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Dry Eye Syndrome after Cataract Surgery

Monika Łazicka-Gałecka[1,2], Tomasz Gałecki[2], Jacek Dziedziak[1,2], Maria Guszkowska[2], Jacek P. Szaflik[1,2]

[1] Department of Ophthalmology, Medical University of Warsaw, Poland
Head: Professor Jacek P. Szaflik, PhD, MD
[2] SPKSO Ophthalmic University Hospital in Warsaw, Poland
Head: Professor Jacek P. Szaflik, PhD, MD

Summary: Cataract is the most common cause of reversible vision loss, and its surgery is a widely performed procedure. Modern cataract surgery carries minimal risk of serious complications, but patients are increasingly reporting post-operative dry eye syndrome. Dry eye syndrome is a multifactorial disease of the ocular surface that can worsen or develop after the procedure. The increased frequency of dry eye syndrome following cataract surgery results from corneal nerve damage, toxic effects of post-operative medications, and dryness of the ocular surface during the procedure.

Dry eye syndrome after cataract surgery can persist chronically, causing symptoms such as burning, dryness, and pain. The incidence of post-operative dry eye syndrome ranges from 8–37%, most commonly occurring in older patients, those with systemic diseases, those taking medications, or those with pre-existing ocular surface disorders. Symptoms can last from a few days to up to 12 months after surgery.

Cataract surgery in patients with dry eye syndrome may lead to exacerbation of the condition and complications, such as difficulties in calculating the power of the intraocular lens implant, problems with visualization during surgery, and dissatisfaction with the surgical outcome. Preoperative assessment of the ocular surface and treatment of dry eye syndrome are crucial to reduce the risk of post-operative complications. Preventive measures for dry eye syndrome include taking a history for ocular surface disorders, assessing the tear film, evaluating the function of the Meibomian glands, and appropriate treatment.

Post-operative treatment of dry eye syndrome involves the use of lubricating drops, anti-inflammatory agents, and, in severe cases, immunomodulatory drugs, which improve symptoms. The application of appropriate surgical techniques, as well as preoperative prevention and post-operative treatment, are essential to minimize the occurrence of dry eye syndrome after cataract surgery.

Key words: cataract surgery, dry eye syndrome (DES), lubricating therapy, risk factors for dry eye syndrome, diagnosis of dry eye syndrome, corneal nerve damage, diagnostic tests (Tear Break-up Time – TBUT), Schirmer test, interferometry.

Introduction

Cataract is the most common cause of visual impairment worldwide, and cataract removal surgery is the most frequently performed surgical procedure globally. Technological advancements have made it possible for modern cataract surgery to not only remove the clouded lens but also correct coexisting refractive errors. The introduction of phacoemulsification, minimization of corneal incision size, and appropriate intraoperative and postoperative management are just some of the factors that have resulted in cataract surgery now being associated with a very low rate of serious, vision-threatening complications (such as endophthalmitis and cystoid macular edema) [1]. Currently, post-operative dry eye syndrome (DES) is one of the most common causes of patient dissatisfaction following an uncomplicated cataract surgery [2]. According to the definition by the Tear Film & Ocular Surface Society (TFOS), DES is a multifactorial disease of the ocular surface associated with the loss of tear film homeostasis and accompanied by a range of ocular symptoms [3]. Key contributing factors in the development of the disease include instability and hyperosmolarity of the tear film, inflammation and impairment of ocular surface structures, as well as neurosensory dysfunctions [4]. The prevalence of DES is difficult to determine precisely due to differences in classification criteria across studies. According to research based on clinical criteria, it varies widely, ranging from 5.5% to 33.7% in individuals over 50 years of age. When focusing solely on patients' subjective symptoms, the prevalence is higher and can reach up to 50%. For both cataract and DES, the prevalence increases with age. It is known that cataract surgery can both exacerbate pre-existing DES and lead to the development of the disease [5].

Epidemiology of DES after cataract surgery

Dry eye syndrome is a frequent occurrence following cataract surgery, with its prevalence estimated between 8% and 100%, depending on the criteria applied. In their 2022 meta-analysis, Miura et al. reported that 37.4% of patients without prior ocular surface disorders developed DES after cataract surgery (95% CI 22.6–52.3). Risk factors for the development of DES identified in the study included age, female gender, systemic diseases, psychiatric disorders, salivary gland dysfunction, and preservatives in eye drops. The peak severity of DES occurred one day after cataract surgery and persisted for at least 1–12 months following the surgical procedure [4]. In another study, it was found that 12 weeks after surgery, 100% of patients showed a reduction in tear break-up time (TBUT) and Schirmer I test results [6]. Sajnani et al., in their original study, showed that one-third of patients (34 individuals) experienced persistent post-surgical pain (PPP) with symptoms characteristic of DES – including burning, dryness, and a gritty sensation in the eyes – six months after cataract surgery. The study also identified the following risk factors for the development of PPP: female gender, autoimmune diseases, neuropathy, and the use of medications (antihistamines, anti-reflux agents, antidepressants, anxiolytics, and hypnotics) [7].

Cataract surgery in patients with DES

The prevalence of DES means that ocular surface abnormalities are frequently identified already during preoperative eligibility assessment. Performing cataract surgery on DES patients not only exacerbates the underlying condition but also introduces multiple challenges. Firstly, there is the difficulty of calculating the intraocular lens power. The tear film is the first light-refracting medium in the eye's optical system and is characterized by the largest change in refraction in the entire system, occurring at the air-tear film interface. Tear film abnormalities affect the overall quality of vision, causing an increase in higher-order aberrations (HOA). Also, astigmatism in eyes affected by DES is often

overestimated and irregular, making it challenging to accurately determine the correct axis for toric lenses [8]. A common complaint reported by patients with DES is hypersensitivity to light, which can lead to poor cooperation during the procedure. Severe corneal drying during surgery impairs visualization and may contribute to intraoperative complications. Postoperatively, DES not only reduces patient satisfaction with the procedure but also leads to poorer wound healing and an increased risk of infection. For this reason, a detailed examination and medical history focused on ocular surface disorders are crucial, along with initiating treatment as early as the stage of eligibility assessment for surgery [9]. For example, the American Society of Cataract and Refractive Surgery (ASCRS) has developed an algorithm for preoperative diagnosis and treatment of ocular surface diseases. The diagnostic process begins with the patient completing the Standard Patient Evaluation of Eye Dryness II (ASCRS SPEED II) questionnaire and with performing screening tests: tear film osmolarity assessment and evaluation of ocular surface inflammation by determining the level of matrix metalloproteinase 9 (MMP-9) in the tear film. In mild to moderate cases, treatment for DES should be initiated immediately, but the surgery can generally proceed on the scheduled date. However, in patients with severe DES, when tear film osmolarity exceeds 336 mOsm/ L and the MMP-9 level is greater than 40 ng/ mL, intensive anti-inflammatory and ocular surface regenerating treatment should be initiated, and the surgery postponed for a minimum of two weeks. After this period, the ocular surface condition is reassessed to determine whether symptoms have diminished, ensuring the procedure can be performed safely [10, 11].

DES after cataract surgery in patients without prior ocular surface disorders

As mentioned above, even uncomplicated cataract surgery causes the development of DES in over one-third of patients. The exact pathogenesis of postoperative DES is not fully understood. Factors disrupting the homeostasis of the tear film and leading to the development of postoperative DES include:

- damage to the corneal nerves during the incision in the transparent cornea,
- damage to the ocular surface caused by the toxic effects of ingredients of eye drops used during the perioperative period,
- toxicity of local anesthetics and povidone-iodine used to disinfect the ocular surface before surgery,
- drying of the ocular surface during the procedure,
- excessive irrigation of the ocular surface during the surgery,
- phototoxicity from the microscope light,
- duration of surgery and the cumulative power of the ultrasound used during the procedure.

Most likely, DES develops after cataract surgery due to the cumulative effect of multiple factors that damage the ocular surface [12].

Studies based on confocal microscopy have confirmed a reduced nerve density in patients after cataract surgery. In their original study, Jing et al. found that corneas after cataract surgery exhibited not only a decline in corneal nerve density but also a reduction in the maximum length of corneal nerves. Moreover, the researchers proved that these values were reduced even three months after the surgery [13].

Postoperative reduction in corneal nerve density leads to decreased corneal sensitivity. As early as 1962, Lyne observed that all eyes undergoing cataract surgery exhibited near-total anesthesia in the upper half of the cornea after one year, with only three out of 38 eyes retaining normal sensitivity after two years [14]. The adoption of phacoemulsification as the standard surgical technique, combined with smaller corneal incisions, has significantly reduced corneal sensitivity loss compared to the era of extracapsular cataract extraction. Nevertheless, a certain degree of corneal sensitivity loss still occurs. The results of the study by Kim et al. demonstrated a significant decrease in corneal sensitivity at the incision site following cataract phacoemulsification. Three months after cataract surgery, corneal sensation returned to nearly normal levels in the majority of patients. It is interesting that the density of corneal nerves remained significantly reduced three months after the procedure compared to the postoperative period. This discrepancy suggests that the morphological recovery of corneal innervation may take longer than the restoration of corneal sensation [15].

The deterioration of the ocular surface in patients after cataract surgery is also linked to reduced conjunctival goblet cell density, which produces the mucous layer of the tear film. Li et al. observed that a significant decline in goblet cell density (measured via impression cytology) persists for at least three months post-surgery. Furthermore, they demonstrated that cataract surgery triggered squamous metaplasia of the conjunctival epithelium in some patients, particularly in the lower fornix, likely due to the toxic effects of eye drops used postoperatively [16].

Cataract surgery has also been found to exacerbate Meibomian gland dysfunction (MGD). The most commonly observed changes include obstruction of Meibomian gland orifices and impaired secretion from these glands. Less frequently, symptoms such as anterior blepharitis and morphological changes, including displacement of the mucocutaneous junction, are noted [17].

Numerous studies have shown that ocular surface disorders can occur after cataract surgery. Abnormalities are detected both in traditional tests used in the diagnosis of DES (including corneal staining, tear film break-up time, or the Schirmer test) and in modern examinations, such as ocular surface interferometry, which allows for the assessment of the lipid layer thickness of the tear film, blink frequency, Meibomian gland morphology, and the TBUT test without the use of dyes (Non-Invasive Tear Break-Up Time, NI-TBUT) [18].

Treatment and prevention of DES following cataract surgery

Preventing DES after cataract surgery is crucial for ensuring optimal surgical outcomes and patient satisfaction.

The cornerstone of both treatment and prevention of DES is appropriate supplementation of the tear film with artificial tear preparations. However, research comparing the effectiveness of different artificial tear formulations remains limited.

Prophylaxis for postoperative DES should commence as early as the preoperative evaluation for cataract surgery. Gathering a thorough medical history is essential, particularly identifying symptoms that may indicate ocular surface disorders. Dedicated questionnaires, such as the OSD or the Standard Patient Evaluation of Eye Dryness II – ASCRS SPEED II, can be helpful for this purpose [11]. In the patient's medical history, attention should be paid to risk factors and conditions predisposing to the occurrence of postoperative DES, such as diabetes, autoimmune diseases, skin conditions, and use of medications (beta-blockers, antihistamines, antidepressants, anxiolytics, and hormonal drugs). Preoperative physical examination should include both an evaluation of the tear film and a comprehensive assessment of ocular protective mechanisms. In patients with significant eyelid malpositioning – such as severe entropion – surgical correction of the eyelid position should be performed first, with cataract removal planned for a later stage. Assessing Meibomian gland function is essential; if dysfunction is detected before surgery, early treatment should

be initiated to prevent postoperative exacerbation. Management strategies should include eyelid margin hygiene, warm compresses, and, in more severe cases, the use of anti-inflammatory medications and matrix metalloproteinase inhibitors [19, 20]. Song et al. examined how preoperative eyelid margin hygiene influences the reduction of DES symptoms following surgical procedure. Patients who maintained eyelid margin hygiene before surgery exhibited less pronounced ocular surface disorders, as indicated by better OSS results, longer NI-TBUT, higher Schirmer I test values, and improved Meibomian gland secretion [21].

To minimize the negative impact of surgery on the ocular surface, the width of the corneal incision can be reduced, the procedure duration shortened, and phototoxic effects mitigated through the use of filters. Additionally, intraoperative exposure to toxic medications can be limited – for example, by using a single drop of povidone-iodine instead of irrigation. Both drying and excessive intraoperative irrigation can damage the ocular surface. He et al. demonstrated that intraoperative application of hydroxypropyl methylcellulose (HPMC) to the cornea provides protective effects on the ocular surface compared to irrigation with balanced salt solution (BSS) [22].

Postoperative treatment should include moisturizing eye drops or gels. There are very few publications comparing the effectiveness of different formulations of lubricating eye drops. Caretti et al. showed that postoperative treatment with a combined hyaluronic acid and trehalose formulation was more effective in alleviating both objective and subjective symptoms compared to hyaluronic acid-based preparations alone [23].

A crucial element in DES prevention is a well-structured postoperative treatment regimen, which should not be prolonged excessively. Due to the key role of inflammation in the pathophysiology of DES, the treatment of more severe cases should include local anti-inflammatory medications, such as cyclosporine A. Chung et al. demonstrated that the use of 0.05% cyclosporine A significantly reduces the symptoms of DES. Kang et al. found that treatment with 0.05% cyclosporine A in patients with DES and MGD led to an increase in TBUT and an improvement in the lipid layer of the tear film [24, 25].

Some studies suggest that mucin secretion promoters, such as diquafosol and rebamipid, have a beneficial effect [26, 27].

In recent years, there has been growing interest in corneal sensitivity and its connection to DES development. Belmonte et al. identified distinct functional roles of corneal nerves. Twenty percent of nerves are mechanonociceptors, responding exclusively to mechanical forces, while 70% are polymodal nociceptors, which react to extreme temperatures, chemical substances, and inflammatory mediators. The remaining 10% are cold-sensitive receptors, known as cold receptors. A key characteristic of polymodal nociceptors is their heightened sensitivity to repeated irritating stimuli. This results in a lowered sensitivity threshold and an amplified response to stimuli, known as hyperalgesia. Additional factors, such as prostaglandins and bradykinin released, for example, due to surgical trauma, can further reduce the sensitivity threshold. This altered receptor sensitivity is believed to be the source of pain, irritation, and dryness reported by patients after surgery. Consequently, interest in the use of nonsteroidal anti-inflammatory drugs (NSAIDs) for DES treatment has increased. These drugs inhibit cyclooxygenases, which not only reduce inflammation but also decrease receptor sensitivity [28, 29].

Conclusions

DES is a common but often underappreciated complication following cataract surgery that can significantly impact patients' quality of life, even after uncomplicated procedures. The increased prevalence of DES in the postoperative population, along with numerous risk factors, demands particular attention during both preoperative patient eligibility assessment and throughout postoperative care. Proper diagnosis and early initiation of treatment, including the use of lubricating eye preparations, anti-inflammatory therapy, and eyelid hygiene, can significantly contribute to reducing DES symptoms. Understanding the mechanisms underlying DES after cataract surgery, as well as implementing modern diagnostic technologies, is crucial for optimizing postoperative patient care. Future therapies may focus on advancing methods that improve corneal nerve regeneration, reduce inflammation, and support healthy tear film production.

Disclosure
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Reprint requests to:

Monika Łazicka-Gałecka, MD (e-mail: lazgal@wp.pl)
SPKSO Ophthalmic University Hospital in Warsaw
Józefa Sierakowskiego 13, 03-709 Warszawa