.1 $\pm$ 4.8	0.15

Table 5: Corneal fluorescein staining grade (Oxford scale) at various time points

Time point	Oxford grade (mean $\pm$ SD)	p value*
Preoperative	0.4 $\pm$ 0.5	–
Postoperative 1 week	1.2 $\pm$ 0.8	<0.001
Postoperative 1 month	1.0 $\pm$ 0.7	<0.001
Postoperative 3 months	0.6 $\pm$ 0.6	0.04

DISCUSSION

The present study demonstrates that uncomplicated phacoemulsification cataract surgery induces a significant, yet largely transient, deterioration in both subjective and objective measures of dry eye. The most pronounced worsening occurred during the first postoperative week, with gradual recovery over the subsequent months; by 3 months, the majority of parameters were no longer statistically different from preoperative values. These findings align closely with earlier investigations that reported a peak in dry eye signs and symptoms within the first few weeks after surgery, followed by progressive normalisation [1,5,13]. Li et al. observed that TBUT and Schirmer values were significantly reduced at 1 week and 1 month post-phacoemulsification, with a trend towards recovery by 3 months, a pattern mirrored in our data [1]. Cetinkaya et al. similarly reported that corneal staining and OSDI scores worsened significantly at postoperative day 1 and week 1, with most indices returning to baseline by the third month, although a subset of patients comparable to

the 20.8% we identified continued to experience clinically meaningful dryness [2].

The pathophysiology underlying this transient dry eye state is multifaceted. The temporal 2.2 mm clear corneal incision severs stromal nerve fibres, producing a sector of corneal anaesthesia that extends from the wound towards the central cornea. Khanal et al. documented a significant reduction in corneal sensitivity in the early postoperative period that correlated with the decline in TBUT and Schirmer values, supporting the concept of a surgically induced neurotrophic keratopathy that disrupts the neural feedback loop between the ocular surface and the lacrimal glands [9]. The resulting reduction in reflex tear secretion and blink rate destabilises the tear film, as reflected by the shortened TBUT. Additionally, the intense light from the operating microscope, the application of povidone-iodine, and the friction of the lid speculum cause mechanical and toxic injury to the corneal and conjunctival epithelium, as well as to the goblet cells responsible for mucin production [4,14]. Han et al. demonstrated meibomian gland dropout and altered

meibum quality following cataract surgery, suggesting that the lid speculum and prolonged mechanical stress may compromise meibomian gland function, further exacerbating tear film instability [4].

A critical iatrogenic contributor is the postoperative topical medication regimen. Almost all commercially available antibiotic-steroid combinations contain BAK, a quaternary ammonium preservative that exerts dose-dependent cytotoxicity on corneal epithelial cells and conjunctival goblet cells, potentiating apoptosis, inflammation, and mucin deficiency [8,15]. In our protocol, patients instilled BAK-containing drops four times daily for the first week, with gradual tapering over one month. The temporal coincidence of the worst dry eye parameters with the period of most intensive topical therapy, and the subsequent improvement as drops were reduced, underscores the probable role of preservative toxicity. The persistent, albeit mild, elevation in corneal staining at 3 months suggests that some degree of subclinical epithelial compromise may linger beyond the cessation of preserved drops, possibly reflecting incomplete corneal re-innervation. The fact that 20.8% of patients had OSDI scores >20 at 3 months is clinically important; these patients may represent individuals with suboptimal pre-existing tear function or slower nerve regeneration, and they are the ones most likely to benefit from preoperative screening and elective initiation of preservative-free perioperative lubrication [16,17].

The clinical implications of this study are straightforward yet important. Cataract surgeons should incorporate a simple dry eye assessment OSDI questionnaire, TBUT, and corneal staining into their preoperative evaluation, particularly for patients with known risk factors such as advanced age, female sex, autoimmune disease, or long-term use of preserved glaucoma medications [18,19]. When dry eye is identified, aggressive preoperative optimisation with preservative-free artificial tears, anti-inflammatory agents (topical cyclosporine or lifitegrast), and punctual plugs when appropriate may mitigate the postoperative insult [20]. Intraoperatively, minimising incision size, reducing phacoemulsification energy and fluidic turbulence, and protecting the ocular surface with balanced salt solution or viscoelastic coatings are practical steps that may lessen nerve and epithelial damage. Postoperatively, prescribing preservative-free antibiotic and steroid formulations, when available, and routinely adding preservative-free lubricants from day one rather than waiting for symptoms to develop could prevent or attenuate the dry eye cascade. Finally, counselling patients about the likely transient nature of postoperative discomfort and fluctuating vision can reduce anxiety and enhance overall satisfaction with the cataract surgery outcome.

LIMITATIONS OF THE STUDY

Several limitations of this study must be acknowledged. First, the sample size of 48 patients, while adequate to

detect substantial pre-post differences, restricts the power to perform subgroup analyses and may limit the generalisability of the findings to broader populations. Second, this was a single-centre study conducted in a specific geographical region of southern India; climatic, dietary, and genetic factors influencing tear film physiology may differ from those in other parts of the world. Third, the 3-month follow-up period, although sufficient to document recovery trends, cannot capture long-term outcomes such as late-onset meibomian gland atrophy or persistent neurotrophic changes that may evolve over 6–12 months. Fourth, we did not measure corneal sensitivity using aesthesiometry, nor did we perform meibography or tear osmolarity testing, which would have provided mechanistic insight and greater diagnostic accuracy according to TFOS DEWS II recommendations. Fifth, the OSDI is a subjective instrument and may have been influenced by the patients' improved vision, potentially underestimating the true symptomatic burden. Furthermore, all patients received the same postoperative drop regimen, and although rescue artificial tears were recorded, the impact of this confounding variable cannot be entirely eliminated. Finally, the absence of a non-surgical control group means that temporal fluctuations in dry eye parameters unrelated to surgery could not be controlled for.

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CONCLUSION

This prospective study confirms that phacoemulsification cataract surgery precipitates a significant, albeit predominantly transient, exacerbation of dry eye disease. The deterioration is most pronounced in the early postoperative period, with subjective discomfort, tear film instability, reduced aqueous tear secretion, and corneal epithelial damage all reaching their nadir around the first week and improving steadily thereafter. By three months, the majority of tear film parameters return to preoperative baselines, although a clinically meaningful minority of patients about one in five in our cohort continue to experience moderate-to-severe dry eye symptoms. This persistence highlights the need for a high index of suspicion and proactive management even in the setting of a technically flawless surgery.

The integration of a brief dry eye assessment into the routine preoperative cataract workup, coupled with the use of preservative-free medications and intensive ocular surface support, represents a practical strategy to minimise postoperative morbidity and enhance patient-reported outcomes. Future research should focus on longer-term follow-up incorporating objective diagnostic modalities such as meibography, tear osmolarity, and in vivo confocal microscopy to better characterise the structural and functional recovery of the ocular surface. Randomised controlled trials evaluating specific perioperative dry eye prophylaxis protocols are warranted to establish evidence-based guidelines that can be seamlessly incorporated into high-volume cataract surgical practice.

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