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REVIEW

A Practical Approach for Optimizing Ocular Surface Status Before Cataract Surgery to Improve Visual Outcomes and Reduce the Risk of Postoperative Dry Eye

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ABSTRACT

Dry eye disease (DED) is highly prevalent among patients undergoing cataract surgery but is frequently underdiagnosed. Its presence can significantly affect preoperative biometric measurements and intraocular lens (IOL) power calculations, along with postoperative outcomes, particularly in patients receiving premium IOLs. Identifying and managing ocular surface disease (OSD) before surgery presents a valuable opportunity to optimize the ocular surface, reduce the risk of refractive surprises, and enhance both visual quality and patient satisfaction. This review summarizes current evidence on the prevalence of DED in patients with cataract, its impact on surgical planning and outcomes, and further outlines a practical approach for preoperative evaluation and optimization. Key strategies include risk stratification, targeted diagnostics, and individualized treatment regimens. Incorporating ocular surface assessment and treatment into the routine preoperative workflow is both feasible and essential in the context of modern cataract surgery. A structured, multimodal approach to DED management can significantly improve surgical precision and long-term visual outcomes.

Keywords: Dry eye disease; DED; Cataract surgery; Ocular surface optimization; Intraocular lens calculation

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Key Summary Points

Dry eye disease (DED) is highly prevalent but frequently underdiagnosed in patients undergoing cataract surgery, despite its significant impact on preoperative measurements, surgical planning, and postoperative visual outcomes.

Preoperative identification and classification of ocular surface disease (OSD) through risk stratification and targeted diagnostics is essential for reducing the risk of refractive surprises and enhancing patient satisfaction.

A structured, multimodal approach to ocular surface optimization, including tear supplementation, inflammation control, and meibomian gland dysfunction (MGD) management, can significantly improve ocular surface stability and surgical precision.

Integrating ocular surface evaluation and treatment into the routine preoperative workflow is both practical and necessary to meet the refractive expectations of candidates for modern cataract surgery.

INTRODUCTION

Cataract surgery is one of the most successful and cost-effective ophthalmic procedures, with approximately 3.8 million cases annually in the USA, over 4.3 million in Europe, and more than 20 million worldwide [1]. It delivers excellent outcomes and rapid recovery [2]; however, as modern cataract surgery increasingly aims for spectacle independence and refractive precision, ocular surface disease (OSD), and particularly dry eye disease (DED), has become a critical preoperative consideration.

According to the TFOS DEWS III, the prevalence of DED, based on TFOS DEWS II diagnostic criteria, ranges from 5.4% to 44.2%, with higher rates observed in females and with advancing age [3]. Despite its high prevalence, DED remains frequently underdiagnosed in patients with cataract [4]. Cataract surgery, through light exposure, incisions, and topical medications, can transiently or permanently impair the ocular surface. The restoration of ocular surface homeostasis or the progression to a transient or chronic dysfunction depends on the adaptive capacity of the ocular surface system to counteract the surgical noxa. In cases of a healthy ocular surface, the system is more likely to adapt effectively to surgical stress, promoting recovery and maintaining ocular surface homeostasis; conversely, in eyes with undiagnosed and untreated preoperative DED, the ocular surface will exhibit an impaired ability to counteract the detrimental effect of the surgery, leading to a higher risk of postoperative DED [5–7] (Fig. 1). Moreover, preoperative DED may lead to variability in corneal measurements and inaccuracies in intraocular lens (IOL) power calculations [4, 8, 9]. This is especially problematic when planning for premium IOLs, where small biometric errors can translate into significant postoperative dissatisfaction.

Despite the well-documented impact of OSD on surgical outcomes, routine screening remains underutilized. In a survey conducted by the American Society of Cataract and Refractive Surgery (ASCRS), over 90% of cataract surgeons acknowledged the influence of DED on patient satisfaction. However, fewer than10% reported routine use of point-of-care tests such as tear osmolarity or MMP-9 preoperatively [10]. More recently, a UK-based survey found that approximately two-thirds of clinicians involved in cataract surgery care performed some form of DED assessment before surgery, most commonly fluorescein staining and/or tear break-up time (TBUT). Despite this, objective testing was rarely complemented by formal evaluation of patient-reported symptoms, with dry eye questionnaires employed in only 4% of cases [11]. This gap highlights the need for streamlined, evidence-based protocols to efficiently identify and manage OSD in patients with cataracts.

Optimizing the ocular surface before surgery is both feasible and essential, and incorporating targeted diagnostics and timely treatment can improve measurement accuracy, reduce postoperative symptoms, and enhance overall patient satisfaction. This review highlights the key challenges posed by a suboptimal ocular

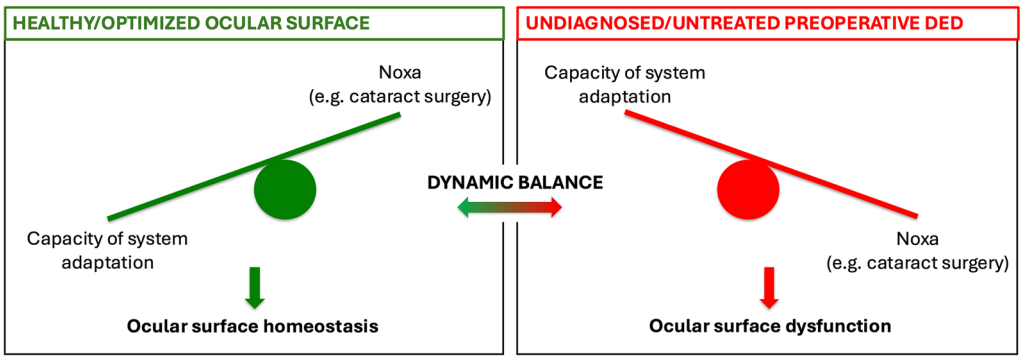

Fig. 1 Schematic representation of the dynamic balance of the ocular surface in response to external insults (e.g., cataract surgery). The outcome, either restoration of ocular surface (OS) homeostasis or progression to dysfunction, depends on the adaptive capacity of the ocular surface system. In cases of a well-optimized preoperative ocular surface, the system is more likely to adapt effectively to surgical stress, promoting recovery and maintaining OS homeostasis. Conversely, in eyes with untreated preoperative dry eye disease (DED), the ocular surface exhibits a reduced ability to adapt, leading to a higher risk of postoperative ocular surface dysfunction

surface prior to cataract surgery and presents an up-to-date overview of preoperative risk stratification, ocular surface screening and optimization strategies.

MATERIALS AND METHODS

A comprehensive literature search was conducted using the PubMed, Scopus, and Google Scholar databases to identify relevant English-language studies and reviews. No date restrictions were applied. The initial search was performed on 30 April 2025 and updated on 25 July 2025 to capture any newly published studies. The search strategy employed the following keywords: "(cataract surgery OR phacoemulsification) AND (dry eye OR iatrogenic dry eye OR ocular surface OR tear film OR meibomian glands)". The primary focus was on studies evaluating the impact of preoperative dry eye disease on postoperative outcomes, as well as those addressing risk stratification and ocular surface optimization strategies prior to cataract surgery. Only articles published in English were included. Titles and abstracts of all retrieved articles were screened for relevance, followed by a full-text review of selected studies. In addition, the reference lists of included articles were reviewed to identify further pertinent publications. Inclusion criteria were: (i) original studies or reviews involving human subjects, (ii) studies evaluating dry eye disease in the context of cataract surgery, and (iii) articles addressing preoperative management or outcomes. Exclusion criteria included: (i) case reports, letters, or editorials; (ii) studies not specifically focused on dry eye or the ocular surface in the context of cataract surgery; and (iii) duplicate publications.

To broaden the scope, the search strategy was subsequently expanded by adding keywords related to preoperative ocular surface treatments, combined with "(cataract surgery OR phacoemulsification)".

This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

PREVALENCE OF DRY EYE DISEASE IN PATIENTS WITH CATARACT

DED is common in the aging population but often underdiagnosed in candidates for

cataract surgery. Hallmark symptoms like grittiness or discomfort are familiar, while fluctuating or blurry vision during visual tasks may be mistakenly attributed to cataracts rather than to DED [12, 13].

The prevalence of DED in the general adult population varies depending on the diagnostic criteria used but has been reported to be as high as 44.2% based on TFOS DEWS II definitions, with higher rates observed among older adults [3]. Notably, studies show that a significant proportion of patients scheduled for cataract surgery exhibit clinical signs of DED, even in the absence of symptoms. Gupta et al. found that 80% of patients had at least one abnormal ocular surface test, including elevated tear osmolarity and matrix metalloproteinase-9 (MMP-9) levels and, surprisingly, frequencies were even higher in the asymptomatic patients, who showed at least one abnormal tear test in 85% of cases [4]. Similarly, Trattler et al. reported that 62% of patients had TBUT ≤ 5 s and 77% had positive corneal staining despite minimal complaints [8]. Meibomian gland dysfunction (MGD), the most prevalent DED subtype, has also been widely observed. Cochener et al. found that 52% of patients with cataract had MGD [14], and Yeu et al. reported meibomian gland atrophy in over 95% of their cohort. Notably, half of these patients were asymptomatic [15]. Additional evidence has been reported by a recent Norwegian study that, using TFOS DEWS II criteria, found that 55% of patients with cataract had undiagnosed DED, with meibomian gland dropout and shortened non-invasive Keratograph break-up time (NIKBUT) as the prevalent findings [16]. Similarly, Giannaccare et al. found that all patients in their cohort had at least one ocular surface abnormality, with 55% meeting criteria for DED [17].

Taken together, these studies suggest that DED, often asymptomatic, affects most patients presenting for cataract surgery, and incorporating noninvasive diagnostic tools such as osmolarity testing, NIKBUT, and meibography into preoperative evaluations may enhance the accuracy of diagnosis.

PREOPERATIVE DRY EYE AS A RISK FACTOR FOR POSTOPERATIVE DRY EYE

Cataract surgery can transiently disrupt ocular surface homeostasis by exacerbating tear film hyperosmolarity, initiating inflammatory cascades, impairing neurosensory function, and inducing temporary dysfunction of the lacrimal and meibomian glands. These alterations are frequently magnified in eyes with pre-existing DED [18, 19].

Patients with established DED were reported to be significantly more likely to experience pronounced postoperative symptoms [18, 19]. Several preoperative parameters have been identified as predictive of postoperative DED, including reduced TBUT [7, 20, 21], increased corneal fluorescein staining (CFS) [20, 21], conjunctivochalasis [21], Schirmer I scores [21], and elevated tear osmolarity. [22] Park et al. demonstrated that patients with preoperative DED exhibited poorer surgical outcomes, characterized by lower TBUT, increased lid margin abnormalities, and compromised meibum quality, in addition to stronger correlations between inflammatory mediators (e.g., Interleukin (IL)-6) and symptom severity [18].

MGD also plays a critical role due to its established association with tear film instability, increased evaporation, and hyperosmolarity [7, 21, 23–26]. Cataract surgery often exacerbates MGD, leading to a further decline in TBUT and increased CFS postoperatively [25]. Moreover, patients with preoperative MGD demonstrated significant postoperative increases in inflammatory mediators, which were closely associated with ocular surface deterioration [27]. A recent meta-analysis involving 2247 eyes reported a significant postoperative reduction in tear film stability as measured by an average decline in TBUT, an effect that was more pronounced in patients with preoperative MGD (− 2.27 s; $p < 0.001$) [28]. While surface staining typically shows minimal change following surgery, a moderate increase was observed in patients with MGD (+ 0.90 points) [28].

Although tear film stability tends to normalize by 3 months postoperatively [29, 30], a substantial proportion of patients, particularly those with baseline OSD, continue to experience symptoms beyond 3–6 months [6, 7, 31].

Importantly, postoperative DED is not limited to individuals with pre-existing disease. In a prospective study of 100 eyes, Sahu et al. observed a consistent deterioration across all dry eye parameters following phacoemulsification, accompanied by the onset of new ocular surface symptoms [32]. Similarly, Li et al. reported a significant increase in postoperative DED incidence within the first 3 months among patients with no prior clinical signs of dry eye [33]. Supporting these findings, a recent meta-analysis estimated that approximately 37% of patients without pre-existing DED developed the condition after cataract surgery [34].

Collectively, these findings underscore that while postoperative DED may develop in any patient, the risk is markedly elevated in those with preoperative DED or MGD.

PREOPERATIVE DRY EYE AND ITS EFFECT ON BIOMETRIC PRECISION IN CATARACT SURGERY

Accurate measurement of corneal refractive power is fundamental for IOL power calculation in cataract surgery [35]. The anterior corneal surface contributes approximately two-thirds of the total refractive power, making its precise assessment crucial to achieving optimal visual outcomes [36]. As cataract surgery has evolved toward refractive precision and postoperative spectacle independence, minimizing biometric error has become a clinical priority [35, 37]. According to the Royal College of Ophthalmologists, biometry outcomes are considered excellent when at least 85% and 55% of eyes achieve a postoperative refraction within ± 1.00 and ± 0.50 diopter (D) of the target, respectively [38]. While these thresholds are based on standard IOLs, studies on premium IOLs report spectacle independence rates ranging from approximately 73% to over 90%, depending on the IOL type and design [39, 40]. In this context, undiagnosed or subclinical DED represents a significant barrier to achieving these outcomes [9, 41–44].

The TFOS DEWS II report emphasizes that even in the absence of overt symptoms, objective signs such as reduced TBUT or increased tear osmolarity can compromise ocular surface regularity, thereby undermining the accuracy of optical measurements [45]. This is particularly relevant for modern biometry platforms, which utilize swept-source optical coherence tomography (SS-OCT) and rely on light reflection from the anterior corneal surface, where the tear film serves as the primary optical interface [46–48]. Thus, a stable and uniform tear film is critical for acquiring reliable keratometric readings.

In fact, tear film disruption in DED introduces irregularities on the optical surface due to mechanisms including hyperosmolarity, inflammation, and epithelial damage [45]. These factors contribute to increased variability in key biometric parameters [9]. Epitropoulos et al. demonstrated that eyes with hyperosmolar tear film (mean osmolarity 327.8 ± 10.5 mOsm/l versus 301.1 ± 4.9 in controls) exhibited significantly poorer repeatability in keratometry and greater variability in IOL power calculations. Notably, 10% of hyperosmolar eyes showed IOL power fluctuations exceeding 0.50 D between repeated measurements 3 weeks apart, with astigmatic variability surpassing 1.00 D more frequently than in normal eyes and reaching values up to 5.50 D [9].

Similarly, Jiang et al. found that tear film instability, as assessed using the Keratograph 5 M, was associated with significantly increased variability in flat keratometry (Kf), mean keratometry (K), total keratometry (TK), and total corneal astigmatism (TCA) [49]. This variability translated into clinically meaningful differences in IOL power calculations, especially when using formulas that heavily weight anterior corneal curvature, such as SRK/T [49, 50]. These findings reinforce the critical role of preoperative tear film stability in achieving precise refractive outcomes.

Beyond static tear film deficiencies, dynamic instability, particularly blink-related fluctuations, adds another layer of complexity to keratometric accuracy. Mrukwa et al. demonstrated that corneal astigmatism can change measurably

within seconds of a blink, emphasizing the importance of standardizing blink timing during measurement [51]. Holly and Goto et al. further explained that localized thinning and the development of dry spots on the ocular surface disrupt the smooth refractive interface of the tear film, thereby inducing fluctuations in corneal power [52, 53]. Erdélyi et al. observed that the Surface Regularity Index (SRI) increased steadily during the 60 s following a blink, highlighting the rapid deterioration of optical surface quality in the absence of tear film renewal [54]. Additionally, Koh et al. showed that the presence of central superficial punctate keratitis (SPK) in patients with dry eyes determined significantly higher post-blink total ocular higher-order aberrations (HOAs) compared to dry eyes without central SPK [55].

Even in healthy eyes, Németh and Erdélyi showed that measurement repeatability declines as time elapses after a blink [54, 56, 57]. More recent studies indicated that eyes with more advanced tear film instability, such as those classified as noninvasive break-up time (NIBUT) level 2, demonstrated higher SRI and Surface Asymmetry Index (SAI) values compared to those at level 1. While short-term improvement in surface regularity has been observed following the instillation of low-concentration sodium hyaluronate, this effect is often modest and temporary [58].

Interestingly, not all imaging devices seem to be equally affected by tear film instability. Studies by Doğan et al. and Güven reported high repeatability of anterior segment measurements in patients with DED using the Sirius and Pentacam devices [59, 60]. These systems utilize Scheimpflug imaging to directly capture corneal architecture, making them less reliant on tear film integrity than devices like the IOLMaster 700, which depend on anterior surface reflection [61]. Nonetheless, caution is still warranted, as severe dry eye can degrade image quality and compromise measurement reliability, even with Scheimpflug-based systems [62, 63].

The influence of tear film instability on IOL power calculation also depends on the formula used. Traditional formulas such as SRK/T, which place considerable emphasis on anterior corneal curvature, are particularly vulnerable to variability in keratometric values. In contrast, modern formulas like Barrett Universal II and Haigis incorporate additional biometric parameters, such as posterior corneal curvature, anterior chamber depth, and predicted lens position, making them less susceptible to noise introduced by an irregular tear film [50]. In a prospective cohort study by Jiang et al., patients with unstable tear film showed significantly greater variability in IOL power calculations between two repeated measurements taken 10 min apart when using the SRK/T formula. In contrast, power predictions remained more consistent with the Barrett Universal II and Haigis formulas, suggesting that these modern formulas are more robust against surface irregularities caused by DED [49]. Further supporting this, Kim et al. found a more pronounced reduction in the mean absolute prediction error for the SRK/T formula after ocular surface optimization, compared to the Barett Universal II [64]. This suggests that pretreatment of DED led to more accurate keratometric values, which in turn had a greater corrective impact on the formula most sensitive to tear film-related errors [64]. Nonetheless, no IOL formula can compensate for poor-quality biometry. Even the more advanced formulas, while less affected by surface instability, demonstrated improved accuracy following ocular surface optimization [64], reinforcing the importance of managing DED before performing preoperative measurements. These findings underscore the importance of identifying and managing tear film instability preoperatively to ensure accurate IOL power calculation and optimize postoperative refractive outcomes.

PRACTICAL RECOMMENDATIONS

Risk Stratification

Preoperative risk stratification for developing DED following cataract surgery is gaining increasing importance, as optimizing the ocular surface beforehand may enhance both visual outcomes and patient satisfaction.

A thorough patient history remains a cornerstone of preoperative risk assessment for DED,

as it helps identify a wide range of systemic and ocular risk factors. These include older age, female sex, hormone replacement therapy, contact lens wear, prior corneal refractive surgery, and environmental exposures such as low humidity or air pollution [65–68]. Equally important is the identification of systemic comorbidities that contribute to ocular surface impairment, such as diabetes, autoimmune diseases, and the use of medications known to exacerbate DED, such as antihistamines, antidepressants, and isotretinoin [67, 69, 70]. Special attention should also be given to patients with Sjögren's syndrome, rosacea, or a history of hematopoietic stem cell transplantation, all of whom carry a significantly higher risk of postoperative ocular surface dysfunction [5, 71–74].

Nonetheless, identifying patients with a clinically normal ocular surface who are still at heightened risk for postoperative DED remains a clinical challenge, as no single historical or examination finding has demonstrated consistent predictive value.

To address this gap, Villani et al. developed the Ocular Surface Frailty Index (OSFI), a novel assessment tool based on the concept of "frailty," defined as a reduced resilience to physiological stressors [21, 75, 76]. The OSFI incorporates 10 easily assessable parameters, including systemic medical history factors such as connective tissue diseases, thyroid dysfunction, and psychiatric conditions; lifestyle habits like computer use; ocular history elements including ocular allergy, prior refractive surgery, and use of topical medications; as well as simple clinical tests such as TBUT with fluorescein, meibomian gland expressibility via digital expression, and lid-parallel conjunctival folds (LIPCOF). Each parameter is assigned a weighted score. For binary variables, the score is either 0 or 1. For TBUT, meibomian gland expressibility, and LIPCOF, intermediate grading scales are used, with a maximum score of 1 assigned for TBUT of 0–4 s, meibomian gland expressibility grade 3, and LIPCOF grade 3, respectively. The OSFI score is calculated as the ratio of positive items to the total number of assessed parameters. An OSFI value of 0.3 or higher has been shown to be a strong predictor of postoperative DED symptom onset [21]. Although implementing the OSFI adds a few minutes to the preoperative evaluation, this modest time investment may be worthwhile given its utility in guiding tailored ocular surface management strategies and improving preoperative counselling [7, 21, 77].

Expanding on this approach, Shi and Chen developed a separate multivariate predictive model based on clinical and psychosocial factors. Their analysis highlighted smoking, diabetes, psychological stress, elevated inflammatory markers, and longer incision length as relevant risk factors for developing DED after surgery. The model demonstrated good predictive ability and may support ophthalmologists in identifying vulnerable patients and implementing preventive strategies accordingly [78]. Together, these models mark a shift toward personalized ocular surface evaluation, enabling more informed decision-making in candidates for cataract surgery, even in those without overt DED.

Preoperative Ocular Surface Workup

Given the high prevalence of undiagnosed OSD in candidates for cataract surgery [4, 17], routine screening of DED prior to surgery should be considered standard practice [10]. A critical element of the preoperative screening is the detection of visually significant OSD that not only compromise Snellen acuity or subjective visual quality but could also distort preoperative measurements, lead to inaccurate IOL power selection [10].

Preoperative OSD screening should begin with a comprehensive review of patient's history, an assessment of risk factors, and evaluation of symptoms (Fig. 2). Symptom assessment may involve standardized questionnaires such as the ocular surface disease index (OSDI), the OSDI-6, the 5-item dry eye questionnaire (DEQ-5), the Symptom Assessment iN Dry Eye (SANDE), the Standard Patient Evaluation for Eye Dryness (SPEED) or the American Society of Cataract and Refractive Surgery (ASCRS) SPEED II preoperative questionnaire [10, 79, 80]. Regardless of whether DED is suspected, preoperative evaluation should also include fluorescein staining, TBUT, and a thorough inspection of the ocular surface system [79], potentially including the look-lift-pull–push sequence [10]. This involves

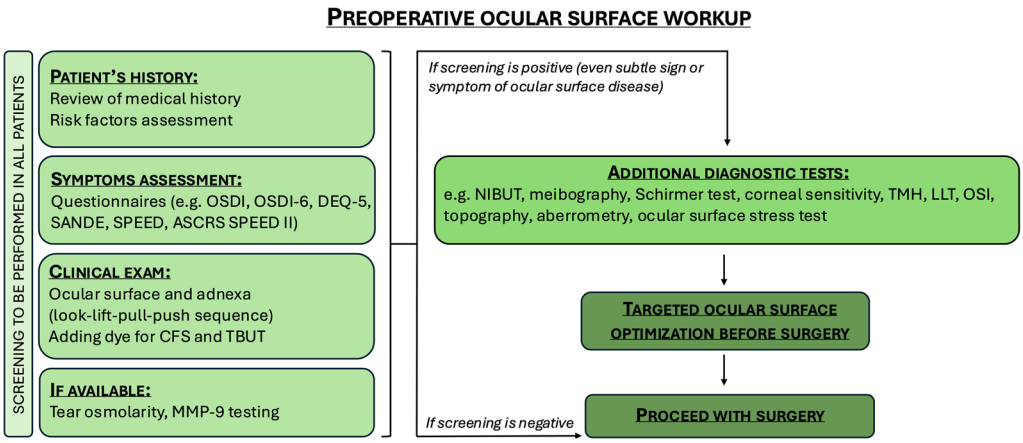

Fig. 2 Preoperative ocular surface workup. *ASCRS SPEED II* American Society of Cataract and Refractive Surgery SPEED II, *CFS* corneal fluorescein staining, *DEQ-5* 5-item dry eye questionnaire, *LLT* lipid layer thickness, *MMP-9* matrix metalloproteinase-9, *NIBUT* noninvasive breakup time, *OSDI* Ocular surface disease index, *OSI* ocular scatter index, *SANDE* Symptom Assessment iN Dry Eye, *SPEED* Standard Patient Evaluation of Eye Dryness, *TBUT* tear breakup time, *TMH* tear meniscus height

inspection of the interpalpebral ocular surface and cornea, blink patterns, lid position, tear meniscus, and blepharitis signs; elevating and everting the upper eyelid to detect superior epithelial basement membrane dystrophy, floppy eyelid syndrome, and other often-overlooked conditions; gently pressing on the lower lid margin to allow assessment of meibomian gland function by evaluating meibum quality and identifying nonobvious MGD [10]. If available, point-of-care tests such as tear osmolarity and MMP-9 testing should also be performed at this stage [10]. A positive screening with the detection of even subtle signs or symptoms suggestive of DED should prompt further investigation using additional diagnostic tools among which infrared meibography, NIBUT, Schirmer test, corneal sensitivity testing, tear meniscometry, lipid layer thickness (LLT), ocular scatter index (OSI), topography, and aberrometry, which can help determining DED severity and guiding appropriate treatment strategies [10, 79, 81]. Additional functional testing like the Hardten's "ocular surface stress test", which is a post-dilation evaluation for punctate keratopathy, has been suggested to help identify individuals at higher risk for epithelial instability post-surgery [82].

After completing the clinical evaluation, if there is evidence of OSD with fluctuating vision that improves after blinking or lubrication, markedly elevated tear osmolarity or MMP-9 levels, unstable or highly irregular corneal topography or aberrometry, interblink increases in OSI, epithelial-related irregular astigmatism, or significant corneal staining, surgery should be performed after having addressed these conditions that may compromise preoperative measurements and/or postoperative outcomes. If OSD is present but not visually significant, surgery can be performed as planned, with appropriate patient counselling and prophylactic treatment to reduce the risk of postoperative DED [10].

Preoperative Ocular Surface Optimization

The consensus on the need for ocular surface optimization before surgery, even in patients with minimal dry eye signs, was recently confirmed by TFOS DEWS III [83]. Rapid restoration of tear film homeostasis, typically through an aggressive, multifactorial approach, improves tear film stability, reduces biometric variability, enhances refractive predictability and minimizes the risk of surgical complications [10]. Furthermore, high levels of HOAs, often seen in dry eye, are a common cause of dissatisfaction in patients receiving multifocal IOLs and should be minimized prior to surgery [84].

Preoperative management should match disease severity [10, 85]. Mild DED cases may proceed with surgery alongside prophylactic therapy and patient education, while more severe or uncontrolled diseases warrants medical treatment. Once a tailored treatment plan is implemented, patients should be reassessed within 2–4 weeks, and surgery should be performed once the ocular surface is optimized [10, 85]. Ongoing therapy should be continued in the postoperative period to maintain improvements and reduce the risk of signs/symptoms recurrence [10].

In the preoperative context, a more aggressive treatment compared to conventional DED is recommended since rapid restoration of ocular surface homeostasis is essential for accurate biometry and optimal surgical outcomes. Therefore, treatment has been suggested to begin at least at Step 2 of the TFOS DEWS II algorithm, targeting tear inflammation, lid margin disease, and ocular surface staining concurrently to prevent surgical delays and postoperative dissatisfaction [10]. A summary of the studies evaluating preoperative ocular surface optimization interventions is presented in Tables 1 and 2.

Tear Substitutes and Mucin Secretagogues Tear substitutes are beneficial when used consistently both pre- and postoperatively. Sodium hyaluronate demonstrated short-term improvements in surface regularity and symmetry. Tear substitutes four times daily before surgery determined more stable OSDI scores postoperatively [86, 87].

Teshigawara et al. reported that rebamipide, a mucin secretagogue, significantly reduced higher-order aberrations, improved TBUT and SPK, and led to more accurate refractive outcomes [88–90]. In a separate study, the same group also demonstrated that diquafosol, a P2Y2 receptor agonist that stimulates secretion across all three layers of the tear film, significantly improved astigmatism measurement repeatability in eyes with short TBUT [91]. Additionally, Miyake et al. showed that diquafosol enhances intraoperative corneal wetting properties, further supporting its value in surgical settings [92].

Interestingly, the use of tear substitutes immediately before biometry has been explored as a strategy to temporarily stabilize the tear film. However, caution towards its use has been recommended. In fact, while some evidence suggests that short-term improvements in ocular surface quality may enhance measurement consistency, the overall findings remain controversial [93–95].

Rochet et al. reported a temporary improvement in keratometric repeatability and IOL power prediction accuracy following the instillation of tear substitutes 1 min before biometry, likely due to transient smoothing of the tear film [94]. However, this benefit was short-lived and inconsistently replicated in other studies. Roggla et al. found that both low- and high-viscosity artificial tears induced significant changes in keratometry values for at least 5 min post-instillation, particularly in patients with DED. They recommended that biometry should be performed either before drop administration or after a delay of at least 5 min, with a preference for the former [93]. Similarly, Chen et al. advised a 5-min delay, having observed that a single drop of 0.1% sodium hyaluronate significantly affected axial length and central corneal thickness readings in both patients with and without DED [96]. Jensen reported no consistent benefit from tear substitutes instillation immediately before keratometric evaluation [97]. Moreover, artificial tear use has been linked to significant increases in measurement variability, with changes in IOL cylinder power observed in up to 43.8% of cases and axis deviations exceeding 10 degrees in nearly 18% of toric IOL candidates [94]. Montes-Mico et al. showed that tear substitutes could introduce higher-order aberrations, including coma and spherical distortions, casting further doubt on the reliability of this approach [95]. These findings suggest that immediate tear supplementation may obscure, rather than solve, underlying surface instability.

Our clinical takeaways are to: (i) use tear substitutes in the weeks leading up to biometry rather than immediately before; (ii) repeat biometry after ocular surface optimization; (iii) avoid instilling drops immediately before measurements, or wait ≥ 5 min if drops are used; (iv) standardize blink timing during

Table 1 Summary of studies evaluating preoperative ocular surface optimization interventions focused on lubricants, mucin secretagogues, anti-inflammatory and immunomodulatory treatments, and epithelial support

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Miyake et al. (2014) [92]	Prospective randomized single-masked comparative	76 eyes (51patients)	Diquafosol 3% 6× day for 4 weeks	Artificial tears (same regimen)	Intraoperative corneal wetting time	Diquafosol significantly improved corneal wetting time (50.1 s vs. 45.3 s; $p < 0.03$)	Intra-op measurement
Favuzza et al. (2020) [166]	Multicenter retrospective	419 patients *Non-DED	Hydroxypropyl guar + hyaluronic acid solution 3× day perioperative *Group A*: 1 week preop and 2 months postop	*Group B*: treatment for 2 months postop only *Group C:* No treatment	SPEED, TBUT, CFS	Group A and B lower postoperative SPEED vs. C at all FU ($p < 0.05$) Group A lower postoperative SPEED vs. B at week 1 ($p < 0.001$) and 4 ($p = 0.021$) Group A and B higher TBUT vs. C at all FU ($p < 0.001$) Group A longer TBUT vs. B at week 4 ($p = 0.016$) Greater % of patients with no CFS in groups A and B vs. C	1, 4, 8 weeks postoperatively
Shokoohi-Rad et al. (2020) [99]	Randomized triple-blind clinical trial	62 patients *Excluded significant DED	Betamethasone acetate 0.1% 4×/day for 3 days ($n = 28$)	Saline (same regimen) ($n = 34$)	OSDI, meniscometry	No significant difference between betamethasone and placebo at days 1, 7, and 30 in OSDI ($p = 0.192$) and meniscometry ($p = 0.578$)	1, 7, and 30 days postoperatively
Hovanesian et al. (2020) [110]	Multicenter prospective open-label	100 eyes (100 patients) *DED	Lifitegrast 5% 2× day for 28 days	Within-eye baseline	Predictive refractive accuracy (SE ± 0.25/0.5/0.75D)	Improved refractive prediction: ± 0.25D in 50% vs. 47% before tx ($p < 0.04$) ± 0.50D in 79% vs. 71% before tx ($p < 0.04$) ± 0.75D in 91% vs. 81% before tx ($p < 0.04$) Reduced HOAs, improved SPEED, TBUT, staining after lifitegrast tx ($p < 0.01$)	1 month postoperatively

Table 1 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Hovanesian et al. (2021) [84]	Open-label, multicenter, prospective clinical trial	64 patients *DED	Cyclosporine 0.09%, 2× day for 28 days	Within-eye baseline	Absolute prediction error (PE)	PE decreased from 0.39 ± 0.30 D pre-treatment to 0.33 ± 0.25 D post-treatment ($p < 0.03$) Improvements in HOAs, SPEED, TBUT, CFS, conjunctival erythema	1 month postoperatively
Teshigawara et al. (2022) [89]	Single-center prospective	35 patients *DED with short TBUT (< 5 s)	Rebamipide 2% 4× day for 4 weeks	Within-eye baseline	Refractive accuracy (PE), TBUT, C-SPK, HOAs	PE ± 0.25D in 54.3% vs. 42.9% before tx ($p < 0.01$) PE ± 0.50D in 88.6% vs. 71.4% before tx ($p < 0.01$) PE ± 0.75D in 97.1% vs. 88.6% before tx ($p < 0.01$) TBUT, C-SPK, and HOAs improved after tx preoperatively ($p = 0.01$)	1 month postoperatively
Teshigawara et al. (2022) [90]	Single-center prospective comparative	72 eyes (36 patients) *DED with short TBUT (≤ 5 s) *Bilateral FLACS with diffractive trifocal IOL	Rebamipide 2% 4× day for 4 weeks and 3 months postoperatively	Artificial tears in contralateral eye	TBUT, C-SPK, HOAs, CDVA, CS, disability glare	Repabimide tx: Higher TBUT and lower C-SPK and HOAs vs. ATs at all FU ($p < 0.001$) Higher CDVA at 1 week and 1 month only ($p < 0.05$) Between-group differences in contrast sensitivity and disability glare favoring repabimide tx.at all FU ($p < 0.05$)	1 week, 1 month and 3 months postoperatively
Teshigawara et al. (2024) [91]	Multicenter prospective study	122 eyes (61 patients) *DED with short TBUT (≤ 5 s)	Long-acting diquafosol sodium 3% 3× day for 4 weeks	Contralateral non-treated eyes	Astigmatism measurement repeatability	Better repeatability of power vectors J0 and J45 within-subjects SD vs. controls ($p < 0.001$ and $p = 0.002$; respectively) Improvements in TBUT ($p < 0.001$), HOAs ($p < 0.001$) vs. no change in controls	Preoperatively, after tx

Table 1 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Nilsen et al. (2024) [167]	Prospective randomized controlled trial	131 patients *DED	*Group A2:* DED patients treated with ATs 6× day for 2 weeks	*Group A1:* DED with no treatment *Group B:* non.DED	Refractive precision	No difference in the mean variability of keratometry or % of outliers in Group A2 before and after tx No difference in refractive precision among all groups	8 weeks postoperatively
Di Zazzo et al. (2024) [109]	Single-center prospective, open-label, clinical trial	100 patients *Group A*: < 65 years ($n = 25$) *Group B-C-D*: > 75 years ($n = 25$ in each)	*Group C:* Cyclosporine A 0.1% CE 2× day for 30 days	*Group A-B*: no preoperative intervention *Group D*: CE lubricants 2× day for 30 days	Change in SANDE, conjunctival hyperemia, CFS, TBUT, Schirmer test I, Cochet–Bonnet esthesiometry, MGD, and inflammatory biomarkers (HLA-DR, ICAM-1, IL-6)	*Group C vs. group B* Lower SANDE at T3 ($p < 0.05$), less hyperemia at all T ($p < 0.01$), less CFS at T1 ($p < 0.05$), improved MGD at all T ($p < 0.001$), longer TBUT at T1, 3 and 4 ($p < 0.05$), and downregulation of all inflammatory markers at T4 ($p < 0.005$) *Group C vs. group D:* Lower SANDE at T3 ($p < 0.05$), less MGD severity at all T ($p < 0.05$), downregulation of IL-6 at T4 ($p < 0.05$)	Day 7 (T1), 15 (T2), 45 (T3) and 90 (T4) postoperatively
Miklaszewski et al. (2025) [87]	Single-center cohort	71 patients *Excluded DED	Sterile aqueous 0.3% hydroxypropyl methylcellulose moisturizing drops 5× day for 1 week	No preoperative intervention	OSDI TBUT OCT (epithelial thickness)	OSDI improvement after tx before surgery (from 11.18 to 6.34; $p < 0.001$) and postoperatively (3.30; $p < 0.001$) vs. minimal OSDI change in controls ($p > 0.05$) TBUT increase after tx before surgery (from 6.20 s to 7.97 s; $p = 0.002$), and stability after surgery (7.78 s) vs. no significant change in controls No change in epithelial thickness vs. decrease in controls ($p = 0.021$)	2 weeks postoperatively

Table 1 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Wongskhaluang (2025) [114]	Prospective	55 eyes (37 patients) *Moderate to severe DED who failed prior conservative treatments	Cryopreserved amniotic membrane (cAM) for 5–7 days	Within-eye baseline	Refractive accuracy (PE)	PE ± 0.25D in 70% vs. 36% before cAM ($p = 0.002$ PE ± 0.50D in 94% vs. 66% before cAM ($p < 0.001$) PE ± 0.75D in 98% vs. 76% before cAM ($p < 0.001$) PE ± 1.00D in 100% vs. 86% before cAM ($p = 0.016$)	1 month postoperatively

ATs artificial tears, *C-SPK* central superficial punctate keratopathy, *CDVA* corrected distance visual acuity, *CE* cationic emulsion, *CFS* corneal fluorescein staining, *cAM* Cryopreserved amniotic membrane, *D* diopters, *DED* dry eye disease, *FLACS* femtosecond laser-assisted cataract surgery, *FU* follow-up, *HLA-DR* Human Leukocyte Antigen-DR isotype, *HOAs* higher order aberrations, *ICAM-1* Intercellular Adhesion Molecule 1, *IL-6* Interleukin 6, *IOL* intraocular lens, *MGD* meibomian gland dysfunction, *OCT* Optical Coherence Tomography, *OSDI* ocular surface disease index, *PE* prediction error, *SANDE* Symptom Assessment iN Dry Eye, *SE* spherical equivalent, *SPEED* Standard Patient Evaluation for Eye Dryness, *Sw* within-subject standard deviation, *TBUT* tear break-up time

measurements; (v) prioritize IOL formulas that place less emphasis on anterior corneal curvature.

Anti-inflammatory and Immunomodulatory Agents In moderate to severe DED, topical corticosteroids are often employed for short-term, preoperative use, due to their potent and rapid anti-inflammatory effects, potentially followed by immunomodulatory agents for maintenance [10, 98].

An initial evaluation of betamethasone acetate 0.1% as a preoperative treatment showed no significant benefit in OSDI scores or meniscometry measurements compared to saline [99]. However, in the study by Shokoohi-Rad et al., the corticosteroid was administered for only 3 days prior to surgery [99], a duration that may have been insufficient to produce therapeutic effects. In contrast, subsequent studies have demonstrated that corticosteroids such as loteprednol etabonate 0.5% and fluorometholone were effective in significantly improving signs and symptoms of DED within 4 weeks, making them suitable for the surgical timeline [100, 101]. Although long-term use is limited by potential side effects, a brief course before surgery can rapidly suppress ocular surface inflammation, enhance tear film stability, and improve patient comfort [102].

Among immunomodulatory agents, cyclosporine A 0.05% and lifitegrast 5% proved to be effective in improving postoperative DED subjective symptoms and objective signs and, thanks to their relatively fast therapeutic response, to be well-suited for preoperative use [86, 103–109].Additionally, they have consistently been associated with improved prediction of postoperative spherical equivalent and likelihood of satisfactory postoperative outcomes [64, 84, 110]. Kim et al. demonstrated that pretreatment with topical 0.5% loteprednol etabonate and 0.05% cyclosporin A for 2 weeks prior to cataract surgery led to more accurate keratometric values and significantly improved postoperative refractive outcomes. In their study, 94.3% and 90.5% of treated eyes versus 65.4% and 73.2% of untreated eyes achieved mean absolute prediction error within ± 0.50 D of target using SRK/T and Barrett Universal II formulas, respectively; the incidence of refractive surprises also dropped substantially, from 17.3% to 3.8% with SRK/T, and from 15.4% to 1.9% with Barrett Universal II [64]. Similarly, Hovanesian et al. reported that 28 days of treatment with cyclosporine 0.09% resulted in 95% of eyes achieving refractive accuracy within ± 0.75 D, compared to 88% in the untreated group, while refractive outcomes within ± 0.25 D of target were reached in 47% of treated cases versus 41% of untreated ones [84]. Additionally, their results showed reduced HOAs, crucial for patients receiving premium IOLs [84]. Hovanesian et al. also reported that a 28-day course of lifitegrast 5% twice daily significantly improved preoperative corneal surface measurement accuracy in patients with confirmed DED who were scheduled for cataract surgery. Specifically, biometry accuracy within ± 0.50 D and ± 0.75 D improved before and after the initial lifitegrast treatment from 71 to 79% and from 81 to 91%, respectively ($p < 0.04$) [110].

Epithelial Support In case of persistent corneal staining, additional therapeutic interventions may be required due to the critical impact of a compromised corneal surface on refractive accuracy [10, 111, 112]. Treatment options may include autologous serum tears, which promote epithelial healing and provide anti-inflammatory effects, and the transplantation of amniotic membrane (AM), which has been shown to result in significant clinical improvements within 5 days [113]. Wongskhaluang et al. reported that preoperative application of cryopreserved AM significantly improved both signs and symptoms of moderate to severe DED unresponsive to conventional therapy, ultimately enhancing refractive accuracy after cataract surgery [114]. Bandage contact lenses may also be used to protect the ocular surface and support epithelial recovery. In addition, punctal plugs can be employed to enhance tear retention and reduce ocular surface stress [10, 115].

MGD Management Preoperative management of MGD has emerged as a critical component in the optimization of surgical outcomes and was shown to significantly mitigate postoperative DED severity [24, 116, 117] and improve refractive accuracy [118–123].

Core MGD management includes warm compresses and lid hygiene/massage. In a randomized clinical trial, 20 min of warm compresses followed by lid massage before cataract surgery led to improved postoperative tear film stability [24]. Despite the widespread use of warm compresses and lid hygiene regimens at home, real-world adherence remains low, and effective meibomian gland expression is frequently inadequate in elderly populations. Thus, intensifying preoperative treatment strategies is essential. Hypochlorous acid-based lid cleansers effectively reduce lid margin bacterial load [124], while tea tree oil scrubs are employed in cases of Demodex-associated blepharitis [125]. Mechanical blepharoexfoliation can debulk bacterial biofilm and collarettes, thereby decreasing microbial resistance and infection risk [126]. For obstructive MGD, in-office thermal pulsation therapy (TPT) using devices such as LipiFlow can restore glandular patency and lipid layer stability more reliably than at-home compresses [127, 128]. Presurgical TPT was shown not only to enhance meibomian gland secretion and TBUT, but also to reduce postoperative dry eye symptoms, improve preoperative astigmatism measurements, IOL calculation accuracy and refractive outcomes, particularly in patients receiving range-of-vision implants [118–123]. The optimal timing for TPT is typically a few weeks before surgery, as tear film stabilization is generally achieved within this period [127–129]. Most studies administered TPT approximately 3 to 6 weeks preoperatively [118–122, 130]. A recent meta-analysis confirmed a moderate but statistically significant improvement in MG function and TBUT with TPT with, however, variable impact on LLT and subjective symptoms like the OSDI, underscoring the need for individualized treatment planning and further high-quality studies [119, 120, 122, 131].

Additional adjunctive modalities such as intense pulsed light combined with meibomian gland expression (IPL-MGX) also showed promise in improving refractive accuracy and reducing HOAs in patients with MGD-related dry eye [132, 133].

Comprehensive perioperative regimens with low-level light therapy (LLLT) performed one week before and one week after surgery also demonstrated efficacy in preventing the iatrogenic exacerbation of dry eye and lid margin disease following cataract surgery [134, 135].

Additionally, dietary omega-3 fatty acid supplementation, despite the negative findings from the DREAM study, continues to be recommended due to its anti-inflammatory benefits and potential to enhance meibum quality and tear film stability, although optimal dosing and duration remain to be established [136–140]. For patients with ocular rosacea or chronic lid margin inflammation, systemic anti-inflammatory therapy with oral tetracyclines such as doxycycline offers additional benefits. These agents exert both anti-inflammatory and antimicrobial effects [141] and their use has been associated with improved epithelial barrier integrity, enhanced tear film stability, and reduced lid margin bacterial load, all of which contribute to a healthier preoperative ocular surface [142, 143]. A 1- to 2-month course of doxycycline before surgery has been shown to significantly improve symptoms and signs in patients with MGD, reduce the risk of postoperative infection, and potentially lower the incidence of endophthalmitis [144–146].

Additional Considerations Avoiding preoperative use of epitheliotoxic agents such as benzalkonium chloride (BAK)-containing drops and non-steroidal anti-inflammatory drugs (NSAIDs) is critical to reduce surface toxicity [85]. Particularly in severe cases such as Sjögren syndrome, cautious use of NSAIDs is advised due to the potential for corneal melting or neurotrophic keratopathy [5]. Patients with high-risk conditions, including graft-versus-host disease (GVHD), Stevens–Johnson syndrome or ocular cicatricial pemphigoid (OCP) benefit from aggressive ocular surface management that may require systemic immunosuppression in selected cases, which has been shown to improve surgical outcomes despite not eliminating complications entirely [71–74, 147].

Surgical Considerations in Relation to DED

Optimizing surgical technique is essential to reduce postoperative DED, particularly in at-risk patients. The choice between femtosecond laser-assisted cataract surgery (FLACS) and conventional phacoemulsification should consider their impact on ocular surface.

FLACS has been associated with a higher risk of early postoperative DED. A 2022 meta-analysis including 611 eyes showed in eyes receiving FLACS worse dry eye parameters, higher OSDI scores, lower Schirmer values, more staining, and reduced TBUT, though differences resolved by 3 months [148]. Ju et al. reported foreign-body sensation in 68.9% and dryness in 48.3% of patients receiving FLACS [149]. Xu et al. observed new-onset DED in 20.9% at one week, dropping to 1.9% at 3 months [150]. This risk is likely multifactorial: the suction ring and docking system can damage conjunctival goblet cells and corneal nerves, compress limbal vessels, and provoke inflammation. FLACS involves more laser energy, light exposure, and operative time. Elevated tear film cytokines have been noted post-FLACS [151]. Tight or incomplete femtosecond incisions may require additional instrumentation, increasing corneal trauma [152, 153]. However, some Chinese studies found less DED worsening with FLACS [154], and Schargus et al. reported no significant differences in tear osmolarity, Schirmer test, or inflammation up to 3 months [155], likely due to patient or technique variability.

In summary, FLACS may transiently worsen dry eye symptoms more than conventional surgery, especially in the first month(s). In patients with preexisting DED or at high risk, thorough preoperative evaluation, tear film optimization, and patient counselling are critical.

Other surgical factors also influence DED outcomes. Smaller incisions preserve corneal nerves, speeding recovery of tear secretion and blink reflexes [156] and reduce surgically induced astigmatism, limiting visual disturbances [157, 158]. While incision location has minimal effect, grooved incisions may temporarily affect corneal sensitivity and worsen symptoms in patients without prior DED [159].

Intraoperative factors such as prolonged light exposure and aspirating specula may reduce TBUT and increase early discomfort, though these normalize by one month [159, 160]. Phacoemulsification's thermal energy can cause transient corneal swelling and evaporative DED [161, 162]. To mitigate these effects, viscoelastic agents like hydroxypropyl methylcellulose protect the ocular surface and improve tear stability postoperatively [163–165].

Overall, surgical planning should prioritize small incisions, reduced light/thermal exposure, and ocular surface protection. For patients at risk of DED, tailored surgical choices, ocular surface optimization, and proper counselling can enhance comfort and visual outcomes.

CONCLUSIONS

DED is prevalent and frequently underdiagnosed in patients undergoing cataract surgery, despite its well-documented impact on preoperative measurements, surgical outcomes, and postoperative satisfaction. Early identification of OSD offers a critical opportunity to optimize the ocular environment and improve both visual and refractive results.

A structured, evidence-based approach, starting from risk stratification and extending through targeted diagnostics and individualized preoperative management, including tear substitutes, anti-inflammatory agents, and MGD treatment, can significantly enhance biometric accuracy and reduce postoperative complications.

Given the increasing demands for refractive precision and patient satisfaction in modern cataract surgery, ocular surface evaluation and optimization, particularly in patients with suspected or confirmed DED, should be an integral component of the preoperative workflow.

Our practical clinical takeaways are:

- Recognize that DED is common and often undiagnosed in patients with cataract.
- Use risk stratification tools (e.g., questionnaires, history, prior ocular surgeries) to guide the need for targeted diagnostics.

Table 2 Summary of studies evaluating preoperative ocular surface optimization interventions focused on meibomian gland dysfunction

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Song et al. (2019) [24]	Prospective randomized clinical trial	120 eyes (120 patients) *Moderate obstructive MGD	*Group II:* warm compresses, lid hygiene + anti-inflammatory tx for ~ 2–4 weeks + routine postop inflammatory tx ($n = 30$)	*Group I:* routine postop anti-inflammatory tx ($n = 60$) *Group III:* enhanced postop anti-inflammatory tx ($n = 30$)	OSS, NIBUT, CFS, Schirmer I, lid margin, meibum quality, expressibility and dropout	Higher NIBUT and lower OSS, lid margin, and meibum quality and expressibility vs. group I (all $p < 0.001$) at 1 month Better outcomes of lid margin and meibum quality and expressibility than group III at 1 month ($p = 0.031$, $p = 0.026$, and $p < 0.001$, respectively) Significantly higher NIKBUT than group I and II at 3 months ($p < 0.001$ and $p = 0.001$, respectively)	1 and 3 months postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Eom et al. (2020) [116]	Multicenter Prospective, randomized, controlled pilot study	69 patients *Obstructive MGD	Eyelid hygiene 2× day for 3 days before until 1 week after surgery ($n = 36$)	No eyelid hygiene ($n = 33$)	SPEED, CFS, LGCS, TBUT, anterior blepharitis grade, eyelid telangiectasia, meibum quality and quantity	SPEED scores decreased in hygiene group only (control unchanged) Blepharitis grade worsened in controls at 1 week, but not in hygiene group Meibum quality/ quantity declined in controls while remained stable in hygiene group	1 and 4 weeks postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Ge et al. (2020) [117]	Prospective observational, controlled clinical study	60 eyes (60 patients) *Mild-to-moderate MGD	M22 OPT IPL perioperatively (preop and at 1 and 2 months posto) as adjunct to standard preparation ($n = 30$)	Standard surgical preparation ($n = 30$)	OSDI, EMAS, MGYSS, CFS, NIBUT, TMH, meibography (MGLS)	OSDI improved from ~ 31 to ~ 28 at 1 month ($p = 0.027$) and ~ 21 at 3 months ($p < 0.01$) MGYSS, EMAS, NIBUT, and MGLS all improved at 3 months ($p < 0.05$) OSDI, MGYSS, CFS were all better compared to controls at 1 month ($p < 0.05$) OSDI, EMAS, MGYSS, NIBUT and MGLS were all better compared to controls at 1 month ($p < 0.05$) Better post-surgical ocular surface status and satisfaction than controls	1 and 3 months postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Matossian (2020) [118]	Single-center, prospective pilot observational study	25 eyes (23 patients) *MGD-related DED	LipiFlow TPT one session at ~ 6 weeks preoperatively	Within-eye baseline	Keratometric astigmatism magnitude (ΔK) and axis change, simulated vs. actual RRA ≤ 0.5 D	ΔK changed in 76% of eyes (52% increased magnitude, 24% decreased, 24% unchanged) Intended astigmatic correction plan changed in 68% of eyes Actual postoperative RRA ≤ 0.50 D was achieved in 76%, compared to simulated 40% ($p = 0.004$)	Post-TPT and ~ 1 month postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Zhao et al. (2021) [120]	Prospective, examiner-masked, contralateral-eye controlled clinical trial	64 eyes (32 patients) *MGD	One LipiFlow TPT session at 1–4 weeks preoperatively **In the more symptomatic eye*	Contralateral eye with no TPT treatment **Also non-surgery MGD control group (w/o LipiFlow)*	DED symptoms, TBUT, LLT, CFS, Schirmer I, MGYLS, MG dropout	Symptoms unchanged Significant improvement in MGYLS ($p < 0.001$), while no change in control non-LipiFlow eyes Prevention of TBUT decline postoperatively compared to control eyes ($p = 0.019$ at 1 week and 1 month) Other parameters did not differ significantly *Main differences seen at 1 week and 1 month	1 week, 1 month, and 3 months post-treatment/surgery

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Park et al. (2021) [119]	Prospective, randomized, controlled, single-center clinical trial	124 eyes (124 patients)	One LipiFlow TPT session ~ 3 weeks preoperatively ($n = 62$)	Standard care, no TPT ($n = 62$)	Meibomian gland atrophy, gland expressibility, MQ, TBUT, CFS, LLT, OSDI, and DEQ-5	Maintained/improved gland expressibility, MQ, LLT, and TBUT, with less CFS and significantly better symptom scores post-surgery, while controls worsened Improvements correlated with baseline MGD severity	1 and 3 months postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Mencucci et al. (2023) [121]	Single-center, prospective, unmasked, randomized controlled clinical trial	46 eyes (46 patients) *Mild–moderate MGD	One LipiFlow TPT session at ~ 5 weeks preoperatively ($n = 23$)	Warm compresses + eyelid massage 2× day for 1 month ($n = 23$)	NIBUT, TMH, Schirmer test, SPEED, CFS, meibomian gland functionality, confocal microscopy of MG alterations	NIBUT, SPEED, and MG function improved significantly by preoperative week 1 and remained stable at 1 month post-op ($p < 0.05$), while controls showed no improvement preoperatively and worsened after surgery Post-op NIBUT, SPEED, MGYLS, MGYSS and MQ better than controls ($p < 0.05$) Fewer MG alterations (confocal)	Preoperatively and 1 week and 1 month postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Szabelska et al. (2023) [123]	Prospective, interventional case series	11 eyes (6 patients) *MGD *Blepharitis, MGD and DED	One LipiFlow TPT session	Within-eye baseline	Keratometry (astigmatism magnitude and axis), choice of IOL power and type (SRK-T formula), OSDI TBUT, Schirmer, BCVA, autorefractometry	Astigmatism power changed in 64% of eyes IOL type or planned surgery type changed in 27% Cylinder axis altered in 27% of eyes IOL power recommendations changed in 46% of eyes	6 weeks after TPT No postoperative FU

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Giannaccare et al. (2023) [134]	Prospective, interventional, randomized, double-masked, sham-controlled clinical trial	153 patients (131 completed)	Two LLLT sessions: one ~ 7 ± 2 days before surgery (T0), and one ~ 7 ± 2 days after surgery (T1) ($n = 73$)	Sham treatment (power output < 30%) ($n = 80$)	OSDI, NIBUT, TMH, MGL (Meiboscore), conjunctival redness	OSDI significantly lower vs. control at T1 (7.2 ± 8.8 vs. 14.8 ± 13.0) and at T2 (9.0 ± 9.0 vs. 18.2 ± 17.9), $p < 0.001$ NIBUT higher at T2 (12.5 ± 6.6 vs. 9.0 ± 7.8 in controls), $p = 0.007$ MGL lower at T1 (1.26 ± 0.69 vs. 1.59 ± 0.70), $p = 0.008$ Only LLLT group showed improvement from baseline to T2 for both OSDI and NIBUT ($p < 0.001$ and $p = 0.007$)	7 (T1) and 30 (T2) days postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Matossian et al. (2023) [122]	Prospective, randomized, open-label, crossover, multicenter clinical trial	232 eyes (121 patients) *Mild-to-moderate MGD *EDOF IOL implantation	One LipiFlow TPT session ~ 5 weeks before surgery ($n = 117$)	Standard care ($n = 115$) Crossover: LipiFlow at 3 months postoperatively	MG score, CFS, LGCS, visual disturbances (halos, double vision)	Significantly lower CFS ($p = 0.04$) and LGCS ($p = 0.002$) at 1 month Greater improvement in MG score ($p = 0.046$), less bother from halos ($p = 0.019$) at 3 months while controls reported less multiple/double vision ($p = 0.016$) After crossover, control group improved in vision and MG score ($p = 0.03$, and $p < 0.0001$, respectively)	1 and 3 months postoperatively; 4 months for crossover

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Teshigawara et al. (2024) [133]	Single-center, prospective, open-label clinical study	134 eyes (67 patients) *MGD-related DED (with TBUT ≤ 5 s) *Diffractive trifocal IOLs	IPL-MGX 4 sessions at 2-week intervals preoperatively	Contralateral eye with no IPL-MGX	TBUT, C-SPK, HOAs, CDVA, CS	Greater TBUT, lower HOAs and C-SPK both after preoperative tx and postoperatively ($p < 0.01$) Higher CS at week 1, 1 and 3 months ($p < 0.05$) Higher CDVA postoperatively ($p < 0.01$)	1 week, 1 and 3 months postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Vasudevan et al. (2024) [130]	Single-center prospective, longitudinal, non-masked, randomized clinical trial	124 eyes (62 patients) *MGD-related DED *Immediate sequential same-day bilateral cataract surgery	One LipiFlow TPT session ~ 1 month before surgery ($n = 62$)	No TPT ($n = 62$)	OSDI, SPEED II, IDEEL quality of life questionnaire, NIBUT, TMH, tear osmolarity, Schirmer test, CFS, LGCS, MGE, MGQ, MMP-9, inflammatory markers	Significant OSDI improvement (from 56.98 ± 18.30 to 14.73 ± 12.22; $p < 0.01$) at 6 months Significant SPEED II improvement (from 13.84 ± 6.12 to 7.10 ± 5.00; $p = 0.01$) at 6 months Control group did not show similar improvements Effects tapered prior to 3 months	1, 3 and 6 months postoperatively

Table 2 continued

Author (year)	Study design	Sample size and population	Presurgical intervention and duration	Comparator	Outcome measures	Main findings of presurgical intervention	Follow-up duration
Kawagoe et al. (2025) [132]	Single-center, prospective, open-label clinical study	56 eyes (56 patients) `MGD-related DED	IPL-MGX 4 sessions at 2-week intervals before surgery	Within-subject baseline	Keratometric repeatability (mean-K), TBUT, C-SPK, HOAs, PE	No change in axial length ($p = 0.85$) or anterior chamber depth ($p = 0.56$) Significant improvement in mean-K, TBUT, C-SPK, and HOAs ($p < 0.01$) Improved refractive accuracy: PE ± 0.25D in 55.4% vs. 14.3% before tx PE ± 0.50D in 92.9% vs. 55.4% before tx PE ± 1.00D in 100% after IPL-MGX ($p < 0.01$)	1 month postoperatively

BCVA best-corrected visual acuity, *C-SPK* central superficial punctate keratopathy, *CDVA* corrected distance visual acuity, *CFS* corneal fluorescein staining, *CS* contrast sensitivity, *DED* dry eye disease, *DEQ-5* 5-item dry eye questionnaire, *EDOF* extended-depth-of-focus, *EMAS* eyelid margin abnormality score, *FU* follow-up, *HOAs* higher order aberrations, *IDEEL* impact of dry eye on everyday life, *IOL* intraocular lens, *IPL* intense pulsed light, *IPL-MGX* IPL combined with manual meibomian gland expression, *K* keratometry, *LGCS* lissamine green conjunctival staining, *LLLT* low level light therapy, *LLT* lipid layer thickness, *MG* meibomian glands, *MGE* volume of expression, *MGD* meibomian gland dysfunction, *MGL* meibomian gland loss, *MGLS* meibomian gland loss score, *MGQ* quality of the meibum, *MGYLS* meibomian glands yielding liquid secretion, *MGYSS* meibomian gland yielding secretion score, *MQ* meibum quality, *NIBUT* non-invasive break-up time, *OPT* optimal pulsed technology, *OSDI* ocular surface disease index, *OSS* ocular symptom score, *PE* prediction error, *RRA* residual refractive astigmatism, *SPEED* Standard Patient Evaluation for Eye Dryness, *TBUT* tear break-up time, *TMH* tear meniscus height, *TPT* thermal pulsation therapy, *tx* treatment

- Integrate objective ocular surface assessments (e.g., TBUT, CFS) into the preoperative evaluation.
- Optimize the ocular surface before surgery to improve measurement precision, postoperative comfort, visual outcomes and overall patient satisfaction.
- Initiate treatment 3–6 weeks prior to surgery, if needed, to allow for tear film stabilization.
- Follow a structured, individualized approach to maximize surgical success.

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