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# Bridging the gap in managing dry eye disease: a consensus report by the Taiwan society of cataract and refractive surgeons

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## Abstract

**Background** An impaired ocular surface presents substantial challenges in terms of planning for cataract surgery. As a multifactorial ocular disorder, dry eye disease (DED) is common in the general population and prevalent in patients scheduled for lens replacement surgery. Cataract surgery can exacerbate DED and worsen several ocular parameters. Timely diagnosis and appropriate treatment of DED are vital to ensuring positive ophthalmic surgical outcomes.

This consensus report of the Taiwan Society of Cataract and Refractive Surgeons (TSCRS) regarding the management of DED before, during, and after cataract surgery highlights the gaps between clinical guidelines and several aspects of DED, including diagnostic testing, diagnostic criteria, and clinical practice treatment.

**Methods** An expert panel of five specialists in the field of ophthalmology was recruited to develop consensus statements regarding the management of DED in both the general population and in patients undergoing cataract surgery in Taiwan. Two separate meetings of the five specialists, who were endorsed by the TSCRS, were convened for this purpose. A survey questionnaire consisting of binary or multiple-choice questions was developed through a consensus-driven formulation process. A percentage value was calculated for each statement, and a minimum of 60% agreement (equivalent to three out of five members) was required to achieve consensus. The second discussion meeting involved the presentation of the finalized consensus statements and concluded the consensus development process. Lastly, the finalized consensus statements were approved by all the experts, and the formulated recommendations for DED in the general population and prospective cataract surgery patients were accordingly presented.

**Results** The optimal algorithm for managing DED in the general population and in patients scheduled for cataract surgery was developed to address the unmet needs of this cohort in Taiwan.

**Conclusion** This report provides recommendations for managing dry eye disease. It is essential to screen and confirm DED through endorsed questionnaires and tests and then diagnose it. Treatment and management of DED should follow a stepwise approach. Screening and diagnosing DED is also recommended before cataract surgery. After cataract surgery, relatively aggressive treatment strategies are recommended to manage DED effectively.

**Keywords** Dry eye disease, Ocular surface disorders, Cataract surgery, Consensus, Ophthalmology

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## Introduction

The increasing global prevalence of dry eye disease (DED) is a growing concern [1–3]. Evidence indicates that DED is among the most prevalent ocular surface diseases globally and is a leading cause of patient visits to eye care specialists. DED imposes a substantial burden on both individuals and health-care systems [1–7]. Demographic and epidemiological studies have demonstrated that Asian ethnicity, greater age, and female sex are the factors that most strongly predispose an individual to DED development [1, 2, 8]. The overall prevalence of DED (7.85%) in Taiwan is consistent with findings for other regions [9]. Furthermore, the prevalence is considerably higher in women (10.49%) than in men (4.92%), and it tends to increase with age [9]. Moreover, medical comorbidities common in the Taiwanese population, such as diabetes mellitus and autoimmune diseases, are also associated with an increased risk of DED and complicate its management [9, 10].

Numerous intrinsic and extrinsic factors are risk factors for DED; they include allergies, hormonal changes, ocular diseases, systemic and autoimmune diseases, excessive screen time, various environmental conditions, and several iatrogenic interventions [1, 11–14]. Iatrogenic interventions can induce or exacerbate DED through various pathophysiological mechanisms associated with ocular surgery. Worldwide, cataract surgery is one of the most common and successful surgical procedures [13, 15, 16]. Cataracts, a leading cause of vision impairment and globally recognized as the primary cause of treatable blindness [15]. The pathological mechanisms of dry eye and cataracts are different, though they are found to be associated [17]. Specifically, when a patient has DED and then develops cataracts, the DED poses substantial challenges before and during cataract surgery and can lead to worse condition following surgery. This often results in a higher likelihood of complications and compromised visual outcomes, thereby reducing the patient's postoperative satisfaction and quality of life [18–20]. Given the strong effect of DED on the outcomes of cataract surgery, effective preoperative diagnosis and management of pre-existing DED in conjunction with effective perisurgical and postsurgical measures are vital to ensuring optimal outcomes [21, 22].

In Taiwan, the complexity of DED is often underestimated. Moreover, due to the absence of unified guidelines defining a comprehensive classification and treatment system, achieving consistent and accurate diagnoses remains a substantial challenge. This limitation is hampering the development of targeted therapies and impeding the implementation of effective management strategies [23–26]. To address this problem, the Taiwan Society of Cataract and Refractive Surgeons (TSCRS) has ratified and endorsed a Taiwan-based consensus, the aim of which is to provide a framework with which general ophthalmologists can manage DED in the general population and in patients who will undergo cataract surgery. The consensus, which is presented in this article, will play a pivotal role in improving both patient outcomes and ophthalmic clinical practice. Moreover, it effectively addresses the gaps arising from the challenges faced in Taiwan, providing unified details regarding the diagnostic criteria, classification system, treatment protocols, and management of DED before, during, and after cataract surgery.

## Methods

An expert panel of five specialists in the field of ophthalmology was recruited to develop consensus statements regarding the management of DED in both the general population and in patients undergoing cataract surgery in Taiwan. Two separate meetings of the five specialists, who were endorsed by the TSCRS, were convened for this purpose. Their consensus statements relating to patients undergoing cataract surgery addressed the preoperative, perioperative, and postoperative periods.

This report has been exempted from review in accordance with the policy of the Institutional Review Board of Chang Gung Memorial Hospital (IRB No. 202301652B1). It does not involve human subjects, data, or tissues, and no written informed consent was required.

The committee considered the most recent scientific evidence pertaining to the management of DED. Recent DED practice guidelines published by affiliated medical associations—including the Tear Film and Ocular Surface Society Dry Eye Workshops (TFOS DEWS) [27], the Asia Dry Eye Society (ADES) [26], the American Society of Cataract and Refractive Surgery [28], and the Asia–Pacific Association of Cataract and Refractive Surgeons [29]—were specifically reviewed; in addition, expert clinical experiences and realistic treatment approaches were discussed and considered.

Two face-to-face panel discussion meetings and one round of individual teleconference meetings were held. In the first panel discussion meeting, the experts were asked to broadly comment on consensus points regarding the current practice patterns for DED screening and diagnosis, DED severity grading, DED classification, and management of the general DED population and the DED population scheduled for cataract surgery in Taiwan. Additionally, specific experts were designated as the reviewers of specific sections.

A survey questionnaire consisting of binary or multiple-choice questions was developed through a consensus-driven formulation process. The questionnaire was used to determine the experts' degree of agreement on each consensus point, and the experts were asked to provide comments where necessary. Following the analysis of the questionnaire results, the areas that required revision were addressed, and

further input was obtained from the experts where necessary. A percentage value was calculated for each statement, and a minimum of 60% agreement (equivalent to three out of five members) was required to achieve consensus.

The second discussion meeting involved the presentation of the finalized consensus statements and concluded the consensus development process. Lastly, the finalized consensus statements were approved by all the experts, and the formulated recommendations for DED in the general population and prospective cataract surgery patients were accordingly presented.

## Discussion

### Diagnosis and classification

Consensus statements
*(a) Triaging for DED*
*1. Specific triaging questions based on TFOS DEWS II should be employed to facilitate the initial differential diagnosis*
*(b) Screening tests for DED*
*2. The Ocular Surface Disease Index (OSDI) or the 5-Item Dry Eye Questionnaire (DEQ-5) is recommended for evaluation of the symptoms of DED*
*(c) Diagnostic tests and DED severity grading*
*1. To confirm the diagnosis of classic DED, at least one symptomatic test (OSDI or DEQ-5) and one diagnostic test (tear break-up time [TBUT], noninvasive tear break-up time [NITBUT], or corneal fluorescein staining [CFS]) should be positive*
*2. A TBUT of ≤ 5 s is regarded as a positive diagnostic test result for DED*
*3. A NITBUT of ≤ 10 s is regarded as a positive diagnostic test result for DED*
*4. Either the TBUT or NITBUT followed by CFS may be used as a diagnostic test*
*5. If a patient presents with symptoms but no signs, they should be assessed for neuropathic pain conditions and managed appropriately*
*6. If a patient presents with signs but no symptoms, they should be assessed for neurogenic conditions and classified as having asymptomatic DED; they should then be managed appropriately*
*7. If a patient has symptoms but no signs or has signs but no symptoms, they should be assessed for a preclinical dry-eye state and managed accordingly*
*8. Once a diagnosis has been made, CFS can be used to determine the severity of DED*
*9. Severity can be determined using a grading scheme based on the level of corneal staining*
➢ Level 1 indicates no corneal staining and represents mild DED
➢ Level 2 indicates < 1/3 staining of the cornea and represents moderate DED
➢ Level 3 indicates between 1/3 and 1/2 staining of the cornea and represents severe DED
➢ Level 4 indicates > 1/2 staining of the cornea and represents advanced DED
*(d) Classification of DED*
*1. DED can be classified into various subtypes, namely evaporative dry eye (EDE), aqueous deficiency dry eye, or a mixed-type dry eye*
*2. The meibomian gland dysfunction (MGD) examination should be performed to classify the DED subtype*
➢ One of the following tests should be positive to confirm an initial diagnosis of MGD: abnormal morphology (observed using a slit lamp), lid margin abnormalities (gland orifice morphology, gland number, patency, telangiectasia, displacement of the mucocutaneous junction, or signs of blepharitis), abnormal meibum quality, and abnormal meibomian gland expression
➢ Additional EDE examinations—such as meibography, lipid layer thickness measurement, blinking frequency, and completeness—are recommended to enable quantification
*3. A positive MGD examination may be used to confirm the diagnosis of evaporative excess-type DED*
*4. Schirmer's test without anesthesia is recommended to be performed to classify the DED subtype*
➢ ≤ 5 mm/5 min is considered abnormal and may indicate DED
*5. An abnormal Schirmer's test without anesthesia should be used to confirm aqueous deficiency-type DED*
*6. A positive MGD and an abnormal Schirmer's test indicate mixed-type DED*

The definition of DED has evolved over time in conjunction with advancements in scientific and clinical knowledge. Initially, DED was primarily described as a condition characterized by insufficient or poor-quality tear production, leading to discomfort and irritation. However, our understanding of DED has since expanded to encompass a range of underlying mechanisms that are more complex than initially thought [30]. The TSCRS has considered multiple factors that contribute to the development and progression of DED, including tear film instability, inflammation, and the effect of several symptoms on the perception of ocular discomfort. These facets align with the widely accepted descriptions of DED illustrated in both the ADES and TFOS DEWS II reports [26, 31]. Thus, the TSCRS has proposed a definition for DED that incorporates the complexity and multifactorial nature of the disease, thereby facilitating a comprehensive approach to its diagnosis and management. The definition is as follows: *the dry eye is a composite disease of the ocular surface and develops from instability of the tear film, where local inflammatory processes may result in the manifestation of ocular symptoms that contribute to ocular surface damage.*

#### *Triaging for DED*

The use of triaging questions assists clinicians in diagnosing DED and guides further evaluation measures and management. In the seven specific triaging questions, adapted from the TFOS DEWS II report [32], detailed inquiries are made into the symptomatic presentation of DED. These questions enable a broad differential diagnosis (Supplementary Table 1).

#### *Screening tests for DED*

Screening tools for DED are essential for initiating diagnostic procedures reliant on both the quantification of subjective symptoms and on objective examinations [12, 26, 32]. However, because of its multifactorial nature, DED is challenging to evaluate and diagnose, and this difficulty often results in inconsistencies between clinical signs, diagnostic testing, and symptomatology [5, 33, 34]. Patient screening is thus crucial because non-DED possibilities must be excluded and the diagnostic process can be streamlined, effectively improving clinical experiences and treatment outcomes [12, 26, 32, 34–36].

The assessment of symptoms by using questionnaires that are easily interpretable and suitable for routine clinical practice is essential in the diagnosis of DED [37]. Of the DED-specific questionnaires, the OSDI and DEQ-5 are the most widely employed [32]. These are well-established DED screening tools were found

to demonstrate concurrent validity [38]. The OSDI contains 12 questions aimed at assessing the severity of ocular symptoms, visual-related function, and environmental triggers of DED [32, 39, 40]. The DEQ-5, a shortened version of the Dry Eye Questionnaire (DEQ), comprises 5 questions focused on assessing disease severity and is widely recommended for clinical use [32, 37, 41]. Both the OSDI and DEQ-5 have exhibited superior discriminative abilities with reliable sensitivity and specificity, substantiating their benefit in clinical practice [32, 42, 43]. However, when using the OSDI, environmental factors that may influence the scores should be considered. For instance, Taiwan's relatively humid climate may lead to variation in OSDI scores compared with the scores obtained in drier regions or Western countries. The OSDI is available in various translated formats, including Mandarin [44]. However, validated DEQ-5 and OSDI questionnaires in Traditional Mandarin are not currently available.[1]

#### *Diagnostic tests and severity grading of DED*

Initial evaluation of DED by using validated questionnaires facilitates its preliminary identification. Subsequent confirmation is achieved using various diagnostic tests based on certain established criteria [12, 26, 32]. Currently, the ADES diagnostic criteria are commonly employed in Asia for the diagnosis of dry eye [45]. A tear-film-oriented diagnosis is used in both the ADES and Japanese Dry Eye Society [30]. This approach involves assessing ocular surface damage, tear film stability, tear secretion, tear volume, tear osmolarity, and the lipid layer as fundamental components of the DED diagnostic process [46–48]. Clinical evaluation of the ocular surface has revealed that an unstable tear film is the most common sign of dry eye, as determined through TBUT analysis, a popular test used to examine dry eye in clinical practice [31, 32, 49]. A short TBUT of ≤ 5 s has been identified as the primary characteristic of dry eye and is the essential criterion for diagnosing dry eye [12, 26, 32, 33, 50]. However, although TBUT is the traditional method used to evaluate DED, application of aqueous fluorescein may affect the final result. Therefore, the NITBUT can also be used in clinical practice, with a reading of ≤ 10 s being regarded as a positive clinical sign of DED [31, 32].

Given the composite nature of DED, singular pathognomonic criteria do not exist, and a combination of clinical sign examinations and symptom evaluations is necessary to establish an accurate diagnosis [51]. Diagnosing DED solely on the basis of symptomatology or clinical sign discrimination lacks specificity because numerous ocular surface diseases may present with similar subjective indications [24]. Furthermore, establishing a clear correlation between signs and symptoms is complicated because fewer than 60% of symptomatic patients present with signs of DED [52, 53]. The complex pathophysiology of DED, in conjunction with poor correlations between various clinical DED tests, results in evident discordance between the various indications [24, 54–56]. In light of this complexity, neurosensory abnormalities have been identified as crucial components contributing to the multifactorial etiology of DED. Symptoms appearing in the absence of signs can indicate a neuropathic or preclinical dry eye state. Similarly, signs identified in an asymptomatic state can indicate preclinical or asymptomatic DED resulting from decreased corneal sensitivity, neurogenic DED, or a predisposition to dry eye [27, 57]. According to the TSCRS expert consensus, classic DED can be diagnosed when both a symptomatic test and a diagnostic test yield positive results.

#### *Classification of DED*

Physicians can observe ocular surface changes at a cellular level and assess tear film stability through a slit lamp examination by using corneal and conjunctival dyes, such as fluorescein, Lissamine Green, and Rose Bengal. Tear film stability is reflected by different break-up patterns indicative of various pathophysiologies, providing valuable insights into the assessment of DED severity [58, 59]. CFS is one of the methods most commonly used for grading the severity of DED and is widely regarded as a crucial and reliable tool frequently used in both clinical and research settings [32, 60, 61]. According to the TFOS DEWS II severity grading scale, severity level is determined through the objective measurement of CFS and categorized into Levels 1, 2, 3, and 4, corresponding to mild, moderate, severe, and advanced DED, respectively. In addition, the proposed assessment considers TBUT or NITBUT results and subjective measurements obtained through patient symptom assessment, all of which assist in determining the relevant severity level [14, 31, 62].

According to the TSCRS consensus, DED severity can be determined from staining results. Level 1 indicates no corneal staining, level 2 indicates < 1/3 corneal staining, level 3 indicates between 1/3 and 1/2 corneal staining, and level 4 indicates > 1/2 corneal staining. Because

[1] The expert panel has specified the intention of developing a Taiwan-based 5-item questionnaire that effectively evaluates the symptomatology of DED (Supplementary Table 2), to be ratified and endorsed by the TSCRS and scientific community.

of variation in the grading schemes used for quantifying CFS severity, it is recommended that in cases where discrepancies may arise, the most severe level should be adopted and the appropriate corresponding treatment should be implemented [62].

Substantial scientific and clinical evidence supports the classification of DED on a continuum ranging from EDE, the most prevalent type, to aqueous deficient dry eye (ADDE), with conditions frequently overlapping [1, 31, 63]. Meibomian gland dysfunction (MGD) is the leading cause of DED and the primary contributor to the EDE subtype [31]. MGD grading involves the assessment of clinical features and gland expression through multiple methods, including morphology (slit lamp examination), meibomian gland expression, meibography, and lipid layer thickness measurement [64, 65]. Schirmer's test is an invasive test used to examine tear volume and the rate of aqueous tear production; it is most useful in cases where ADDE is suspected [66]. Given the variability in diagnostic cutoff values, the TSCRS has determined a Schirmer's test value of ≤ 5 mm/5 min as being indicative of DED. Patients with values between ≤ 10 and > 5 mm/5 min may be categorized as borderline DED cases, in line with the diagnostic accuracy observed in several reports [32]. The complex pathophysiology of DED can lead to a combination of EDE and ADDE presentations, and various diagnostic tools can provide further insight into the etiology in a specific case [63, 67]. Although the pathogenesis of DED involves various alterations in ocular mucins, defining a DED subtype specifically related to mucins remains challenging because of the difficulty of their evaluation. However, ophthalmologists must recognize that DED can arise from mucin abnormalities, which can be assessed through impression cytology and other relevant tests [26, 33, 68].

The expert panel has developed a Taiwan-specific algorithm outlining the diagnosis and classification of DED on the basis of the current scientific and clinical evidence in conjunction with expert clinical experience (Fig. 1).

## Treatment and management

**Consensus statements**

*1. Individualized management of DED should be implemented in a stepwise approach*
*2. Treatment should be offered in 4 steps and directly correspond to the 4 disease severity levels*
*3. Step 1 treatment should be applied to all cases of DED in conjunction with the treatment step corresponding to the severity level diagnosed on the basis of the patient's clinical presentation*
*4. Response to treatment should be measured in accordance with symptom reporting and clinical observations of the TBUT and CFS*
*5. Higher-stage treatment may be applied in patients who do not respond to the treatment recommended for the corresponding disease stage*
*6. The escalated treatment may be used in conjunction with the continued application of the previous treatment step*

Comprehensive and individualized treatment approaches are vital to successfully restoring homeostasis of the ocular surface. These approaches include various therapeutic interventions that are typically determined by the clinical presentation, accurate diagnosis, disease severity level, and DED classification [14, 69].

The treatment progression for DED follows a stepwise intervention approach, adapted from the protocol of the TFOS DEWS II report, and is presented in Fig. 1. Additional details are provided Table 1 [12–14, 70–94]. The process begins with step 1, which emphasizes education, lifestyle modifications, and the use of lubricating eye drops. It then advances to step 2, which involves both nonpharmacological and mild pharmacological management, including use of a nonpreserved ocular lubricant and specific prescription medications. If these initial treatment steps are inadequate, more intensive pharmacological management can be implemented in step 3, with further progression to surgical interventions combined with aggressive pharmacological prescriptions in step 4 [14, 79, 90, 95]. The severity level of DED may be used to determine the corresponding treatment step (Table 2). If a patient responds positively to the initial treatment, the treatment may be de-escalated to the corresponding disease severity level.

(See figure on next page.)

**Fig. 1** Algorithm for DED diagnosis and classification in the general population in Taiwan. This clinically designed algorithm outlines the diagnosis, severity classification, subtype classification, and related management procedures for DED in the general population. Abbreviations: CFS, corneal fluorescein staining; DED, dry eye disease; DEQ-5, 5-Item Dry Eye Questionnaire; MGD, meibomian gland dysfunction; NITBUT, noninvasive tear break-up time; OSDI, Ocular Surface Disease Index; TBUT, tear break-up time; TFOS DEWS II, Tear Film and Ocular Surface Society Dry Eye Workshops II. *Note.* In the context of the OSDI or DEQ-5, a positive result typically refers to a higher score, whereas a negative result typically refers to a lower score. However, the interpretation of the result is dependent on the attending ophthalmologist who assesses the score on the basis of the patient's symptoms and clinical findings. A TBUT of ≤ 5 s is considered positive and a TBUT of > 5 s is considered negative. A NITBUT of ≤ 10 s is considered positive, and a NITBUT of > 10 s is considered negative. In the algorithm, the disease severity levels 1, 2, 3, and 4 correspond to mild, moderate, severe, and advanced DED, respectively. The details of treatment option steps 1 + 2, 3, or 4 in the algorithm refer to Table 1

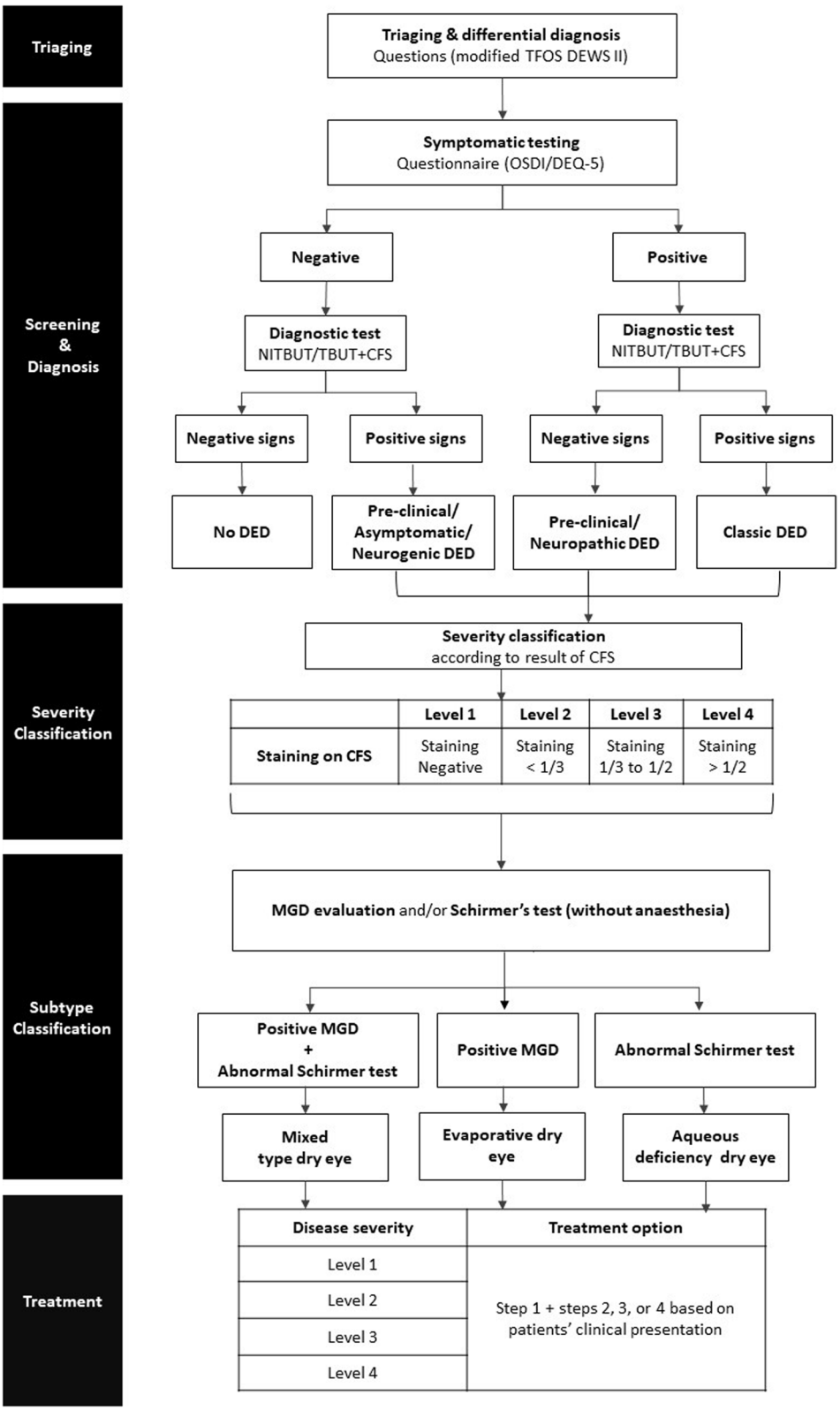


**Fig. 1** (See legend on previous page.)

**Table 1** Recommended treatment approach for the management of DED in the general population

**STEP 1**

**Patient education**

Patients should be educated regarding the nature of the disease and its course, causes, management, and prognosis

Education should be provided specifically for users of visual display terminals:
➢ The importance of complete blinking and blinking frequency (which is lower when staring). Patients should remind themselves to blink more frequently (> 10 times/minute) when using a computer or watching TV

Environmental considerations:
➢ Patients should be educated that excess dryness can be caused by wind (e.g., driving a scooter) and dry environments

➢ Patients should be educated that air-conditioned environments will increase the risk of DED

Patients should be cautioned against the use of certain cosmetics

Dietary modifications inclusive of Mediterranean-diet-oriented suggestions should be recommended

Patients should be educated to not independently purchase OTC eye drops because many eye drops contain preservatives or vasoconstricting agents

**Specific considerations for ophthalmologists**

A comprehensive patient assessment should be performed that prioritizes the identification and potential modification or elimination of systemic and topical medications that may contribute to the patient's condition

**Ocular lubricants of various types**

If MGD is present, then consider lipid-containing supplements

Artificial tears (ATs):
➢ Preserved AT use is acceptable, but nonpreserved use is better

➢ Preservative-containing ATs are only recommended at a maximum frequency of ≤ 4 times/day

➢ Preservative-free ATs are recommended for patients with poor ocular surface condition (i.e., severe corneal epithelial defects or SPK) and patients who frequently instill ATs (> 4 times/day)

Lid hygiene and warm compresses of various types are recommended

**STEP 2**

Tea tree oil treatment for Demodex (if present)

Tear supplementation or conservation:

➢ Nonpreserved ATs are recommended

➢ Temporary punctal occlusion

➢ Moisture chamber spectacles/goggles

➢ Overnight treatments (e.g., ointment or moisture chamber devices)

**In-office therapy for MGD**

➢ Physical heating and expression of the meibomian glands

➢ Intense pulsed light therapy and/or thermo pulsation therapy

**Drugs**

Antibiotics and ATs:

➢ Topical antibiotics or antibiotic–steroid combinations can be applied to the lid margins for anterior blepharitis (if present)

➢ Preservative-free ATs are recommended for patients with poor ocular surface condition (i.e., severe corneal epithelial defects or SPK) and patients who frequently instill ATs (> 4 times/day)

**Table 1** (continued)

➢ Topical antibiotics are suggested if patients have epithelial defects and when ophthalmologists are concerned about infection

➢ Antibiotics should be administered when large epithelial defects require therapeutic contact lens use

➢ Tetracycline antibiotics or oral macrolides can be administered orally

Anti-inflammatory drugs:

➢ Topical steroids are administered for short-term use and then treatment can be shifted to cyclosporine for long-term use (long-term low-dose steroids are only for patients with autoimmune diseases or patients with moderate to severe DED); weak potency steroids are acceptable

➢ Steroid use is acceptable

➢ Topical steroids are still needed for patients with autoimmune diseases receiving systemic steroids

➢ Cyclosporine should be administered to patients with SPK and patients with severe symptoms refractory to present medications

➢ Topical steroids may still be prescribed for short-term use to patients in the general population receiving systemic steroids

Topical secretagogues

Topical LFA-1 antagonist drugs[a]

**STEP 3**

Weaker potency steroids are recommended, such as fluorometholone

Autologous/allogeneic serum eye drops

Therapeutic contact lens options:

➢ Soft bandage lenses

➢ Rigid scleral lenses

**STEP 4**

Stronger potency steroids are recommended, such as betamethasone

Topical steroids for longer use

Long-term low-dose use of topical steroids is recommended for patients with autoimmune diseases or those with moderate to severe DED

A combination of contact lenses with an amniotic membrane graft is better than an amniotic membrane graft alone

Amniotic membrane graft

Other surgical approaches

Tarsorrhaphy and salivary gland transplantation

Lid or conjunctiva surgery

*Abbreviations: ATs* Artificial tears, *DED* Dry eye disease; *LFA-1* Lymphocyte function-associated antigen-1, *MGD* meibomian gland dysfunction, *OTC* Over the counter, *SPK* Superficial punctate keratopathy

[a] Lifitegrast is not currently available in Taiwan, although it is anticipated to become available in the future

**Table 2** Disease severity evaluation and corresponding treatment step

| Disease severity | Treatment option |
|---|---|
| Level 1 (mild) | Step 1 + steps 2, 3, or 4 based on patients' clinical presentation |
| Level 2 (moderate) | |
| Level 3 (severe) | |
| Level 4 (advanced) | |

## Preoperative management of DED

**Consensus statements**

***(a) Selecting eligible patients for cataract surgery***

*1. DED should be screened for and diagnosed before surgery*
*2. Patients should be cautioned that ophthalmic surgery can worsen DED*
*3. Surgery should be postponed if a visually significant ocular surface disease (VS-OSD) is detected*
*4. Surgery can be conducted once the VS-OSD has been ameliorated to a nonvisually significant ocular surface disease (NVS-OSD)*
*5. Patients should receive an invasive/noninvasive refractive test prior to surgery (keratometry, topography, or optical biometry)*
*6. DED should be treated before surgery*
*7. Asymptomatic incidence of DED in patients undergoing cataract surgery is high, and additional consideration is required regarding surgery candidates*

***(b) Special treatment considerations for patients scheduled for cataract surgery***

*1. In cases of a preoperative VS-OSD, treatment can be initiated at a higher treatment step number*
*2. A multitherapy approach should be employed to rapidly restore the tear film*
*3. Preoperative treatment should be initiated at step 2 to minimize surgical delays, maximize preoperative measurement confidence, improve postoperative outcomes, and increase patient satisfaction*

***(c) Risk stratification for patients with DED***

*1. Patients who are scheduled for cataract surgery should be identified as being at low, moderate, or high risk of the potential development of DED and should be managed accordingly*

With the continual advancement of surgical techniques aimed at improving vision and ameliorating vision loss, corneal- and lens-based surgeries have gained popularity and resulted in rapid progress being made in certain operative procedures [96]. Cataracts, characterized by visual symptoms and recognized as the leading cause of blindness and the second leading cause of vision impairment, are a major factor contributing to pathologic ocular health and represent a substantial portion of the global disease burden [15]. Thus, cataract surgery is the most commonly performed ocular procedure and has had substantial success in delivering excellent treatment and safety outcomes [97].

Numerous studies have reported that the association between DED and cataract surgery is multifactorial and complex. Given the increasing prevalence of cataract surgery, a significant linear relationship exists with the incidence of DED [20]. Thus, an essential objective of DED management in the context of cataract surgery is to optimize treatment outcomes [98]. The current objectives of preoperative ocular surface disease (OSD) management are to reduce inflammation, resolve infection, improve epithelial pathology, stabilize the tear film, and ease symptoms, all of which increase the likelihood of positive outcomes [99]. In this regard, it is crucial to acknowledge that asymptomatic DED is highly prevalent [100]. When addressing the development of DED in patients undergoing cataract surgery, ophthalmologists should focus on the possible asymptomatic existence of this condition before the procedure. Preoperative preparation should focus on restoring the ocular surface, with a specific emphasis on identifying and managing subclinical DED to minimize potential postoperative complications and optimize patient outcomes [101].

### *Selecting eligible patients for cataract surgery*

There are several crucial considerations regarding DED in the context of ophthalmic surgery. First, patients who have received a diagnosis of DED should be informed that surgical intervention can exacerbate existing ocular surface diseases (OSDs) and that surgical outcomes may be compromised due to these preexisting pathologies [28, 29]. Subsequently, clinicians should implement preemptive diagnostic measures to identify any form of OSD regardless of symptom involvement [28, 29]. Independent of the results, systematic preoperative screening for DED symptoms should be followed by objective clinical testing for DED signs [21, 98, 102]. Noninvasive tear testing, including the NITBUT test, and invasive TBUT testing are crucial for preoperatively diagnosing DED and differentiating between NVS-OSDs and VS-OSDs [28, 103]. In cases of VS-OSDs, surgery should be postponed until significant improvement is observed [28].

The expert panel has developed a preoperative DED diagnosis, severity grading, classification, and management algorithm on the basis of the current scientific and clinical evidence in conjunction with expert clinical experience (Fig. 2).

### *Special treatment considerations for patients scheduled for cataract surgery*

Presurgical candidates with a visually significant DED require a more aggressive treatment approach and multiple treatments to rapidly restore the homeostasis of the tear film, optimize postsurgical outcomes, and ensure high patient satisfaction [27, 28]. Thus, a more advanced level of treatment is recommended in patients with visually significant DED [28]. Additionally, all treatments should start at step 2 of the treatment and management algorithm to effectively reduce the rate of surgical suspensions, increase confidence in preoperative measurements, and minimize postoperative complications [27, 28]. Adopting a more aggressive approach to treatment along with the implementation of several therapies administered simultaneously as opposed to singular treatments is crucial for achieving

rapid improvement and facilitating a swift recovery of the tear film in preparation for surgery [22, 28, 29].

Clinical considerations should include whether the patient belongs to a special population requiring exclusive attention due to a specific medical history. Autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus, and Sjögren's syndrome are diagnoses that require stringent presurgical attention. To qualify for ocular surgery, patients with these diseases should consult with their rheumatologist to confirm their eligibility for surgery and should have a mild, stable, and well-controlled dry eye condition [29, 104, 105].

Appropriate preoperative measures should be implemented for patients with diabetes, who are at increased risk of presenting with keratopathy or corneal neuropathy, which can manifest similarly to DED symptoms [29, 106]. Additionally, patients with diabetes exhibit longer healing times, and any postoperative epithelial pathologies that develop may thus take longer to heal than they would patients without diabetes. Thus, caution should be exercised before, during, and after the operation [29, 106, 107]. The blood glucose and hemoglobin A1C levels of patients with diabetes should be within the corresponding acceptable range, and their attending physician should be similarly consulted for a supporting evaluation [108].

### *Risk stratification of patients with DED*

A patient's risk of DED is higher when they have undergone cataract surgery [13]. Several factors affect the occurrence of DED in patients who have undergone cataract surgery [10]. Accurate identification of the risk factors associated with DED development is beneficial for facilitating effective management of the condition in presurgical candidates. Current evidence supports a risk stratification system in which the risk of DED development is described in terms of specific signs, symptoms, and comorbid diagnoses (Table 3) [1, 21, 109, 110].

## Perioperative and postoperative management of DED

**Consensus statements**

***(a) Considerations during surgery***

*1. The use of viscosurgical devices is recommended*
*2. The surgical duration and light exposure should be minimized*
*3. Large corneal incisions and the use of aspirating speculums to aspirate excess fluid during cataract surgery should be avoided*
*4. The thermal energy of the phacoemulsification device should be kept low*
*5. Periocular administration or intraocular injection of antibiotics and/or steroids immediately before the end of surgery is recommended*
*6. The use of a dropless strategy (where applicable) can be considered*
*7. Care should be taken to perform adequate sterilization by using povidone-iodine solution to minimize the need for antibiotics*
*8. A clear corneal approach is recommended where applicable*
*9. Perioperative use of antiseptic e.g., povidone-iodine should be carefully considered*

***(b) Considerations following surgery***

1. *Aggressive treatment strategies may be adopted to optimize postoperative outcomes and increase patient satisfaction*
2. *Follow-up treatment for postoperative DED should be frequent*
➢ *Short-term (within 1 month) and long-term (after 1 month) postsurgical treatment strategies are recommended for the treatment of DED*
3. *A specific postsurgical follow-up regimen is recommended*

***(c) Therapy for DED following surgery***

1. *Individualized management of postsurgical DED should be implemented in a step-wise approach*
➢ *Postsurgical treatment is offered in three steps and is to be decided on the basis of the clinical presentation of the patient and the attending ophthalmologist's diagnosis*
2. *Postsurgical treatment of DED differs from the general management of DED and should be more aggressive, starting at a more advanced level*
3. *The aim of the treatment is to mitigate ocular surface damage and increase patient satisfaction*

### *Considerations during surgery*

Several intraoperative factors substantially contribute to the pathogenesis of DED, especially in cases of pre-existing DED or postoperative development. The specific considerations are to maintain the homeostatic environment of the ocular surface, which can be achieved through the implementation of a specific surgical regimen [28]. Physicians should be aware that certain surgical factors can contribute to the development of DED. These include the antiseptic procedures and pupillary dilation [111–113], the type and duration of anesthetic [114, 115], the location and length of incisions [116], the procedure's duration [13, 117], the phacoemulsification machine settings [118], phototoxicity [119], and the surgery type [21, 120, 121].

(See figure on next page.)

**Fig. 2** Taiwan preoperative DED algorithm. A clinically designed algorithm representing the presurgical screening, severity classification, and related management objectives of DED prior to cataract surgery. Abbreviations: CFS, corneal fluorescein staining; DED, dye eye disease; DEQ-5, 5-Item Dry Eye Questionnaire; IOL, intraocular lens; NITBUT, noninvasive tear break-up time; OSDI, Ocular Surface Disease Index; TBUT, tear break-up time. *Note.* In the context of the OSDI or DEQ-5, a positive result typically refers to a higher score, whereas a negative result typically refers to a lower score. However, the interpretation of the result is dependent on the attending ophthalmologist who assesses the score based on the patient's symptoms and clinical findings. A TBUT of ≤ 5 s is considered positive and a TBUT of > 5 s is considered negative. A NITBUT of ≤ 10 s is considered positive and a NITBUT of > 10 s is considered negative. In the algorithm, the disease severity levels 1, 2, 3, and 4 correspond to mild, moderate, severe, and advanced DED, respectively

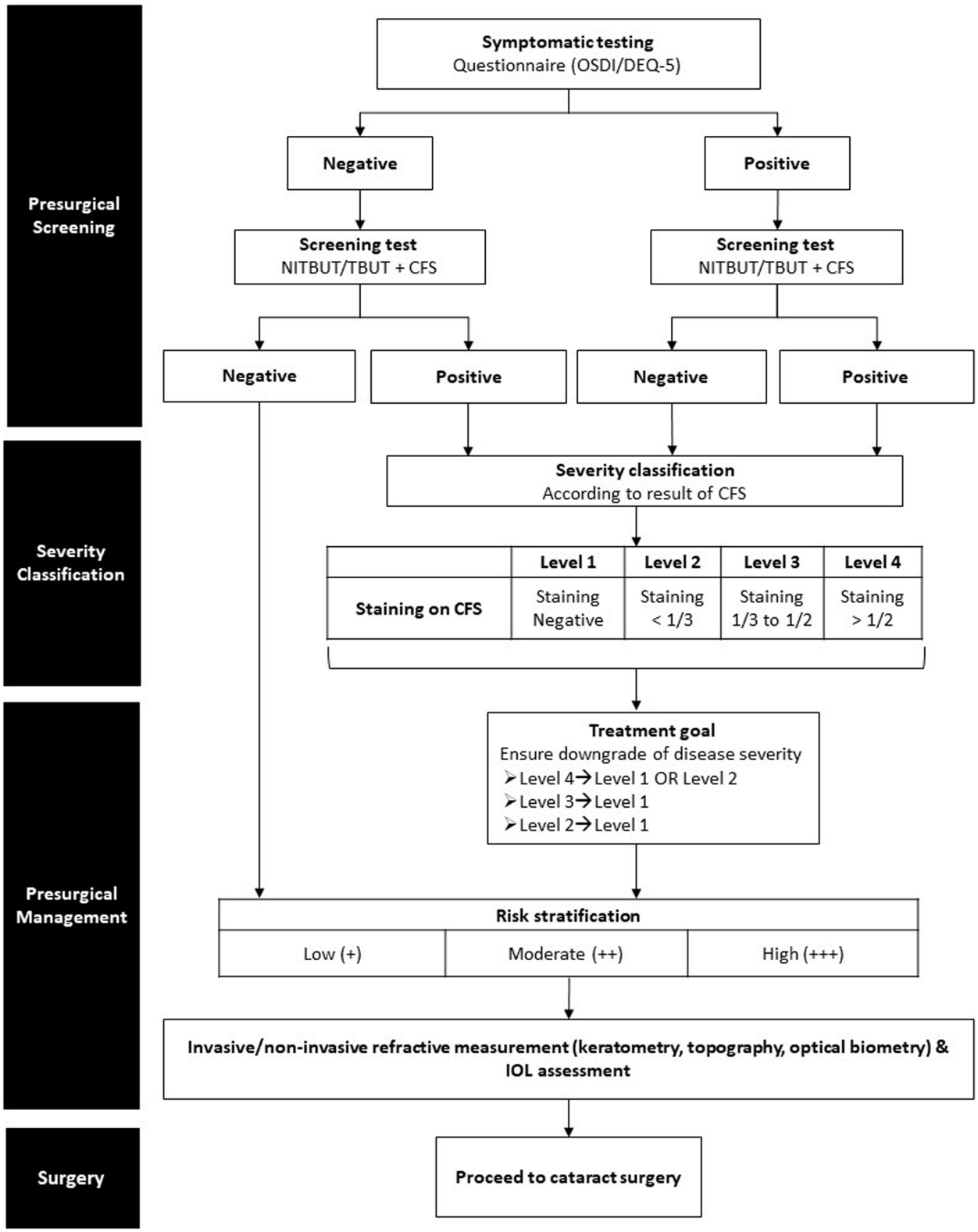


**Fig. 2** (See legend on previous page.)

**Table 3** Preoperative classification of patients in accordance with their risk of DED developing after cataract surgery

| Relevant medical history | Risk level |
|---|---|
| Dry eye disease | + + (Pretreated DED); + + + (Refractory DED) |
| Sjogren's syndrome, rheumatoid arthritis, systemic lupus erythematosus, graft versus host disease, cicatrizing conjunctivitis, ocular rosacea | + + (Unknown DED); + + + (Known DED) |
| History of previous refractive surgery | + + (No DED symptoms); + + + (DED symptoms) |
| Ongoing antidepressant dr8ugs | + + |
| Previous history of HSV/VZV | + + (No DED symptoms); + + + (DED symptoms) |
| Recent history of adenoviral keratoconjunctivitis | + + |
| Menopause with hormonal therapy | + + |
| Diabetes/ Peripheral nerve disorders | + + |
| Current use of NSAIDs | + + |
| Current use of BAK-containing eye drops | + + |
| Allergic conjunctivitis | + + |
| Contact lens use | + + |
| History of cataract surgery-induced DED | + + + |
| None of the above | + |

Low risk (+); moderate risk (+ +); high risk (+ + +)

*Abbreviations: BAK* Benzalkonium chloride, *DED* Dry eye disease, *HSV* Herpes simplex virus, *NSAIDs* Nonsteroidal anti-inflammatory drugs, *VZV* Varicella-zoster virus

Cataract surgeons should be aware that the postoperative risk of DED is high due to several aggravating factors. Preservative-free eye-drop regimens are suggested for preventing the exacerbation of DED and the associated toxicity that damages the ocular surface. Given that preservatives are a source of ocular irritation, the use of preservative-containing eye drops should be minimized in high-risk patients [109, 122]. Similarly, the use of medications that can induce epithelial toxicity should be carefully considered to minimize ocular surface irritation and improve visual acuity [109, 123]. A dropless strategy, where applicable, can be considered. In this approach, ophthalmologic surgeons can administer intraoperative antibiotics and anti-inflammatory materials through intraocular or subconjunctival injections; this effectively reduces the postoperative burden on the patient and improves surgical outcomes [28].

#### *Considerations following surgery*

Current evidence indicates that cataract surgeons should proactively and aggressively employ DED management regimens in the days and weeks following cataract surgery because this surgery is known to cause or exacerbate pre-existing DED [124]. Following surgery, therapy for DED should be more frequent than before and can be divided into short-term (within 1 month) and long-term (after 1 month) follow-up periods. Follow-ups are necessary to ensure the ocular surface's tolerance and to determine the relevant modifications of DED management that will optimize long-term visual outcomes [117]. On the basis of the current evidence and clinical expertise, preservative-free ATs, topical steroids, and topical NSAIDs are recommended for use within the first postsurgical month. Thereafter, in addition to the aforementioned treatments, punctal plugs, topical autologous serum, topical cyclosporine, eyelid warming therapy, and mucin secretagogues are suggested for use in the treatment of post-cataract-surgery DED where necessary (Supplementary Table 3) [98, 109, 125, 126]. Moreover, postoperative follow-up is essential for ensuring proper healing, detecting and managing any complications, optimizing treatment, and establishing a long-term management plan that will optimize the eye health of the patient [29, 127]. Expert advice suggests that the optimal postoperative follow-up schedule be employed to optimize surgical outcomes and ensure high patient satisfaction (Table 4).

#### *Therapy for DED following surgery*

Considering the aforementioned details, specific therapeutic interventions following surgery are essential for restoring ocular health and ensuring the ideal optical outcomes [29]. Specific evidence and expert clinical advice support the use of aggressive therapeutics in cases of postsurgical DED complications with severe ocular surface inflammation. Treatments should be initiated at an advanced treatment level to reduce the incidence of postoperative DED (Table 5).

**Table 4** Postsurgical follow-up regimen

| |
|---|
| **Postsurgical follow-up on day 1** |
| Check for any signs of infection or inflammation |
| Assess intraocular pressure |
| **Postsurgical follow-up in weeks 1 and 2** |
| Check for any signs of infection, DED occurrence, or ocular surface damage |
| Initiate relevant treatment where necessary |
| Evaluate visual acuity |
| Assess intraocular pressure |
| Perform a TBUT examination with or without CFS to evaluate the development of DED |
| Perform Schirmer's test if necessary |
| Use imagery to record corneal erosion (if applicable) |
| **Postsurgical follow-up at 1 month** |
| Evaluate the treatment effect in cases where the patient received DED treatment |
| Evaluate visual acuity |
| Assess intraocular pressure |
| Perform a TBUT examination |
| Use imagery to record obvious corneal erosion where applicable (to be used for preoperative and postoperative conditional comparisons) |
| **Postsurgical follow-up at 2 months** |
| Evaluate visual acuity |
| Assess intraocular pressure |
| Evaluate refraction (e.g., myopia and astigmatism) |
| Perform a TBUT examination |
| Use imagery to record obvious corneal erosion where applicable (to be used for preoperative and postoperative conditional comparisons) |
| **Postsurgical follow-up at 3–6 months** |
| General management and regular consultation procedures as suggested by the attending ophthalmologist |

*Abbreviations*: *CFS* Corneal fluorescein staining, *DED* Dye eye disease, *TBUT* Tear break-up time

**Table 5** Step-wise treatment and management of postsurgical DED

| |
|---|
| **STEP A**[a] |
| **Patient education** |
| Patients should protect their eyes from contact with water |
| Certain cosmetics should be avoided (i.e., mascara and eyelash extensions) |
| Education regarding postoperative lid hygiene should be routinely implemented |
| Patients should be educated regarding Demodex infestation, and if they have this infestation, lid hygiene procedures should be implemented |
| Sterilized single-pack wet wipes to remove excess oily discharge may be used within the 1 month following surgery or for longer |
| Nonsaponifiable (non-soap-forming) agents (e.g., eye or eyelid scrubs) should be used after 1 month following surgery |
| **STEP B**[b] |
| **Tear supplement/conservation or lubricants** |
| ATs are recommended (preservative-free ATs [HA-containing or non-HA-containing] are preferred for patients with an obvious lesion) |
| Punctal plugs are recommended for patients with severe ocular surface damage and low tear meniscus height |
| Lubricating ointments or gels are recommended |
| **Drugs** |
| Anti-inflammatory drugs may be initiated if DED cannot be managed using ATs<br>➢ Topical cyclosporine/steroids: For severe ocular surface inflammation, combined use or interchangeable use is recommended |
| Eyelid warming therapy may be performed 2 months after surgery, depending on the clinical presentation |
| **STEP C**[b] |
| Topical autologous serum is recommended for use in patients with autoimmune disease with refractory ocular surface damage |

*Abbreviations: ATs* Artificial tears, *DED* Dye eye disease, *HA* Hyaluronic acid

[a] Unless otherwise specified, step A should be implemented within the first month following surgery

[b] Steps B and C are indicated for patients with corneal lesions or when postoperative dry eye is noted. In such cases, unless otherwise specified, steps B and C may be begun immediately and continued until the condition subsides

## Conclusion

DED has become a growing concern in modern society because people are spending more time on digital screens. The incidence and severity of DED are expected to continue to increase in the foreseeable future. Thus, a rigorous set of standards for the diagnosis, classification, and treatment of DED is needed. With the advancement of cataract surgery and IOL technology, patients and clinicians have higher expectations regarding postoperative outcomes than they did in the past. However, DED can cause measurement errors in preoperative IOL power calculations and affect ocular surface health; if not properly treated before surgery, DED can cause dissatisfaction and complaints from patients after surgery. This article presents the first consensus proposed by experts on DED in Taiwan. We hope that clinicians can leverage this report to make informed decisions regarding their management of DED in patients undergoing cataract surgery, and it can provide valuable guidance to clinicians seeking to optimize patient outcomes.

## Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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**Authors' contributions**
C.C.S. devised the project, proof outline, and main conceptual ideas. S.L.H. and C.M.L. performed the literature search. C.C.S., S.L.H., C.M.L., Y.Y.T., and P.Y.L. contributed to data interpretation, drafting, and revising the manuscript. All authors read and approved the final submitted version.

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**Availability of data and materials**
The dataset generated during the current report is available in Supplementary Material File.

## Declarations

**Ethics approval and consent to participate**
This report has been exempted from review in accordance with the policy of the Institutional Review Board of Chang Gung Memorial Hospital (IRB No. 202301652B1). It does not involve human subjects, data, or tissues, and no written informed consent was required by the Institutional Review Board of Chang Gung Memorial Hospital.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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