

# Ocular Surface Disease: Impact on Pre-Surgical Biometry and Symptoms in Refractive and Cataract Surgery

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## Key Messages

- Tear film irregularities due to dry eye disease (DED) can alter critical pre-surgical biometry measurements used to develop an accurate surgical plan.
- The high prevalence of DED in the pre-surgical population puts untreated DED patients at risk for continued ocular surface discomfort and inaccurate biometry measurements used to calculate intraocular lens implants leading into surgery.
- Algorithms have been developed to help clinicians thoroughly and efficiently diagnose and treat DED in order to optimize the tear film quality and symptoms leading up to surgery.

## Introduction

A healthy tear film is important for preserving the integrity of the ocular surface and providing good vision and comfort. When the tear film is compromised in dry eye disease, it can result in increased tear evaporation, ocular surface inflammation, and symptoms of discomfort and blurry or fluctuating vision. Dry eye is commonly reported after refractive and cataract surgery, so much so that 91% of surgeons feel that mild to moderate dry eye disease impacts patient satisfaction postoperatively.<sup>1</sup> Historically, a dry eye examination was only warranted for symptomatic patients, but approximately half of patients with ocular signs of dry eye presenting for cataract surgery are asymptomatic and go undiagnosed and untreated before surgery.<sup>2,3</sup> Treating dry eye preoperatively can improve tear film quality prior to surgery, resulting in more accurate biometry measurements and improved symptoms.<sup>4</sup> As a result, a paradigm shift is underway in preoperative care to examine for, diagnose, and treat dry eye disease prior to refractive and cataract surgery to optimize biometry and symptoms leading into surgery.<sup>1</sup>

## Ocular Surface Disease Prevalence in the Refractive and Cataract Preoperative Population

Cataract surgery is the most common ophthalmic surgical procedure performed worldwide, while refractive surgery is the most popular elective procedure performed in the United States. In 2017, approximately 3.8 million Americans underwent cataract surgery, and an estimated 700,000 Americans elected for refractive surgery according to Market Scope.<sup>5,6</sup> An estimated 9.8% and 6.0% of patients report symptoms of dry eye after cataract and refractive surgery, respectively.<sup>7,8</sup> In post-LASIK patients, the prevalence can range between 20-53%.<sup>9,10</sup> While there are several risk factors for the development of postoperative dry eye, one suspected risk factor is pre-existing, undiagnosed and/or untreated preoperative dry eye. A few studies have reported on the prevalence of dry eye in the preoperative refractive and cataract populations. Because eye care practitioners leverage a number of diagnostic tests to determine the presence and severity of dry eye disease, prevalence varies based on the diagnostic tools used.<sup>11</sup>

In the refractive surgery population, preoperative dry eye symptoms have been reported in 38% of LASIK patients and 48% of photorefractive keratectomy patients.<sup>12,13</sup> Albeitz, et al., reported that among 565 LASIK patients in her study, 7% were diagnosed with dry eye, while another 18% reported having dry eye symptoms but did not have significant dry eye signs.<sup>14</sup>

Gupta, et al., studied 120 patients who presented for cataract evaluation by performing a battery of diagnostic tests for dry eye, including tear osmolarity, test for MMP-9 (matrix metalloproteinase 9), corneal staining, and symptoms assessment.<sup>3</sup> Of the 120 patients, 56.7% had abnormal tear osmolarity, 63.3% tested positive for MMP-9, and 39.2% had corneal staining. Of 100 patients, 54 reported symptoms suggestive of ocular surface dysfunction. Overall, 80% had at least one abnormal diagnostic test suggestive of ocular surface dysfunction and 40% of patients had two abnormal results. Interestingly, 50% of asymptomatic patients had abnormal tear osmolarity and tested positive for MMP-9.

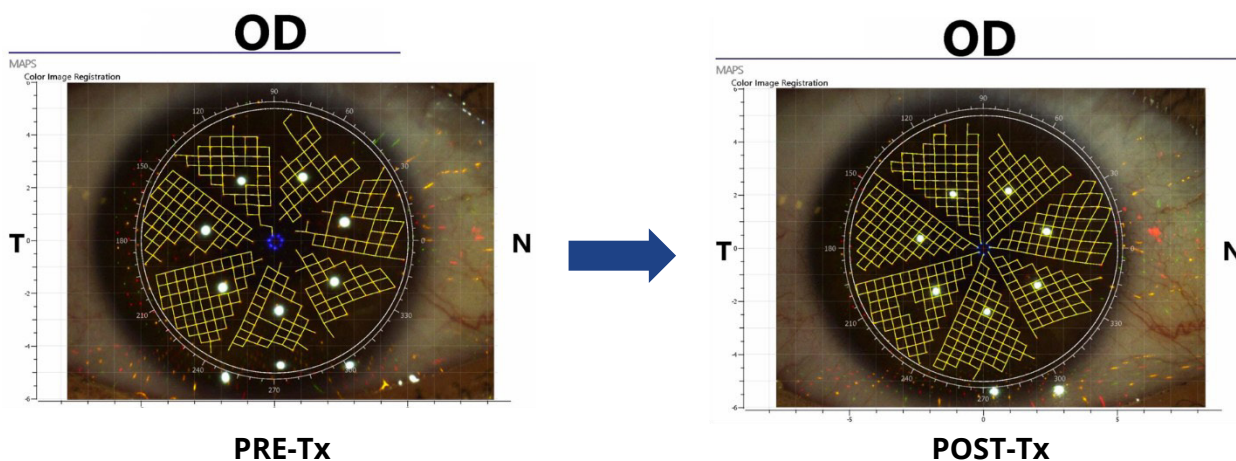
Other studies focused on more traditional diagnostic tests and found a higher prevalence of abnormal ocular surface characteristics. Trattler, et al., examined 136 cataract patients being preoperatively and found that 69.2% of patients had fluorescein tear breakup time < 5 seconds, 77% of eyes had corneal staining, 50% of eyes had central corneal staining, and 18% had Schirmer's score with anesthesia < 5 mm.<sup>15</sup> Cochener, et al., evaluated 180 cataract patients (342 eyes) specifically for signs of meibomian gland dysfunction (MGD), and found that 54% of patients had low meibomian gland expression score and 56% of patients had some level of meibomian gland atrophy.<sup>2</sup> Among the asymptomatic patients, 71% of patients had poor gland expression and some level of meibomian gland atrophy. Finally, Viso, et al, evaluated 619 subjects for MGD, defined as presence of viscous or waxy white secretion upon digital expression, two or more lid margin telangiectases, and plugging of two or more gland orifices.<sup>16</sup> They reported weighted prevalence of 21.9% of asymptomatic MGD patients and 8.6% of symptomatic MGD patients.

In summary, prevalence of dry eye can vary widely depending on the diagnostic parameter or criteria used. Study results, however, show that a significant proportion of asymptomatic patients (50-71%) can present with multiple clinical signs suggestive of ocular surface disease. Because these patients have no symptom complaint, they often go undiagnosed and untreated in a preoperative workup.

## Tear Film and Biometry Measurements

In order to understand the implications of performing refractive or cataract surgery on an untreated dry eye patient, it is important to review the impact that the tear film has on preoperative measurements, which include keratometry, corneal topography, and wavefront analysis. These instruments base their measurements on light projections and reflections off of or through the tear film, which contributes to nearly 2/3 of the eye's total refractive power due to the change in index of refraction between the air-tear interface and curvature on the ocular surface.<sup>17</sup> Keratometers rely on reflections from 2 to 24 points within a 3.2mm diameter on the central cornea to roughly estimate the corneal curvature.<sup>18</sup> Corneal topographers, on the other hand, rely on the reflection of thousands of points measured within larger 3-, 5-, and 7-mm zones providing significantly more data points to estimate corneal curvature.<sup>18</sup> Wavefront aberrometers project light onto the pre-corneal tear film through to the retina to detect distortions, or aberrations, along its path.<sup>19</sup>

Because the air-tear interface contributes to a majority of the eye's refractive power and it is the first refracting surface encountered by light from the instruments, a smooth pre-corneal tear film will yield more reliable and repeatable measurements than an irregular and highly dynamic tear film, such as in dry eye patients. As demonstrated in Figure 1, local corneal variations measured using surface regularity index (SRI) and surface asymmetry index (SAI) with corneal topography are higher in dry eyes than in healthy eyes.<sup>20</sup>



**Figure 1: Cassini surface qualifier projections belonging to a patient with dry eye before (left) and after (right) brief exposure to a warm compress mask. [Photos: Courtesy of Cynthia Matossian, MD]**

Epitropoulos, et al., found that significantly more variability in average keratometry and anterior corneal astigmatism was observed in hyperosmolar patients ( $> 316$  mOsm/L in at least one eye) compared to normal patients ( $< 308$  mOsm/L in both eyes) ( $p=0.05$ ), with significant resultant differences in IOL power calculations ( $p=0.02$ ).<sup>21</sup> The authors suggest that measurement of tear osmolarity at the time of cataract surgery planning can effectively identify patients with a greater risk of high unexpected refractive error resulting from inaccurate keratometry.

Matossian reported the results of a pilot study designed to determine if eyelid thermal pulsation treatment prior to cataract surgery altered preoperative keratometry measurements. She found that, among 24 patients, significant changes in delta-K (difference in horizontal and vertical keratometry values) and axis occurred between pre- and post-thermal pulsation treatment ( $p<0.001$ ).<sup>22</sup> The results changed planned interventions for astigmatism correction for 40% of case. Post-surgically, 60% of patients achieved their refractive target, 28% were within  $\pm 0.25D$ , 4% were within  $\pm 0.50D$ , and 8% were within  $\pm 1.00D$ .

In addition to affecting objective biometric measurements, an irregular tear film can also induce fluctuating vision. The Dry Eye Assessment and Management (DREAM) Study Research Group explored the association between dry eye signs and symptoms with visual acuity and contrast sensitivity. The study reported that, among 487 participants, worse mean score on the Ocular Surface Disease Index (OSDI) questionnaire was associated with worse visual acuity ( $p=0.02$ ).<sup>23</sup> Severe meibomian gland plugging and abnormal secretions, as well as shorter tear breakup time, were associated with worse contrast sensitivity ( $p=0.04$  and  $p<0.001$ , respectively).

Tear film irregularities, as evidenced by these studies, can impact preoperative visual acuity, contrast sensitivity, biometry measurements, and, ultimately, IOL power calculations.

## Preoperative Dry Eye Diagnosis and Treatment

Because of the prevalence of DED in the presurgical population and the potential impact of untreated DED on preoperative measurements, there is growing interest by surgeons for DED patients to be treated and managed preoperatively. However, according to an ASCRS survey of surgeons, DED and ocular surface disorders were identified as topics of confusion, and more than 75% of respondents were unfamiliar with the Tear Film & Ocular Surface (TFOS) Society and Dry Eye Workshop (DEWS) II, which have published extensively on epidemiology, pathophysiology, diagnosis, and treatment options for dry eye disease.<sup>1</sup> Below are high-level summaries of the TFOS DEWS II and ASCRS guidelines for the pre-operative DED diagnosis and treatment.<sup>1,24</sup> DED is a multifactorial disease that can be very complex to diagnose and treat. However, a systematic approach in an ocular surface examination can facilitate the development of a diagnosis, treatment recommendation, and management plan.

### Diagnosis

TFOS DEWS II DED Diagnostic Battery (Figure 2) was designed to identify the underlying cause of ocular discomfort symptoms so that treatment can be more targeted.<sup>24</sup> Triaging questions are designed to eliminate conditions that can mimic DED, and the risk factor analysis may help to ultimately guide management. The standardized questionnaires can trigger diagnostic testing using tear breakup time, tear osmolarity, and/or ocular surface staining (cornea, conjunctiva, and eyelid margin) with fluorescein or lissamine green. Evaluation for signs of meibomian gland dysfunction (MGD), including gland secretion quality and quantity, and tear volume will help to further classify the DED as either aqueous-deficient or evaporative dry eye. Symptoms in the absence of signs suggest an element of neuropathic pain, but signs alone may still warrant treatment to prevent DED manifestation and restore ocular surface integrity. Figure 3 offers guidance on diagnosis and management in the presence or absence of symptoms and signs.

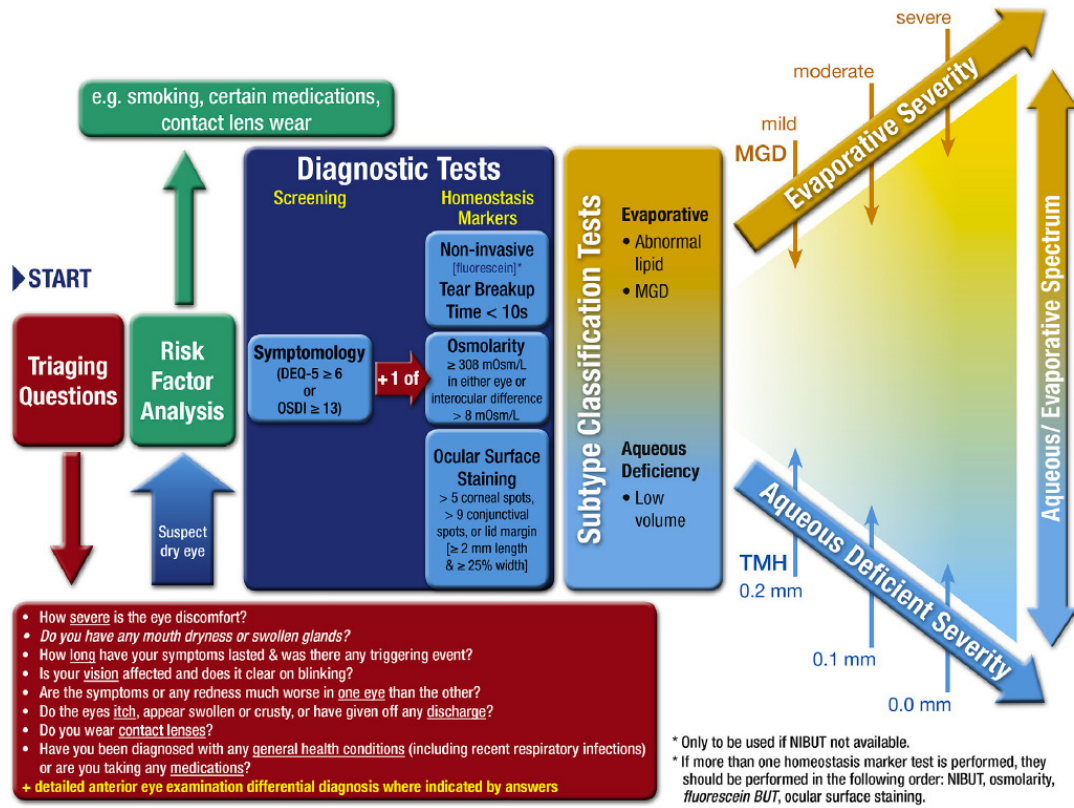


Figure 2: Dry Eye Disease Diagnostic Battery from the TFOS DEWS II – Diagnostic Methodology Report<sup>24</sup>

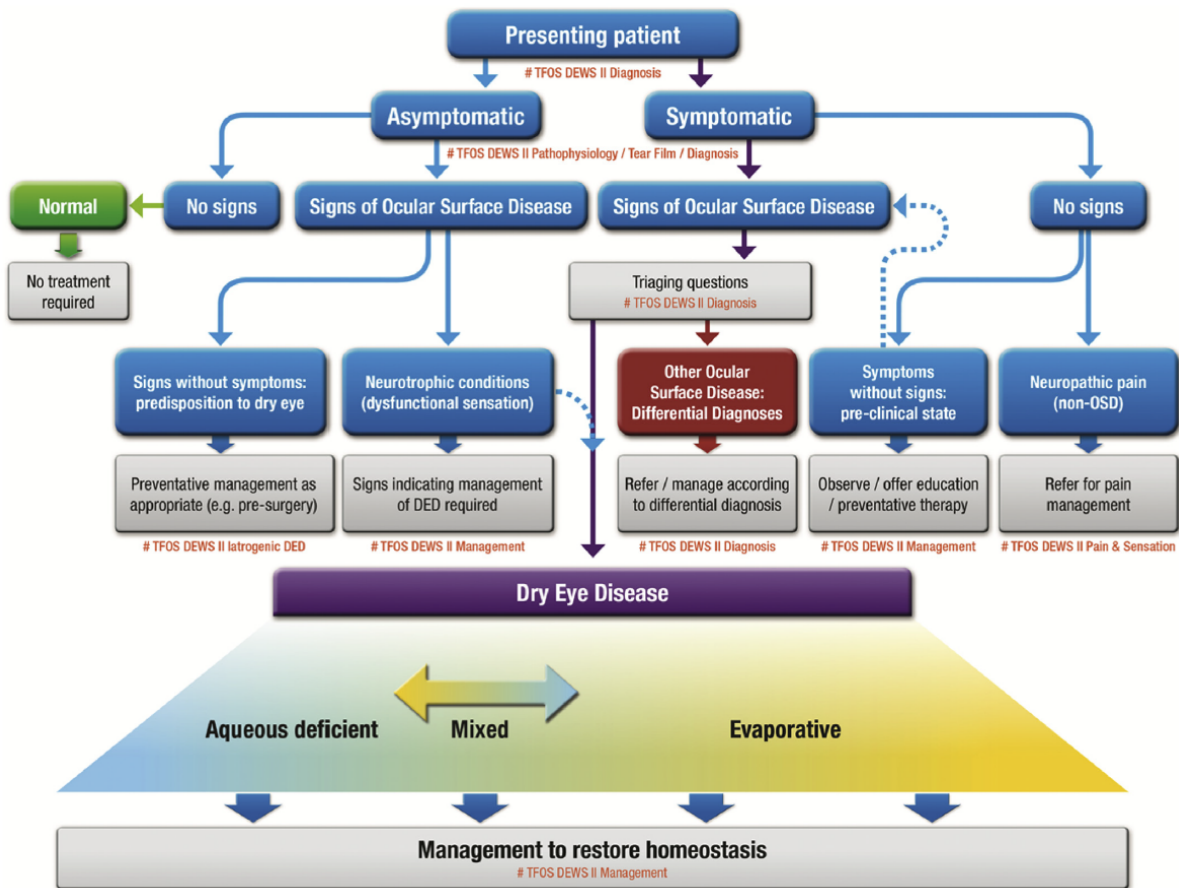
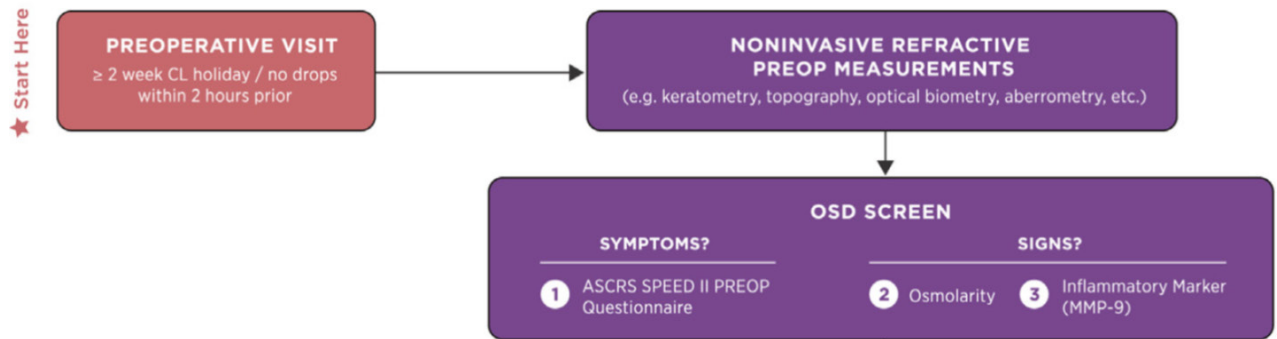


Figure 3: Dry eye diagnosis and management decision tree from TFOS DEWS II Report.

The ASCRS Cornea Clinical Committee developed the Preoperative Ocular Surface Disease Algorithm (Figure 4 and 5) designed for a preoperative setting with an emphasis and reliance on objective, non-invasive tests that can be performed by technicians.<sup>1</sup> The rationale is that preoperative visits already involve significant, often technician-driven refractive and biometric testing, so the algorithm would save physicians time.

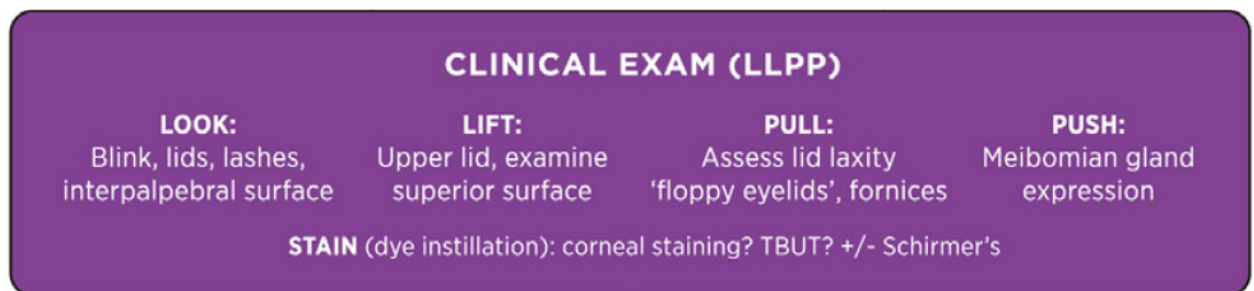


**Figure 4: ASCRS Preoperative Ocular Surface Disease Algorithm - Part 1.<sup>1</sup>**

Figure 4 represents the initial screening procedures, possibly performed by a technician, recommended by the ASCRS Cornea Clinical Committee in a preoperative setting. The procedures include the ASCRS Standard Patient Evaluation of Eye Dryness (SPEED) II questionnaire, tear osmolarity, and matrix metalloproteinase (MMP-9) testing. The ASCRS SPEED questionnaire is a modified SPEED II questionnaire, and similar to the original SPEED questionnaire, higher scores should raise suspicion for visually-significant ocular surface disease.<sup>1</sup> Tear hyperosmolarity is regarded as a key mechanism in the ocular surface inflammatory cascade and can be tested in-office to assess severity.<sup>1,25</sup> MMP-9 is an enzyme released during inflammation, and it has been found to be elevated in patients with ocular surface disease and can be tested in-office to detect presence of  $\geq 40$  ng/ML of MMP-9 with 85% sensitivity and 94% specificity.<sup>26</sup>

According to ASCRS recommendation, if any of the three tests are abnormal, then the presurgical patient is at risk for ocular surface disease, and additional diagnostic tests can be performed to determine dry eye sub-type. Non-invasive tests are recommended in order to minimize disruption to the ocular surface, cornea, and tear film. These tests can include tear lipid layer thickness, non-invasive tear breakup time (NIKBUT), tear meniscus height, meibography, topography, and measures of optical scatter.

In addition to the preliminary diagnostic tests, a “Look, Lift, Pull, and Push” examination is imperative regardless of the previous test results (Figure 5).<sup>1</sup> “Look” is a visual examination of the eyelids, lashes, and ocular surface. “Lift and Pull” is an eyelid eversion to evaluate epithelial basement membrane dystrophy and lid laxity. “Push” involves applying pressure to the lower eyelid to evaluate quality and quantity of expressible meibum from the meibomian glands.



**Figure 5: ASCRS Preoperative Ocular Surface Disease Algorithm - Part 2.<sup>1</sup>**

The final phase of the examination is considered invasive and includes the use of common vital dyes, including sodium fluorescein to measure tear breakup time and to assess cornea staining, and lissamine green or rose bengal dye to stain devitalized cells on the ocular surface.<sup>1</sup>

Both TFOS DEWS II and ASCRS offer regimen for the diagnosis and management of DED, each tailored to different clinical settings. Both recommend a small set of screening tests, including subjective and objective tests, to determine if more extensive testing is warranted. Because the tear film plays such a critical role in accurate keratometry measurements, and because those measurements are essential to a successful pre-surgical plan for both cataract and refractive procedures, it is recommended that all patients preparing for these surgeries are screened and treated, if necessary, for ocular surface disease preoperatively in order to optimize preoperative biometry measurements and postoperative outcomes.

## Treatment

Treatment options have been discussed extensively in the DEWS II report, as well as the International Workshop on Meibomian Gland Dysfunction, but if visually-significant ocular surface disease is diagnosed during a preoperative cataract or refractive workup, a more aggressive approach is recommended by the ASCRS group.<sup>1</sup> This is due to the need for rapid resolution to homeostasis for accurate preoperative measurements and maximum post-surgical outcomes. The goal is to address ocular surface inflammation, corneal staining, and lid margin disease simultaneously to minimize time-to-surgery. A summary of the treatment options recommended by the ASCRS Cornea Clinical Committee are presented in Table 1.<sup>1</sup>

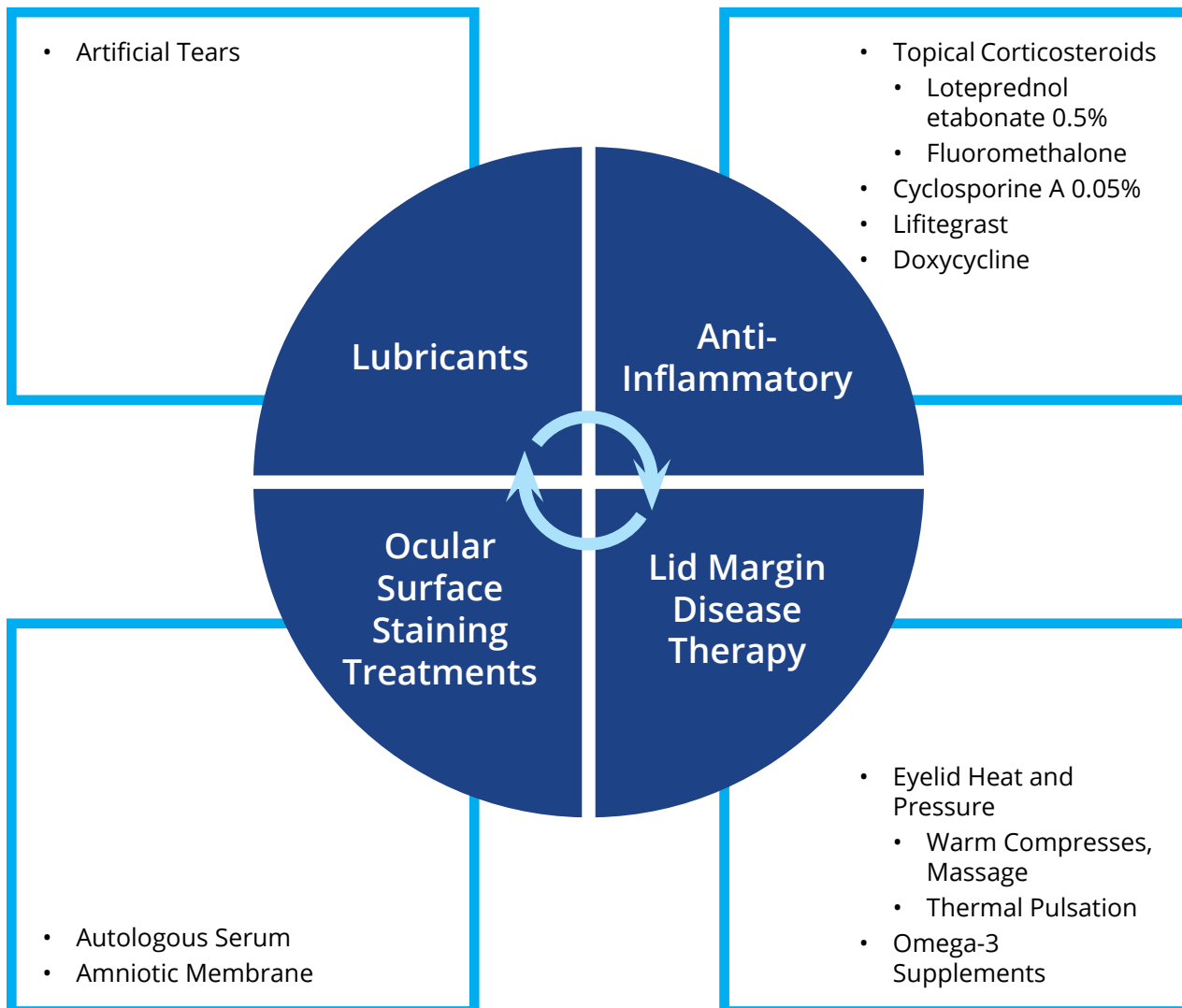


Figure 6: ASCRS recommended treatment options for ocular surface disease preoperatively.<sup>1</sup>

## Conclusion

Approximately half of the pre-surgical population is believed to have symptoms and/or signs of DED, and over half of asymptomatic patients present with signs suggestive of DED.<sup>2,7,9,10,13-15</sup> Since preoperative biometry measurements are highly dependent on a smooth, healthy tear film, diagnosing and treating DED prior to refractive and cataract surgery can optimize biometry measurements and symptoms leading into surgery. Dry eye diagnosis and treatment can be complex, but algorithms have been provided by the TFOS DEWS II report and the ASCRS Preoperative Ocular Surface Disease Algorithm to facilitate this process. Treatment of DED has been shown to improve biometry accuracy and symptoms, underscoring the importance of preoperative screening, diagnosis, treatment, and management of ocular surface disease.



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