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The Impact of eye cosmetics on the tear film - exploring the outcomes, mechanisms, and effects on ocular health

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Abstract. The paper extensively analyses cosmetic migration into the tear film through mechanical pressure from blinking and temperature effects on viscosity and cosmetic product properties. The entry of cosmetic particles into the eye causes damage to the meibomian glands, resulting in impaired lipid secretion and destabilising the tear film. Preservatives, colours, scents, and waterproofing chemicals act as inflammatory agents that lead to epithelial harm, hyperosmolarity, and chronic inflammation cycles that worsen eye surface damage. The standard dry eye treatments, including artificial tears and anti-inflammatory drugs, and eyelid hygiene routines, serve as the primary methods for treating cosmetic-related eye pain. The regular use of cosmetics reduces treatment effectiveness, which demonstrates why patients need personalised care plans. The use of ophthalmologist-endorsed cosmetic products combined with barrier products enables safer cosmetic applications. Patients who learn correct cosmetic application techniques together with proper hygiene practices reduce their chances of eye complications. The key focuses involve creating skincare products that are safe for the skin and employing technology to observe how tears behave over time, as well as setting up consistent ways to assess these changes in a standard manner. Enhancing the well-being of the eye surface amidst the growing trend of using cosmetics will rely on ventures between eye doctors, cosmetic scientists, and regulatory bodies to ensure that cosmetic practices are carried out safely.

Keywords: ocular surface damage; cosmetic ingredients; interdisciplinary collaboration.

1. Introduction

The story behind eye makeup is fascinating. It dates back to times when people first used it to enhance and beautify the appearance of their eyes. Early societies, like the Egyptians, were pioneers in using eye cosmetics for both spiritual and medical purposes. (Eldridge, 2015) Ancient civilisations, particularly the Egyptians, were among the pioneers in using eye cosmetics, serving both aesthetic and religious or medical functions. Ben-Noun et al. concluded that two non-natural Pb chlorides, including Pb2Cl2CO3 and Pb(OH)Cl, had been used to treat eye illness and makeup (Ben-Nun, 2016). In ancient Egypt, Kohl was used around the eyes, which is believed to possess protective properties against the sun's brightness and eye diseases. (Mahmood, Azhar, & Ahmed, 2019) Over time, the principal purpose of eye cosmetics transitioned from defence to aesthetic improvement, leading to its widespread adoption across various cultures. The practice was disseminated outside the Middle East, and by the 18th and 19th centuries, eye cosmetics were firmly entrenched in Western societies (Hardy, Sutherland, & Vaishnav, 2002). In contemporary society, eye cosmetics have become an essential component of everyday routines for millions globally. These items have developed into representations of self-expression, culture, and identity, as well as to improve appearance. Eye cosmetics, including mascara, eyeliner, eyeshadow, and eyebrow pencils, rank among the most frequently utilised products in the global cosmetics sector. Women typically use eye makeup based on fashion trends and social expectations as well as their individual preferences.Eye cosmetics serve both visual objectives and produce substantial psychological impacts because numerous women state that makeup application enhances their self-esteem and confidence and improves their general well-being. (Tran, Rosales, & Copes, 2020) People commonly believe that eye makeup possesses the same strength because it enables individuals to showcase their natural flair and improve their perceived attractiveness.. A market study from the United States, the United Kingdom, and other nations indicates that a substantial percentage of women across diverse age

demographics consistently utilise eye cosmetics. The most common cosmetics are mascara, eyeliner, and eyeshadow; their growing worldwide demand highlights their great relevance in the daily lives of many people.

Still, even though eye makeup has a lot of positive effects on your mind and eyesight, it also has some risks.. A notable illustration of the possible dangers associated with eye makeup is the application of Kohl. Kohl has been utilised for millennia and is prevalent in these locations, yet it is linked to significant health concerns.(Al-Hazzaa & Krahn, 1995) Kohl usage has been associated with lead toxicity, potentially leading to significant health complications, including neurological disorders and colouring of the conjunctiva and periorbital areas. The issues have elicited apprehensions over the safety of Kohl, particularly when misused or contaminated. (Parry & Eaton, 1991) Cosmetics, from the West, must undergo safety tests and government inspections to prevent health issues. Notwithstanding these laws, current clinical research has commenced to underscore the long-term hazards linked to contemporary Western ocular cosmetic products. (Al-Ashban, Aslam, & Shah, 2004) Evidence has developed that specific components in these cosmetics, including waterproof formulations, pigments, and preservatives, may extend beyond the eyelid edge and into the tear film, compromising its stability. The research conducted by Baudouin and associates demonstrated that ammonium-containing substances can induce instability in the film, resulting in a decrease in goblet cells in the eye, alterations in the conjunctiva to a squamous morphology, and apoptotic processes; furthermore, they inflict damage on the protective layer of the corneal epithelium and adversely affect deeper ocular structures within the eye's anatomy. (Baudouin, Labbé, Liang, Pauly, & Brignole-Baudouin, 2010) Instability in the tear film, which may lead to dry eye, irritation, and other conditions affecting the eye's surface, may become more common in those who do this.

The complicated tear film protects the eye from environmental threats with its multi-layered structure. The lipid layer may be compromised when eye makeup, including waterproof dyes and chemicals, migrates into the tear film. (Wang & Craig, 2018) Millions of people throughout the globe suffer from dry eye disease, which this instability might potentially cause. Dry eye illness is marked by several symptoms, such as pain, dryness, redness, and poor vision, which can profoundly impact an individual's quality of life. Furthermore, the translocation of cosmetic particles into the tear film may incite inflammation, aggravating symptoms and contributing to disorders such as meibomian gland dysfunction (MGD) and blepharitis, which are intricately associated with dry eye illness. (Messmer, 2015) Further investigation into how tear films may be affected by eye makeup and the increasing popularity of these cosmetics is crucial to safeguarding the well-being of individuals who use them. This study will discuss solutions for the problem of eye makeup causing harm to the eyes by looking into safer product ingredients and specialised treatments for dry eyes.

2. The micro-structure and function of the tear film

The main safeguard and functional connection of the eye's surface is the layer of tears that shields the conjunctiva and acts as a fluid barrier. (Braun, 2012) The film of tears protects the eye from environmental irritants, facilitates eyelid movement during blinking, and ensures clear vision by acting as an optimum refractive medium. The film of tears consists of three layers. The mucin layer, the intermediate watery layer, and the external lipid layer. Each assumes a unique purpose in preserving the integrity and efficacy of the tear film together. Designed to convert the normally hydrophobic corneal epithelium into a wettable surface, the innermost mucin layer is a gel-like matrix mostly released by conjunctival goblet cells. This mucin layer guarantees consistent coverage and prevents local dry patches or uneven tear film thinning by improving adhesion of aqueous tears to the corneal surface. The aqueous layer, mostly generated by the lacrimal glands, is immediately next to the mucin layer. Essential nutrients, including electrolytes and dissolved oxygen, are provided by this aqueous component, which hydrates ocular cell metabolism. It also contains antibacterial chemicals that help to protect the eyes and help to remove metabolic waste and particle debris from the ocular surface, therefore preserving the best physiological conditions.

The proper functioning of the tear film emerges from the balanced relationship between these three components. Every blink uniformly redistributes tears, reconstitutes the lipid layer, and maintains a steady eye surface environment. (Jiang et al., 2022) A breakdown of tear film stability occurs when any single layer becomes deficient, thus starting a chain reaction that leads to tear film instability and dryness. Aqueous secretion deficiencies lead to insufficient eye surface nutrition, which causes discomfort and pain, while mucin deficiency leads to irregular tear distribution. The lack of lipid production leads to excessive tear drying, which intensifies eye surface dryness and discomfort. The instability of the tear film allows epithelial cells from the ocular surface to become exposed, thus triggering inflammatory reactions. The inflammatory response damages the tear film layer function and secretion, which creates a continuous negative cycle that worsens ocular surface health. Tear film instability that persists over time results in dry eye syndrome, which produces symptoms such as eye irritation, burning sensations, vision problems, and increased susceptibility to corneal damage and infections. (Fassi & Naidoo, 1989) Knowledge of tear film layer functional dynamics enables the assessment of ocular health maintenance and surface disease pathophysiology.

The boundary is the constantly changing structure on the surface of the eye. Helps to keep the eyes moist, protect them from irritation, and also helps achieve vision. Elements such as the mucin layer affect the balance and strength of the membrane, including water and lipids. The function of these three pathways is to maintain the stability of the film and promote eye health. The inner layer is called viscoprotein kihi. This changes the surface hydrophobicity to hydrophilicity, promoting the diffusion of lactate in the surface area of the eye. This supports the thin film of the corner to avoid dry boards and reduce air emissions. The boundary is mainly water. Help cells navigate and nourish the tissues beneath them. Ensuring the osmotic pressure of tears remains balanced, supporting the metabolism of the cornea, providing nutrients such as electrolytes and oxygen, is crucial for maintaining eye health. If there is insufficient excretion of tears, it may lead to unstable tears, resulting in symptoms of dryness and irritation. Diseases can interfere with the function of mucosal proteins and lipid layers. Start interfering with the movie project. By forming a protective barrier on the water layer to maintain a stable environment for the eyes, while also protecting dust and other environmental substances such as smoke and chemicals. Lack of lipid secretion in the glands can interfere with the function of the lipid layer in the eyes, leading to an increase in tear evaporation and a higher likelihood of dry eyes.

An insufficient lipid section or dysfunction can lead to increased evaporation, which further destroys the tears. It brings instability to the film, leading to increased exposure of the eye surface, which evaporates over time, which reduces the stability of the film and slowly worsens the symptoms of dry eye. This persistent damage is harmful to the eye surface and leads to corneal epithelial liorosis, exacerbates binding rot and triggers the development of subcutaneous fibrosis. In addition, it increases the risk of corneal scarring and subsequent infection.Dry eye syndrome is becoming increasingly common as people use more devices and come into contact with pollutants. The methods of managing the condition and improving treatment options are crucial. At present, the treatment of eye diseases includes the use of tears, certain anti-inflammatory drugs, and tamponade to prevent the discharge of tears. But this method mainly focuses on alleviating eye disease symptoms, rather than addressing the root cause of unstable tear gas film. Various factors are related to the pathophysiology of the eyes. For example, restoring the balance of membrane components, reducing inflammation on the surface of the eye, and improving the function of the Meibomi gland. The research on lipids and polymers in bioengineering, as well as other creative ideas, has demonstrated the potential for repairing lipid layers and effectively reducing evaporation rates. In addition to environmental variables, personalized medical methods that consider factors such as film dynamics and genetic influences may provide better and more personalized treatment options for patients with chronic dry eye syndrome. Improving the effectiveness of treatment plans requires research to evaluate the long-term benefits of using combination drugs and lipid formulations containing inflammatory agents and compounds that stimulate mucin synthesis.

3. The Contamination Mechanism of Tear Film

Numerous prospective studies have verified that this migration can transpire passively and inadvertently, especially during routine eyelid movements like blinking. (Codner & McCord Jr, 2016) As depicted in Figure 1, these prevalent applications may result in the migration of cosmetic items along the eyelid margin and over the ocular surface. Figure 2 further exemplifies clinical instances of periocular and inner lash line eyeliner applications.

Fig.1 Eyeliner applied to the upper eyelid margin.

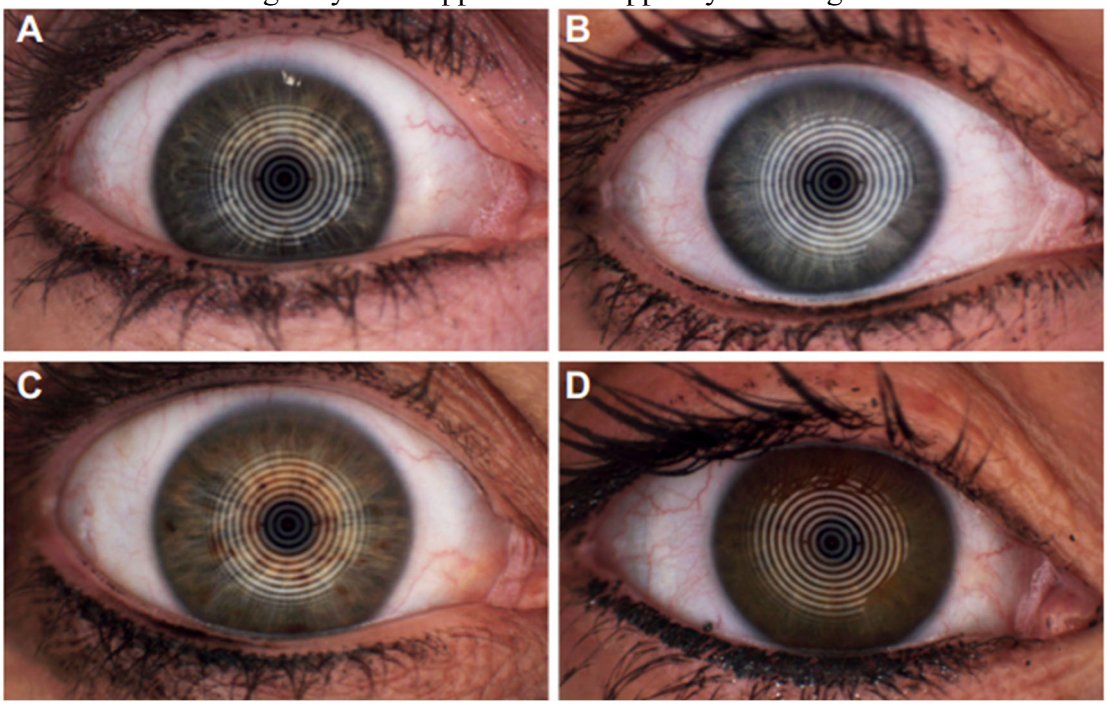

Fig.2 (A-C) After periocular eyeliner application, varying degrees of eyeliner drift to the eyelid margin was observed incidentally during the examination for ocular hyperemia; (D) eyeliner application behind the lash line.

The precise mechanisms governing the transfer of substances covering the eyelid margin have not been thoroughly investigated. Many arguments, therefore, have been presented to explain this occurrence. According to a well-known hypothesis, mechanical forces produced by eyelid movement during blinking drive periocular particle transport towards the tear film. The exact process producing these forces is hotly debated. Research on "over blink" phenomena suggests that eyelid border physical contact is not necessary for migration to take place. Though its involvement is unknown, mechanical rubbing could be incorporated. (Cooper, 2020) Involuntary blinking might increase the migration of periocular particles even further. Another theory is that Riolan's muscles—made of vertically aligned fibres beneath the periocular skin—may assist in moving particles across the eyelid barrier. Though their precise function is yet unclear, Riolan's muscles are thought to be rather vital

for many tasks. Furthermore, these muscles may influence minor vertical movements of the eyelid skin, aiding the transfer of periocular particles to the ocular surface.

The skin around the eyes frequently feels somewhat warmer than the surrounding region, which might enhance the absorption of cosmetic products on the eyelids. (Bouhmidi et al., 2024) . The slight temperature difference might facilitate applying and better blending eye cosmetics with the skin's surface. The natural pull from the tear surface tension could aid particles moving from the eyelid edge toward the eye surface. Processes like diffusion and mass likely influence the movement of particles within this area, and other mechanisms are at work. Elements with no charge usually move along the gradient by diffusion. In contrast, particles with a charge are influenced by electrolytes and glycocalyx molecules that carry a charge in the mucin layer in your eyes. Tears continuously flow in your eyes to wash away dirt and particles when you blink or activate the tear pump mechanism to ensure any makeup residue can be easily drained through the tear duct system. The movement of eye makeup products onto the surface of the eye is a process affected by bodily functions and the specific features of makeup compositions. The current research has introduced important findings about product movement, but additional studies are required to understand basic processes and their effects on eye health and tear film integrity.

4. Impact of cosmetic migration on lipid layer integrity of tear film

An analysis of another study involving these patients and comparing them to nonusers of eye cosmetics shows that women who use eye makeup have less foaming at the inner corners of their eyes, called the palpebral canthus. (Mohiuddin, 2019) The mixture of sebum and meibum is supposed to generate foam on the edge of the eyelid, which is why a decrease in foaming is linked to symptoms of the eyes. The scientists proposed that certain ingredients in eye makeup products could potentially affect the stability of phospholipids and prevent the formation of foam bubbles in the film around the eyes due to their nature. This viewpoint contrasts with the accepted theory regarding foaming at the margins. Traditionally linked to issues with meibomian glands, it is considered a sign of bacterial lipases causing the saponification of lipid secretions. It's not clear whether the observed patterns in the study could be due to the impact of cleaning routines linked to using eye makeup.

Initial spectroscopy tests were conducted to study how mixing liquid and pencil eyeliners affects human meibum oil secretions' composition and lipid phase changes. The results showed that the cosmetics tested had higher lipid phase transition temperatures than meibum oil. The introduction of pencil eyeliner causes a temperature rise in the meibum lipid phase transition temperature, with reductions in frequency and changes in enthalpy and entropy during the transition process. (Hunter, Bhola, Yappert, Borchman, & Gerlach, 2015) After applying pencil eyeliner to meibum (a substance), there were noticeable changes in lipid order, indicating an increase in viscosity that could affect tear film stability negatively, as suggested by researchers. A study involving 24 participants investigated the impact on the skin and mucocutaneous junction after using pencil eyeliner for seven days in a randomised crossover design. (Ng, Evans, North, & Purslow, 2013) The results indicated that applying eyeliner at the junction between skin and mucous membranes led to lipid layers and reduced eye comfort without affecting film stability. Additionally, the scores on the Ocular Surface Disease Index (OSDI) showed a decrease in the area where the eyeliner meets the skin compared to the skin around the eyes after applying eyeliner makeup products. The researchers inferred that the movement of oily eyeliner components probably played a role in the increased lipids observed in tears. The negative impact on the symptoms indicated that the transfer of beauty products disturbed the balance on the eye's surface.

Furthermore, there is a discussion about the impact of preservatives in eye makeup products. The study revealed that benzalkonium chloride (BAk), a preservative and a detergent, in its properties has the potential to disturb lipid layers. Nonetheless, BAK is now commonly used in eye cosmetics, likely because it is less effective as a preservative in products with particles or ionic emulsions. A

recent trial found that cosmetics removal products can move into the tear film after applying the solution on closed eyelids.

5. Inflammatory mechanisms and ocular surface damage related to the use of cosmetics

Usually caused by inflammatory pathways triggered by cosmetic components and contaminants, the great use of ocular cosmetics has been associated with various negative ocular surface outcomes. Sometimes, cosmetic products lose the efficacy of their preservative systems with prolonged use. Hence, there is a greater chance of microbial contamination from several sources. Sharing cosmetic products among users raises this risk even more since it brings germs that could lead to infections, including bacterial conjunctivitis or keratitis.(Liu et al., 2019) One could outline a series of steps to understand how various inflammatory processes are interconnected. The process of eye-related particles involves a journey, from the instability of the tear film to the release of immune factors and potential injuries, to the eyelids. Movement of cosmetic particles into the tear film triggers an inflammatory response, damaging epithelial cells and impairing conjunctival goblet cell activity, hence lowering mucin production. This interferes with the stability of the tear films and accelerates the evaporation of tears. Consequently, the tear film becomes less stable and initiates a cycle of inflammation. Mechanical damage to the eye surface and the production of inflammatory mediators maintain the instability of the tear film and encourage the development of chronic dry eye symptoms, hence worsening dry eye disease symptoms.

6. Conclusion

Though there are many psychological and visual benefits of ocular cosmetics, their overuse causes major problems with ocular surface health, mostly by upsetting tear film stability. Moving over the eyelid edge, cosmetic particles and chemical components have been shown to damage the structural integrity of the tear film lipid layer, hence encouraging tear evaporation, instability, and the following dry eye symptoms. All of these aggravate tear film dysfunction, and chronic exposure to these cosmetic contaminants—including preservatives, pigments, fragrances, and waterproofing agents- can cause ocular surface inflammation, irritative dermatitis, and disorders, including meibomian gland dysfunction (MGD) and blepharitis. The direct epithelium damage together with hyperosmolarity and changes in viscoelastic characteristics independently promote tear film instability, which interacts complexly with ocular surface homeostasis generated by cosmetic migration. Standard dry eye treatments, such as artificial tears, lipid-containing formulations, and anti-inflammatory medications, show reduced effectiveness when cosmetic particles persistently migrate. To enhance treatment results and minimise harm to the eyes, it is crucial to understand how cosmetics can disturb the film and trigger inflammation processes..

In the future, researchers should focus on factors that significantly impact the condition of the eyes through eye makeup products. In the beginning stages of implementation of proven methods to assess eye safety and compatibility with film, continuous evaluations and compliance with regulations should be ensured. Advanced crack lamp equipment and infrared spectroscopy are two tools for imaging and analyzing the interactions between particles and tear film at the microscopic level. Clinical trials help us understand the dangers of regular use of beauty products and how prolonged exposure can affect our overall health and well-being. Studying the nature and lasting effects of thin films and cosmetics-induced inflammatory reactions over time provides valuable information for health professionals to make informed decisions. In addition, ophthalmologists work with experts from chemical and regulatory agencies to create eye products that support a stable tear film and improve overall eye health. One of the aspirations to reduce pollution and irritation to the surface of the eyes through cutting-edge technologies concerns substances, preservative-free cosmetics and barrier protection formulas. Educating consumers about cosmetic products, adopting hygiene habits

and making product choices can significantly reduce the risk of eye problems caused by cosmetic products. To protect our health from the increasing use of eye makeup products, a strategy is needed, which includes product research and creation, as well as ensuring that consumers are well informed and educated about their choices.

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