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Review

Eye Cosmetics and Ocular Surface Diseases: An Emerging Concern in Modern Aesthetic Practices

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Abstract

Eye cosmetics, including eyeliners, mascaras, eyeshadows, and eyebrow products, are widely used to enhance the aesthetic appearance of the eyes. While generally considered safe, their application to the delicate periocular region can pose significant risks to ocular surface health. Growing clinical and experimental evidence links the use of eye cosmetics to ocular surface disorders, including blepharitis, conjunctivitis, dry eye syndrome, and meibomian gland dysfunction. These adverse effects may result from mechanical irritation, chemical exposure, microbial contamination, or allergic reactions associated with cosmetic ingredients such as pigments, preservatives, emulsifiers, and fragrances. In addition, emerging periocular aesthetic procedures and novel formulations containing nanoparticles and complex additives may further contribute to ocular surface instability and inflammation. The growing popularity of eye cosmetics, influenced by social media, cultural trends, and the global beauty industry, underscores the importance of understanding their impact on ocular health. Thus, this review provides a comprehensive overview of the composition, types, ocular migration, and potential adverse effects of eye cosmetics and periocular aesthetic practices. By highlighting the clinical implications of cosmetic use on the ocular surface, this study emphasizes the need for evidence-based guidance, safe cosmetic practices, and further research to mitigate lifestyle-related ocular risks.

Keywords: eye cosmetics; periocular aesthetic practices; ocular surface disease; dry eye disease

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Academic Editor: Enzo Berardesca

Received: 29 May 2026
Revised: 11 July 2026
Accepted: 11 July 2026
Published: 16 July 2026

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1. Introduction

The use of eye cosmetics, including eyeliners, mascaras, eyeshadows, and eyebrow products, has become increasingly prevalent worldwide, reflecting their central role in modern aesthetics. While primarily intended to enhance appearance, these products are applied near the delicate periocular region, potentially affecting the ocular surface and adnexa [1]. Cosmetic formulations typically contain pigments, preservatives, emulsifiers, fragrances, and polymers that are considered safe under standard conditions; however, repeated, prolonged, or improper application may expose the ocular surface to mechanical friction, chemical stress, and microbial contamination. Such exposures can disrupt epithelial barrier function and tear film stability, creating a microenvironment conducive to irritation, inflammation, or infection and, in some cases, corneal epithelial damage and visual disturbances [2–10].

In addition to conventional cosmetic products, the periocular region is increasingly subjected to a wide range of modern aesthetic procedures. These include eyelash curling, dyeing, tinting, and perming; botulinum toxin, dermal filler, and platelet-rich plasma (PRP) injections; chemical peels; conjunctival tattooing; eyelid piercing and tattooing; and microdermabrasion, microneedling, and skin resurfacing or tightening procedures [11]. Many of these interventions are performed in close proximity to the ocular surface and adnexal structures, potentially disrupting normal anatomy and physiology. Consequently, as cosmetic practices and aesthetic procedures continue to evolve, understanding their subtle and cumulative effects on ocular surface homeostasis becomes increasingly important in both clinical and research settings [12].

The widespread adoption of eye cosmetics is fueled by cultural trends, social media influence, and the global beauty industry. Surveys indicate high usage rates among women worldwide, with mascara being the most applied product [13]. The trend is also extending to men and younger populations, including adolescents, reflecting the broadening appeal of eye makeup. Globally, the eye makeup market is experiencing strong growth, driven by rising beauty consciousness, especially in the Asia–Pacific region, which continues to lead consumer demand in countries such as China, India, and South Korea due to expanding disposable incomes and social media influence [14–16]. As the global market continues to expand, understanding the impact of cosmetic products and periocular aesthetic procedures on ocular health is essential for both consumers and healthcare providers. Ophthalmologists, optometrists, dermatologists, and primary care clinicians must remain informed about cosmetic practices to accurately recognize and manage related ocular conditions [17]. Figure 1 illustrates different types of eye cosmetics and periocular aesthetic practices.

This narrative review aims to critically summarize the current evidence on eye cosmetics and periocular aesthetic practices, with emphasis on their composition, application characteristics, ocular migration, and their association with ocular surface and ocular adnexal complications. The review further evaluates the reported clinical manifestations and adverse effects associated with cosmetic use and aesthetic practices, highlighting factors that influence risk and discussing strategies for prevention, early recognition, and clinical management. By integrating current clinical and experimental evidence, this review provides a comprehensive resource for clinicians and consumers to better understand cosmetic-related ocular complications and promote long-term ocular surface health.

To conduct this review, we performed a comprehensive literature search of PubMed (https://pubmed.ncbi.nlm.nih.gov/ (accessed on 1 February 2026)) and Google Scholar using the terms “eye-cosmetics,” “makeup,” “aesthetic practices”, and “ocular surface diseases” and covered publications from March 2000 to February 2026. Additional information from authoritative reports and publicly available sources was included to provide relevant market data and insights into cosmetic usage trends.



Figure 1. Common eye cosmetic products and periocular aesthetic practices. Illustration showing various eye-related cosmetic products and beauty practices commonly applied around the periocular region, including eyeliner, glitter, false eyelashes, eyeshadow, primer, mascara, eyelash curler, contact lenses, tattooing, and skincare products such as makeup removers, toners, and creams that are commonly used around the ocular surface.

2. History of Eye Cosmetics

2.1. Early Development and Historical Use

The application of eye cosmetics dates back more than 5000 years, with documented use in ancient Egyptian civilization around 3000 BCE. Mineral-based pigments, including green malachite (udju) and black kohl (galena, lead sulfide), were commonly applied to the eyelids and eyelashes. These preparations served not only cosmetic purposes but also cultural, medicinal, and spiritual roles. Ancient Egyptians believed that eye cosmetics

provided protection against intense sunlight, infectious diseases, and supernatural harm, such as the "Evil Eye" [18,19].

Historical medical texts, including the Ebers Papyrus (~1550 BCE), describe the therapeutic use of eyelid pigments for managing ocular inflammation and infections, suggesting an early recognition of the potential antimicrobial properties of metallic salts used in cosmetics [3]. Subsequent toxicological studies have demonstrated that lead-based compounds present in traditional kohl preparations may exhibit antimicrobial activity through nitric oxide-mediated immune responses, although prolonged exposure is associated with systemic lead toxicity and ocular surface irritation [20,21].

The use of eye cosmetics later expanded across multiple civilizations, including Greek, Roman, Indian, Chinese, and Middle Eastern cultures. Roman cosmetic practices included the use of *Atropa belladonna* extracts to induce pupillary dilation, which was culturally associated with attractiveness and youthfulness [22]. Similarly, traditional Middle Eastern and South Asian populations widely used kohl for both cosmetic and perceived therapeutic purposes, despite the documented risks of heavy metal exposure [23].

2.2. Medieval and Renaissance Period

During the medieval era, particularly in Europe, cosmetic use declined due to religious and societal restrictions that associated makeup with immorality and deception. However, cosmetic practices persisted in certain aristocratic and regional populations [24]. The Renaissance period marked a renewed interest in cosmetic enhancement, including the continued use of botanical agents such as *belladonna* for aesthetic pupillary dilation and facial cosmetic preparations aimed at achieving a pale and youthful appearance, despite recognized toxicity risks [24,25].

2.3. Industrialization and the 20th Century Cosmetic Expansion

The 20th century represented a major transformation in cosmetic development, driven by industrial manufacturing, commercialization, and increased consumer accessibility. Advances in chemical formulation allowed the replacement of highly toxic ingredients, including mercury and lead compounds, with relatively safer alternatives [26].

Commercial production of mascara and eyeliner expanded rapidly following innovations by companies such as Maybelline, Max Factor, and Helena Rubinstein. Eyelash curlers, false eyelashes, and eyelash-enhancing products became central to achieving dramatic and expressive eye looks, establishing the modern foundation for contemporary cosmetic culture. However, early cosmetic products were associated with serious ocular complications. A notable example is Lash-Lure mascara, introduced in the 1930s, which contained coal tar-derived paraphenylenediamine. The product caused severe conjunctivitis, corneal ulceration, visual loss, and fatalities, leading to widespread public health concern [27]. These events significantly contributed to the establishment of modern cosmetic regulatory oversight, including the U.S. Federal Food, Drug, and Cosmetic Act of 1938, which strengthened safety requirements for cosmetic products [27].

2.4. 21st Century: Innovation, Personalization, and Aesthetic Expression

In the 21st century, eye cosmetics have become a hub of aesthetic creativity and personal expression. Modern products such as mascaras, eyeliners, eyeshadows, brow pencils, eyelash extensions, and growth serums allow individuals to shape, define, and enhance their eyes, turning them into the primary focus of facial beauty [28]. Consumers experiment with a wide range of styles, from soft, natural looks to bold artistic designs, including vibrant eyeliners, smoky eyes, glitter, and pearlescent finishes.

Advanced tools such as electric eyelash curlers, precision brushes, and high-performance applicators make it possible to achieve salon-quality results at home. In

parallel, periocular aesthetic procedures, such as Botox injections, dermal fillers, and PRP therapy, have gained prominence as minimally invasive approaches specifically targeting the eyelid and periorbital area for wrinkle reduction, volume correction, and skin rejuvenation [29,30]. Semi-permanent techniques, including eyelid tattooing and lash tinting, provide long-lasting aesthetic effects that enhance personal style. Across cultures, generations, and social platforms, the 21st-century eye makeup trend positions the eye as a canvas for artistry, self-expression, and aesthetic allure.

3. Types of Eye Cosmetics

Eye cosmetics encompass a wide range of products and procedures designed to enhance the aesthetic appearance of the eyes, and this section focuses on the different types commonly used. The different types of eye cosmetics, their potentially harmful ingredients, and associated ocular complications are summarized in Table 1.

Table 1. Major eye cosmetic products, their key toxic ingredients, and associated ocular adverse effects.

Eye Cosmetics	Toxic Ingredients	Ocular Complications
Mascara	Wax, pine tar derivative	-Obstruction of meibomian gland openings, unstable tear film, difficulty during removal, increased risk of blepharitis.
Eyelash extensions	Methacrylates, formaldehyde-containing preservative	-Eye irritation, allergic dermatitis, chemical conjunctivitis, redness, burning, itching, excessive tearing; poor hygiene may promote blepharitis, *Demodex* infestation, and incomplete blinking due to lash weight.
False eyelashes (strip lashes)	Formaldehyde-releasing preservatives	-Similar adverse reactions to eyelash extensions including irritation, inflammation, and eyelid disease.
Prescription eyelash growth serum	Prostaglandin analog formulations	-Eyelid and conjunctival redness, irritation, burning sensation, periorbital fat atrophy, periocular skin pigmentation, possible iris color change.
Eyelash perming and tinting	Paraphenylenediamine (PPD), ammonium thioglycolate (strong alkaline agents)	-Acute conjunctival inflammation, eyelid swelling, tearing, and redness.
Liquid or pencil eyeliner	Waxes, pine tar derivatives, benzyl alcohol; frequent application along the waterline or tightlining	-Lockage of meibomian glands, deterioration of tear film quality, evaporative dry eye.
Eyeshadow (especially glitter or metallic powders)	Particulate glitter and metal-based pigments	-Inadequate removal may result in conjunctivitis, keratitis, blepharitis, and contact lens intolerance.
Eye makeup remover	Benzalkonium chloride (BAK), formaldehyde-releasing preservatives	-Eyelid eczema, allergic contact dermatitis, tear film instability, conjunctival hyperemia, and ocular surface irritation.

3.1. Eyelash Cosmetics

3.1.1. Mascara

Mascara enhances the appearance of the eyes by darkening, lengthening, and adding volume to the eyelashes, creating a larger and more defined look [26]. It is available in

several formulations, including cake, cream, gel, and liquid types, with liquid mascara being the most widely used today.

Cake mascara, the earliest form of mascara, consisted of a soap–pigment mixture molded into blocks. Its use posed two major challenges: first, a wet brush was required to convert the block into a workable paste; second, the resulting film was prone to smudging or running when exposed to tears, perspiration, or rain due to its water solubility. Although the addition of waxes improved water resistance, consumer preference eventually shifted toward cream and liquid formulations.

Cream mascara quickly gained popularity for its ease of application and reduced tendency to run or clump when exposed to moisture. Typically, it consists of dispersions of waxes and pigments in water, producing a consistency akin to vanishing cream. Its water-retentive properties allow the incorporation of natural and synthetic film formers to enhance lash adhesion; however, this advantage comes at the cost of a limited application window as clumps form when water evaporates [31].

Consequently, liquid mascaras emerged as the dominant modern formulation. They are classified into water-based types (containing waxes such as carnauba and beeswax, pigments, and resins), non-water-based types (including candelilla wax, ozokerite, pigments, and petroleum distillates), and hybrid types that combine the fast-drying and waterproof qualities of the other categories [32–34]. Market trends indicate that mascara holds the largest share among eye makeup products, followed by eyeliners and eyeshadows [35].

3.1.2. Artificial Eyelashes

Artificial eyelashes, commonly referred to as eyelash extensions (EEs), are widely used cosmetic enhancements, although they are not formally classified as cosmetics under the European Commission (EC) Regulation No. 1223/2009 [36]. These extensions are applied by attaching artificial lashes made from natural materials, such as silk, mink, human hair, or horsehair, or synthetic fibers like polybutylene terephthalate. Application of eyelash extensions typically requires adhesive formulations containing cyanoacrylates or methacrylates, which have been associated with ocular irritation, allergic reactions, and eyelid inflammation [37].

Typically, extensions last between four and eight weeks [38]. Their popularity has increased substantially, with applications performed by both trained professionals and non-professionals. To address concerns related to adhesive use, alternative approaches such as magnetic eyelashes have been developed; these systems rely on magnetic liners or paired magnets to secure lashes without glue [1].

3.1.3. Eyelash Growth Serums

Eyelash growth serums often contain prostaglandin analogs (PGAs), such as bimatoprost, which stimulate the anagen (growth) phase of the eyelash cycle and enhance melanin production. This results in thicker, darker lashes along the eyelid margin. Bimatoprost received U.S. Food and Drug Administration (FDA) approval in 2008 and is used to treat conditions including hypotrichosis, chemotherapy-related lash loss, trichotillomania, and alopecia areata [39]. The product is applied nightly to the eyelid margin, and noticeable results typically require consistent use for approximately 16 weeks [1].

3.1.4. Eyelash Dye and Tint

Eyelash dyes and tints are used to darken lashes and enhance their apparent density. These formulations commonly contain coloring agents such as para-phenylenediamine (PPD), which has been associated with periocular hypersensitivity reactions and ocular irritation [40]. Tinting effects generally last several weeks, whereas dyeing may provide longer-lasting color enhancement.

3.1.5. Eyelash Perming

Eyelash perming, also known as eyelash lifting, involves the chemical reshaping of lashes to create a curled appearance that usually lasts for 6–8 weeks. The procedure commonly utilizes alkaline reducing agents, such as ammonium thioglycolate, followed by neutralizing solutions to maintain the curled configuration of the eyelashes. The effect is primarily driven by chemical agents used during the curling and fixing steps of the procedure [1].

3.2. Eyelid Cosmetics

Eyelid cosmetics are used to accentuate the eyes, creating a larger, more defined, and visually striking appearance. Among these, eyeliners and eyeshadows are the most widely utilized, while specialized eye makeup removers facilitate their safe and efficient removal [41].

3.2.1. Eyeliner

Eyeliners are available in several formulations, including cake, liquid, cream/gel, and pencil types, with liquid eyeliners currently being the most popular among consumers. Depending on the formulation, eyeliners commonly contain waxes, pigments, preservatives, and film-forming agents that enhance product adhesion, durability, and water resistance. Pencil eyeliners are widely used and are typically applied either along the inner eyelid margin or on the skin just adjacent to the lash line, depending on the desired cosmetic effect [26,34,42].

3.2.2. Eyeshadow

Eyeshadow is applied to the eyelids and the area beneath the eyebrows to add depth, dimension, and visual emphasis, thereby enhancing eye shape and color. Eyeshadow formulations generally consist of pigments; fillers; binders; preservatives; and, in glitter-containing products, reflective metallic or synthetic particles that contribute to their cosmetic properties. Early paste shadows used before World War II often creased easily due to their high wax or oil content. Emulsion creams reduced greasiness but required preservatives and sealed packaging. Anhydrous cream to powder formulations provide smooth color distribution but may migrate into eyelid folds or melt in heat [32]. Gel formulations use clay gelling agents instead of waxes, while sticks, pencils, and crayon eyeshadows are valued for portability, ease of application, and long-lasting wear.

Liquid eyeshadows offer high pigmentation and rapid setting properties, whereas powder eyeshadows, available in loose or pressed forms, dominate the market, with binders commonly added to pressed formulations [26,34]. Recent innovations, such as baked eyeshadows prepared by heating rather than pressing, provide an improved texture and application experience.

3.2.3. Kohl (Surma/Kajal)

Kohl, also known as surma or kajal, is a traditional eye cosmetic applied around the eyelids to create a bold and defined appearance. Historically, some traditional kohl formulations contained lead-based compounds, although the composition of modern commercial products varies considerably depending on the manufacturer and region [43]. As one of the earliest forms of eye cosmetics, its use remains widespread in parts of Africa and Asia, reflecting both cultural practices and aesthetic preferences [44].

3.2.4. Eye Contour Cream

Eye contour creams are specialized skincare products formulated for the delicate periocular skin. They primarily provide targeted hydration to improve skin elasticity and

reduce the appearance of fine lines and wrinkles. Many formulations contain caffeine to minimize puffiness by vasoconstriction, peptides to address dark circles, and ingredients such as retinol or hyaluronic acid to support collagen production [45–47].

Additionally, eye creams often include antioxidants that protect the skin from environmental stressors and oxidative damage associated with premature aging [45].

3.2.5. Glitter

Glitter particles incorporated into eye cosmetic formulations can migrate to the ocular surface, adhere to contact lenses, and accumulate at the meibomian gland orifices, potentially compromising ocular surface integrity. Cosmetic-grade glitter is typically composed of synthetic materials such as polyethylene terephthalate, synthetic fluorphlogopite, or borosilicate coated with metallic pigments to enhance reflectivity [44]. Furthermore, the irregular morphology and sharp edges of these particles increase the likelihood of corneal microtrauma and epithelial abrasions.

Additionally, preservatives commonly associated with glitter-containing products, particularly methylisothiazolinone, have been implicated in allergic contact dermatitis [48]. Despite these concerns, regulatory approval and standardized safety guidelines for periocular glitter application remain limited [49].

3.3. Toner

Toners are liquid skincare formulations commonly used to remove residual waterproof makeup and prepare the skin for subsequent moisturizing products. They are formulated for different skin types and often contain ingredients that help maintain skin pH and barrier integrity, and provide anti-inflammatory or antimicrobial effects, such as aloe vera and rose water [50].

However, certain toner formulations may contain potentially harmful components, including phthalates, alcohols, parabens, fragrances, synthetic dyes, and retinyl palmitate [51]. These substances have been associated with ocular surface irritation, epithelial toxicity, and periocular adnexal inflammation, raising concerns regarding their use near the eye region.

3.4. Eye Makeup Remover

Eye makeup removers are designed to facilitate the gentle and effective removal of cosmetics from the eyes and surrounding areas, thereby enhancing overall cleansing efficiency. They are available in a wide range of formulations, including oils, creams, balms, foams, sticks, waters, and pre-soaked pads or wipes. Depending on the formulation, these products may also contain surfactants, preservatives, and solubilizing agents that can contribute to ocular surface irritation in susceptible individuals. Their mechanism of action follows the basic solubility principle of “like dissolves like,” meaning that water alone is insufficient to remove cosmetics containing lipophilic ingredients [42,52].

Based on formulation, eye makeup removers are generally classified as oil-based, oil-free, or micellar products. Micellar removers utilize microscopic oil-based structures, known as micelles, which attract and encapsulate makeup residues, allowing them to be removed easily with minimal rinsing [53].

It is important to note that this review focuses specifically on the ocular effects of products intended for use on or around the eyes. Consequently, broader cosmetic formulations such as primers, concealers, foundations, sunscreens, and facial masks that may be applied to the eyelids or periocular region are not addressed here, although these products may share certain ingredients with eye-specific cosmetics.

4. Modern Aesthetic Practices

4.1. Periocular Rejuvenation

Periocular aging is characterized by dermatologic and structural alterations that may influence ocular function, including skin atrophy, ligament laxity, and periocular volume loss. These changes have contributed to the increased use of periocular rejuvenation procedures such as blepharoplasty, botulinum toxin injections, dermal fillers, and energy-based devices [54]. Because the periocular region forms a functional unit comprising the eyelids, lacrimal functional unit, ocular surface, and adnexal tissues, aesthetic interventions may disrupt eyelid biomechanics, tear film homeostasis, or local neurovascular integrity. Procedure-related mechanical trauma, thermal injury, vascular compromise, and inflammatory responses may subsequently impair ocular surface protection and contribute to ophthalmic complications [55,56].

Although these procedures are intended to improve periocular aesthetics, they may also pose potential ophthalmic risks. Energy-based modalities, including lasers, intense pulsed light, ultrasound, and radiofrequency devices, promote collagen remodeling but have been associated with ocular complications when applied improperly. Reported adverse events include exposure keratopathy, corneal injury, retinal injury, and macular neovascularization [57–59].

4.2. Botulinum Toxin Injections

Botulinum neurotoxin (BoNT), initially developed for strabismus and blepharospasm, is now widely used in periocular aesthetic procedures. By inhibiting acetylcholine release, BoNT induces temporary muscle paralysis, improving periocular rhytids but potentially affecting ocular surface homeostasis [60]. Diffusion of the toxin beyond the intended injection site may weaken the orbicularis oculi or levator palpebrae muscles, resulting in impaired blinking, incomplete eyelid closure, reduced lacrimal pump function, and altered tear distribution [61–64]. Adverse effects may occur due to toxin diffusion and include blepharoptosis, lagophthalmos, diplopia, and reduced lacrimal secretion [65–69].

BoNT has been associated with dry eye disease (DED) through incomplete blinking, lacrimal gland hyposecretion, and meibomian gland dysfunction, contributing to tear film instability and corneal exposure [68]. Interestingly, medial eyelid injections may improve tear retention in selected cases [64,70,71].

4.3. PRP Injection

Autologous PRP injections are increasingly used for periocular aesthetic rejuvenation to reduce hyperpigmentation and wrinkles [72,73]. PRP contains growth factors that promote tissue repair and enhance skin regeneration [74]. However, periocular injection may provoke transient inflammatory responses or, in rare cases, vascular compromise due to inadvertent intravascular injection, thereby affecting the surrounding ocular and adnexal tissues [75,76]. Although generally considered safe, reported complications include injection-site pain, infection, vascular events, and skin discoloration, which may compromise periocular tissue integrity.

4.4. Microneedling

Microneedling is a minimally invasive cosmetic procedure that creates controlled micro-injuries in the epidermis to stimulate collagen production and improve periorbital hyperpigmentation and skin rejuvenation [46]. These controlled micro-injuries initiate a wound-healing cascade characterized by the release of inflammatory mediators, growth factors, and collagen remodeling; however, excessive tissue injury or improper technique may disrupt the periocular barrier and increase susceptibility to inflammation or infection [77].

It has shown clinical benefit in improving skin texture and under-eye dark circles, particularly when combined with topical agents such as kojic acid [78]. Potential complications include bleeding, bruising, and local irritation, which may affect periocular tissue health.

4.5. Cosmetic Contact Lenses

Cosmetic contact lenses, increasingly used for aesthetic purposes by healthy individuals, are associated with a substantially higher risk of ocular complications compared with conventional refractive lenses [79,80]. Clinical studies report markedly elevated rates of contact lens-related microbial keratitis, particularly among young and first-time users [80,81]. Factors related to lens design, including surface-exposed pigments, increased roughness, and reduced wettability, promote microbial adhesion and epithelial microtrauma, thereby compromising the integrity of the ocular surface barrier [82]. The resulting epithelial disruption facilitates microbial invasion and triggers inflammatory responses, ultimately destabilizing the tear film and increasing the risk of infectious keratitis and other ocular surface disorders [83,84].

These risks are exacerbated by unregulated distribution, lack of professional fitting, and poor compliance with lens hygiene and replacement schedules. Infections commonly involve *Pseudomonas aeruginosa*, *Staphylococcus* species, fungal pathogens, and *Acanthamoeba*, often linked to improper lens care and water exposure [85]. Collectively, cosmetic contact lenses represent an under-recognized risk to ocular surface health, underscoring the need for stricter regulation, improved manufacturing standards, and targeted user education.

4.6. Cosmetic Tattooing

Ocular and periocular tattooing, including scleral, conjunctival, corneal, and eyelid procedures, has grown in popularity worldwide due to trends in body modification and cosmetic enhancement (Figure 2). Although precise prevalence data are scarce, ocular tattoos remain rare, representing less than 1% of all tattoo procedures [86].

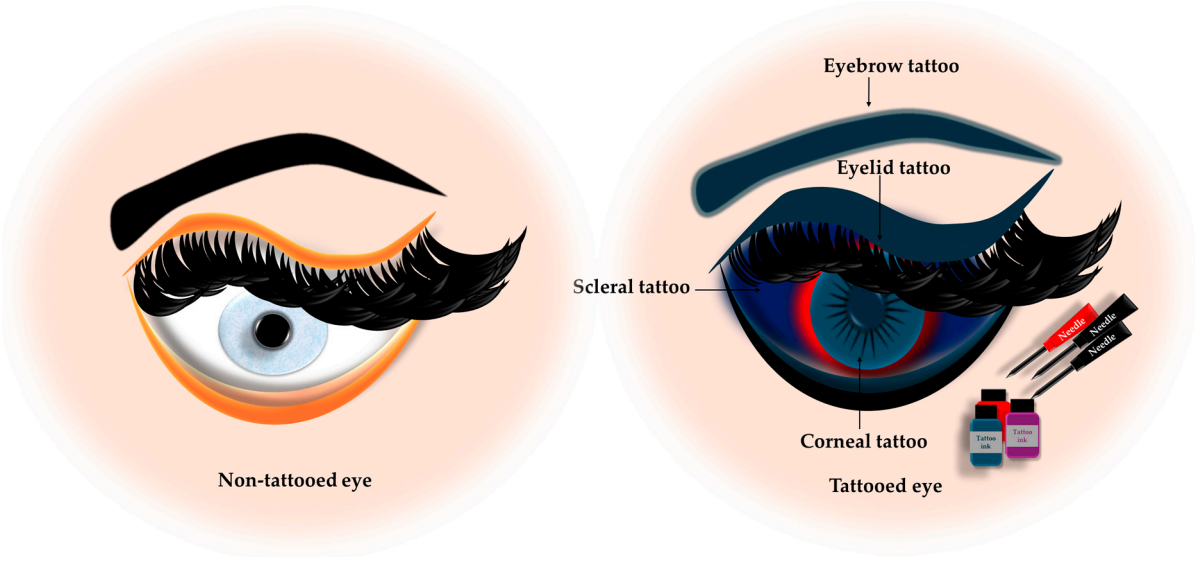


Figure 2. Cosmetic tattooing practices involving the ocular and periocular regions. Schematic representation of cosmetic tattooing procedures related to the eye, including eyebrow tattooing, eyelid tattooing (permanent eyeliner), and corneal tattooing. The illustration also compares a tattooed eye with a non-tattooed eye, highlighting the anatomical locations and visual differences associated with each procedure.

Scleral and conjunctival tattoos are particularly uncommon, reported in roughly 0.05% of individuals with body modifications, whereas periocular tattoos, such as eyelid or eyebrow applications, are more frequent, especially in permanent makeup [87]. Most data

come from case reports rather than large-scale studies, limiting statistical accuracy [88]. Pigment deposition within or adjacent to ocular tissues may induce foreign body reactions, chronic inflammation, granuloma formation, pigment migration, or direct mechanical injury, depending on the depth and location of injection. These pathophysiological processes may compromise ocular surface integrity and, in severe cases, threaten visual function [86]. Unlike conventional skin tattoos, ocular tattoos involve pigment application directly to the sclera or conjunctiva, a practice that has recently attracted both fascination and controversy [89]. Table 2 provides a comprehensive overview of the various types of ocular tattoos, highlighting their locations, pathophysiological mechanisms, and clinical considerations.

Table 2. Different types of ocular and periocular tattoos and major complications and mechanism.

Tattoo Location	Major Complications and Pathophysiological Mechanisms	References
Scleral tattoos	-Severe intraocular complications have been reported, including granulomatous anterior uveitis, retinal detachment, infectious inflammation, allergic responses, and lasting visual impairment. -These outcomes are largely attributed to toxic or immunogenic effects of tattoo pigments combined with direct mechanical damage caused by deep scleral penetration during ink injection.	[90–93]
Conjunctival tattoos	-Documented adverse effects include intraocular migration of foreign material, episcleral mass formation, hemorrhage, infection, chronic inflammation, and vision loss. -Such complications are thought to arise from chemical irritation induced by ink components and needle-related trauma to the conjunctiva and adjacent ocular tissues.	[94–97]
Corneal tattoos	-Corneal tattooing has been associated with corneoscleral perforation, pigment dispersion, inflammatory reactions, microbial keratitis, corneal scarring, and permanent visual decline. -These effects are primarily driven by physical injury to the cornea and pigment-induced inflammatory responses.	[98–100]
Eyelid tattoos	-Eyelid tattooing may disrupt ocular surface homeostasis, leading to meibomian gland dysfunction, tear film instability, DED, corneal pigmentation, granuloma formation, diffuse lamellar keratitis, and eyelid structural damage. -These complications are linked to local pigment toxicity and repeated mechanical stress on eyelid tissues.	[11,101–103]
Eyebrow tattoos	-Periocular cosmetic tattooing of the eyebrow region has been associated with pigment migration, papillary conjunctivitis, hypersensitivity reactions, granulomatous inflammation, and cosmetic dissatisfaction. -These effects are commonly attributed to irritant or allergenic ink constituents and mechanical disturbance of surrounding soft tissues.	[104–106]

5. Composition and Potentially Harmful Ingredients in Cosmetics

Eye cosmetic formulations incorporate a wide range of chemical ingredients, each serving specific functional roles essential for product performance and stability. These components may act as abrasives, absorbents, antioxidants, antimicrobials, buffers, colorants, emollients, emulsifiers, film-forming agents, humectants, pH regulators, preservatives, ultraviolet filters, solvents, surfactants, or skin-conditioning agents. In addition, certain substances are included to prevent caking or foaming, reduce static, increase bulk, modify viscosity, or enhance opacity. Collectively, these ingredients are found across numerous eye-related products, including eyeliners, eyeshadows, mascaras, eyelash adhesives, periocular creams, serums, moisturizers, makeup primers and removers, lotions, and cleansing wipes [32,107].

Despite their widespread use, the safety of many cosmetic ingredients remains a substantial concern. According to estimates from the FDA, approximately 12,500 chemicals are currently used in cosmetic products; however, fewer than one-fifth have undergone formal safety evaluation by the Cosmetic Ingredient Review panel [108]. Regulatory oversight varies considerably across regions. While only a limited number of cosmetic ingredients are prohibited in the United States, regulatory authorities in the European Union have restricted or banned more than 1300 substances due to potential health risks [109]. Many of these compounds have been associated with adverse biological effects, including allergenicity, carcinogenicity, endocrine disruption, immunosuppression, irritation, mutagenicity, and systemic toxicity. Importantly, such ingredients may pose risks to the ocular surface and its associated adnexal tissues.

Exposure to these substances through routine cosmetic use or cosmetic procedures involving the periocular region can lead to a spectrum of undesirable reactions. These include inflammatory responses, hypersensitivity reactions, and structural or functional damage to ocular tissues. Multiple adverse outcomes have been reported following the use of eye cosmetic products containing potentially harmful ingredients, underscoring the need for greater regulatory scrutiny and continued evaluation of ingredient safety [110]. The different types of eye cosmetics and their potentially harmful ingredients are discussed in the following section.

5.1. Preservatives

Preservative agents are intentionally incorporated into cosmetic formulations to suppress microbial proliferation, including bacteria, fungi, yeasts, and molds, thereby ensuring product stability during storage and repeated use [3,10]. In eye-related cosmetics, a range of chemical preservatives is routinely employed, most notably formaldehyde-releasing agents, parabens, phenoxyethanol, and chlorphenesin [111–114]. These compounds are particularly prevalent in products applied to the periocular area that remain on the skin or ocular surface for extended periods, raising concerns regarding prolonged tissue exposure.

5.1.1. Benzalkonium Chloride

Benzalkonium chloride (BAK) is a quaternary ammonium compound with strong antimicrobial activity and has been widely used as a preservative in both cosmetic formulations and topical ophthalmic preparations [115]. Within the European Union, regulatory guidelines permit the inclusion of BAK in cosmetic products at concentrations up to 0.1% [111].

However, substantial experimental evidence challenges the ocular safety of BAK even at concentrations far below approved regulatory limits. In vitro investigations have revealed that exposure to BAK at levels several orders of magnitude lower than those used in commercial products results in rapid and complete loss of viability in human corneal, conjunctival, and meibomian gland epithelial cells within a relatively short time frame [7]. Notably, cytotoxic effects persist at concentrations tens of thousands of times lower than the maximum allowable dose. These findings are consistent with a broad range of prior studies demonstrating BAK-induced cellular damage across both laboratory-based and animal models [116–119].

In vivo studies further corroborate the deleterious impact of BAK on the ocular surface. Repeated exposure has been shown to disrupt tear film homeostasis, reduce conjunctival goblet cell density, promote epithelial apoptosis and squamous metaplasia, induce corneal nerve injury, and compromise epithelial barrier integrity [120–123]. Clinically, the use of BAK-containing products has been associated with a spectrum of ocular adverse effects, including irritation, burning, pruritus, foreign body sensation, conjunctival

hyperemia, blepharitis, meibomian gland dropout, and the onset or worsening of DED. Moreover, chronic exposure to BAK has been linked to reduced success rates following glaucoma filtration surgery and, in rare but severe cases, hypersensitivity reactions such as anaphylaxis [116,124–126].

5.1.2. Formaldehyde-Releasing Compounds

Formaldehyde-releasing agents, including compounds such as DMDM hydantoin, quaternium-15, imidazolidinyl urea, diazolidinyl urea, and 2-bromo-2-nitropropane-1,3-diol, are widely employed as preservatives in cosmetic formulations [10,113]. These substances are characterized by their chemically labile structure, which allows the slow release of free formaldehyde over time under ambient conditions, thereby providing sustained antimicrobial activity.

Within the European Union, cosmetic regulations permit formaldehyde at concentrations up to 0.2%, although safety evaluations conducted by the Cosmetic Ingredient Review panel have recommended a substantially lower threshold of 0.074% [111,127]. Notwithstanding these regulatory limits, experimental evidence indicates that formaldehyde exerts pronounced cytotoxic effects on ocular surface cells at concentrations far below both European Union and Cosmetic Ingredient Review recommendations. In vitro studies have demonstrated that formaldehyde levels hundreds to thousands of times lower than approved limits are sufficient to induce toxicity in human corneal, conjunctival, and meibomian gland epithelial cells [7].

Short-term exposure experiments further underscore the sensitivity of ocular tissues to formaldehyde. Brief treatment of rabbit corneal epithelial cells with low formaldehyde concentrations markedly reduces cell viability and promotes apoptotic and necrotic cell death [128]. Comparable cytotoxic responses have been reported in human conjunctival epithelial cell lines following exposure to environmentally relevant formaldehyde levels [129]. Importantly, the damaging effects of formaldehyde are not confined to ocular tissues; similar toxic responses have been documented in human bronchial epithelial cells, vascular endothelial cells, natural killer cells, and lymphocytes, highlighting its broad biological reactivity [130,131].

Even at very low ambient concentrations, formaldehyde has been shown to cause ocular discomfort. Exposure levels in the sub-parts-per-million range are sufficient to trigger eye irritation and conjunctival hyperemia, while slightly higher concentrations can irritate the upper respiratory tract. Beyond its acute irritant properties, formaldehyde is of particular concern due to its established genotoxic, carcinogenic, and allergenic potential [132,133]. These risks have led to heightened public health scrutiny, culminating in its classification as a human carcinogen by the International Agency for Research on Cancer [134].

5.1.3. Parabens

Parabens are widely used cosmetic preservatives, with methylparaben and ethylparaben being the most common [44]. These p-hydroxybenzoic acid esters are approved for use at concentrations up to 0.8% in mixtures or 0.4% individually. However, in vitro studies have demonstrated that methylparaben and ethylparaben induce significant cytotoxicity in human meibomian gland epithelial cells at concentrations several hundred- and tens-fold lower, respectively, than approved limits. Similar toxic effects have been observed in human corneal and conjunctival epithelial cells.

In addition to their direct cytotoxicity, parabens are recognized allergens and endocrine-disrupting chemicals with estrogenic and antiandrogenic activity. Chronic topical exposure may prolong local estrogenic effects by inhibiting estrogen sulfotrans-

ferase [135], thereby impairing meibomian gland function. Consistent with these mechanisms, elevated systemic paraben levels have been associated with meibomian gland dysfunction and DED. Moreover, paraben exposure has been linked to an increased risk of hormone-related malignancies, raising further concerns regarding their long-term safety [136].

5.1.4. Phenoxyethanol

Phenoxyethanol is a widely used broad-spectrum preservative permitted at concentrations up to 1.0%; however, exposure to levels an order of magnitude lower significantly reduces the viability of human meibomian gland epithelial cells and has been associated with tear film instability. Systemic toxicities, including hepatic, renal, and hematologic effects, combined with its high dermal absorption in leave-on products, have led to recommendations against its use in eye-contact formulations [137].

5.1.5. Chlorphenesin

Chlorphenesin, an antibacterial and antifungal agent approved at concentrations up to 0.3%, exhibits marked cytotoxicity to meibomian gland epithelial cells at concentrations several hundred-fold lower and is a known ocular irritant. Its efficient dermal absorption has contributed to its classification as moderately hazardous in eye-related cosmetics [12,138].

5.1.6. Ethylhexylglycerin

Ethylhexylglycerin, used as a preservative and skin-conditioning agent, has been implicated in contact dermatitis and ocular irritation, particularly in leave-on products [139].

5.1.7. Methylisothiazolinone

Methylisothiazolinone is associated with a high risk of sensitization and potential toxicity. Regulatory authorities have concluded that no safe concentration exists for leave-on products, with strict limits imposed for rinse-off formulations; it has been banned in cosmetics in several regions, including Canada [140].

Thimerosal, a mercury-based preservative, remains present in select cosmetic products despite its removal from contact lens solutions. It is a common contact allergen and has demonstrated neurotoxic and endocrine-disrupting properties. While prohibited in some countries, limited use around the eyes is still permitted in the United States under restricted conditions [108,141].

5.2. Other Harmful Ingredients

Beyond preservatives, several non-preservative cosmetic ingredients pose potential risks to the ocular surface and adnexa.

5.2.1. Acrylates

Acrylates, derivatives of acrylic acid, are widely used in plastic polymer and commonly found in cosmetics such as artificial nails, nail adhesives, eyelash products, hair fixatives, and makeup. Their strong film-forming ability makes them useful in products like eyeliners, mascaras, sunscreens, lipsticks, creams, and lotions [142].

Acrylates encompass a diverse group of compounds widely used in both ophthalmic and cosmetic applications. Methacrylate and polymethyl methacrylate (PMMA) are extensively utilized in contact lenses and intraocular lenses while also serving cosmetic functions by providing a matte, oil-absorbing finish. Similarly, hydroxyethyl methacrylate (HEMA) and poly(2-hydroxyethyl methacrylate) (PHEMA) are key materials in soft contact lenses and artificial corneal devices [143]. Other acrylate derivatives, including ethyl acrylate, 2-ethylhexyl acrylate, and butyl acrylate, are commonly employed in cosmetics, pharma-

ceuticals, and adhesive formulations. Notably, some acrylates have been classified by the International Agency for Research on Cancer as possibly carcinogenic to humans, and certain methyl acrylates have been linked to allergic contact dermatitis [144,145].

5.2.2. Carnauba Wax

Carnauba wax, obtained from the tropical palm *Copernicia cerifera*, is widely used in cosmetic formulations due to its strong emulsifying properties, oil-binding capacity, hydrophobic nature, and ability to increase the melting point of cosmetic products. It is frequently incorporated into mascaras, eyeliners, and eyeshadows to enhance glossiness and smooth texture, with approximately 60% of commercial mascaras containing this ingredient. Notably, carnauba wax is recognized as one of the hardest naturally occurring plant waxes [146].

However, its use has been associated with eyelid contact dermatitis in some individuals [147,148]. Additionally, other waxes commonly found in eyeliners, such as candelilla and microcrystalline wax, have been shown to interact with human meibum, potentially altering its phase transition properties and increasing its melting temperature, which may affect tear film stability [149].

5.2.3. Castor Oil

Castor oil is widely incorporated into cosmetic and periocular products, including eyelash conditioners, eye creams, eyeliners, eyeshadows, primers, makeup removers, mascaras, and serums. Although it is commonly believed to enhance eyelash growth, scientific evidence supporting its direct effects on eyelash follicles or ciliary growth remains limited. The primary active component of castor oil, ricinoleic acid, has been shown to inhibit prostaglandin D_2, a mediator implicated in androgenic alopecia [150,151]. However, its potential role in promoting eyelash growth has not been clearly established and requires further investigation.

Castor oil is generally considered to have low irritant and sensitizing potential in humans, although individuals with occupational skin disorders may exhibit allergic reactions to castor oil or ricinoleic acid. Importantly, ocular surface exposure to castor oil formulations has been reported to cause mild and transient ocular discomfort and may induce corneal epithelial cell damage and barrier disruption [152]. Furthermore, ricinoleate has demonstrated dose-dependent cytotoxic effects on epithelial cells, suggesting that excessive or prolonged exposure may adversely affect ocular surface integrity [153].

5.2.4. Cocamide Diethanolamine

Diethanolamine is widely used in cosmetic and personal care products as an emollient and a thickening and dispersing agent, particularly in formulations containing cocamide diethanolamine derived from coconut oil fatty acids. Although early safety evaluations considered it acceptable for cosmetic use, it was recognized as a potential ocular irritant. More recent regulatory assessments have raised safety concerns, with cocamide diethanolamine listed as a carcinogen by the California Department of Health and both diethanolamine and its coconut-derived condensates classified by the International Agency for Research on Cancer as possibly carcinogenic to humans [154].

5.2.5. Fragrances

Oxidized fragrance compounds, such as linalool, have been associated with the development of contact dermatitis [155]. Additionally, synthetic musk fragrances have been reported to disrupt cellular function and interfere with hormonal regulation. Due to these potential health concerns, certain synthetic musks have been banned in Europe, although they remain permitted in the United States [156].

5.2.6. Gold

Gold was recognized by the American Contact Dermatitis Society as the Contact Allergen of the Year in 2001, reflecting its significant role in allergic reactions [157]. Despite this designation, the inclusion of gold in cosmetic formulations has remained largely unchanged over the past two decades, and many products continue to promote gold as a beneficial ingredient without adequately addressing its allergenic potential. Clinical evidence indicates that approximately 10% of patients undergoing patch testing in North America exhibit Type IV hypersensitivity reactions to gold [158].

5.2.7. Heavy Metals

Despite its well-known toxicity, trace amounts of lead and other heavy metals are still present in various cosmetic products, including lipsticks and metal-based makeup such as eyeshadows and blushes, where they may cause irritation or allergic reactions [159].

Several metals, including nickel, arsenic, mercury, chromium, cobalt, cadmium, zinc, iron, and lead, are recognized sensitizers, with nickel being a particularly common cause of cosmetic-related hypersensitivity. Nickel-free products, typically containing less than 1 ppm nickel, are generally better tolerated by sensitive individuals [160]. Additionally, certain pigments, including black iron oxide in mascara, have been associated with eyelid contact dermatitis [161].

5.2.8. Lanolin

Lanolin, a lipid-rich substance obtained from sheep wool secretions, is commonly used in cosmetic formulations as a moisturizing and emollient agent. Although generally regarded as a relatively weak sensitizer, lanolin has been associated with periorbital allergic contact dermatitis, particularly when applied to compromised or damaged skin [162].

5.2.9. Nylon

Nylon is commonly incorporated into cosmetic formulations as a bulking and opacifying agent, with nylon-6 frequently used in mascaras and eyebrow pencils and nylon-12 widely used in eyeshadows and face powders [163]. Early safety evaluations suggested that low concentrations of nylon-12 were generally well tolerated and did not cause significant ocular irritation, even in individuals with sensitive eyes or contact lens users [163].

However, isolated clinical reports have described the embedding of microscopic nylon fibers into conjunctival tissues following the use of fiber-enhancing mascaras, leading to localized inflammatory responses [164]. Additionally, contact dermatitis related to nylon exposure has been reported from other sources near the ocular region, including eyeglass frames and nail polish transferred to the eyes through manual contact [165,166].

5.2.10. Phenylethyl Resorcinol

Phenylethyl resorcinol is a depigmenting agent commonly used in cosmetic products to reduce melanin production by inhibiting tyrosinase activity [167]. It is often combined with other skin-lightening compounds such as retinol, disodium glycerophosphate, and L-leucine [168,169]. Clinical studies have reported good tolerability when applied to the periocular area for the treatment of dark circles and when used alongside microneedling procedures [170]. However, case reports have documented instances of allergic contact dermatitis associated with its use in skin-lightening cosmetics and sunscreen formulations [4].

6. Ocular Migration of Eye Cosmetic Products and Periocular Aesthetic Interventions

Although cosmetic products are applied externally to the periocular skin or eyelash margin, they can migrate onto the ocular surface through mechanical and tear film-mediated processes. Slit-lamp examination frequently demonstrates suspended pigments and particles within the tear film, reflecting direct migration, improper application, or eye rubbing [171]. Application close to the lid margin promotes movement toward the anterior ocular surface via blinking, forceful eyelid closure, contraction of the Riolan muscle fibers, and tear meniscus surface tension forces, with migration increasing over time and after eye drop instillation [171–173].

Evidence from translid margin drug delivery studies further confirms that compounds can traverse the lid margin and reach the ocular surface without direct instillation [174,175]. Once deposited, these materials spread across the tear film through blink-induced hydrodynamic forces and tear redistribution, penetrate the lipid layer (particularly lipophilic constituents), and diffuse within the aqueous layer toward the conjunctival and corneal epithelium [112,176–179].

Tear film integrity, especially the lipid and mucin layers, limits epithelial exposure; however, tear film instability, mucin deficiency, or dry spot formation can compromise barrier function, facilitating epithelial interaction and promoting tear film destabilization, inflammation, and dry eye pathology [180–184].

Periocular products, including makeup removers, can migrate into the tear film even when applied to closed eyelids, and topical formulations may disperse up to 1 cm from the application site, potentially reaching the meibomian glands and ocular surface [10,53]. Similarly, periocular aesthetic procedures, including eyelash extensions, periocular tattooing, injectable agents, and energy-based modalities, may facilitate the introduction and subsequent redistribution of exogenous materials, particulate matter, or bioactive substances toward the ocular surface via translid margin diffusion, mechanical displacement, or tear film dynamics, particularly when applied in close proximity to the lid margin [17,86]. Additionally, contaminated applicators such as brushes and sponges may serve as microbial reservoirs, and oil-based cosmetic use has been associated with increased *Demodex* infestation, contributing to duct obstruction and posterior blepharitis, particularly in older individuals and patients with DED [185].

7. Impact of Eye Cosmetics and Periocular Aesthetic Practices on the Ocular Surface

Eye cosmetics and periocular aesthetic practices are increasingly recognized as potential contributors to ocular surface pathology due to their complex chemical composition and direct periocular application. Accumulating clinical and experimental evidence suggests that cosmetic constituents can disrupt tear film stability, induce inflammatory or hypersensitivity responses, and cause mechanical or toxic injury to ocular tissues. The following sections critically summarize current evidence linking cosmetic use with major ocular surface disorders (Figure 3 and Table 3).

7.1. Dry Eye Disease (DED) and Tear Film Alterations

DED is a multifactorial disorder of the ocular surface characterized by symptoms such as dryness, irritation, burning, and visual fluctuation, resulting from abnormalities in tear film quantity and/or quality [186]. Although DED can occur at any age, it is more prevalent in women and older individuals. Epidemiological studies estimate that 5–50% of the global population is affected, underscoring DED as one of the most common ocular surface disorders [187]. The tear film, which is predominantly aqueous but also contains

lipids, electrolytes, and proteins, is essential for ocular surface lubrication, nutrition, and protection, as well as for maintaining optical clarity. Disruption of tear film homeostasis compromises ocular surface integrity and leads to the development of DED, with clinical manifestations ranging from mild discomfort to severe pain and visual impairment [188]. Central to DED pathophysiology are tear film hyperosmolarity and inflammation, driven by complex cellular and molecular networks involving cytokines, chemokines, and matrix metalloproteinases (MMPs) [189].

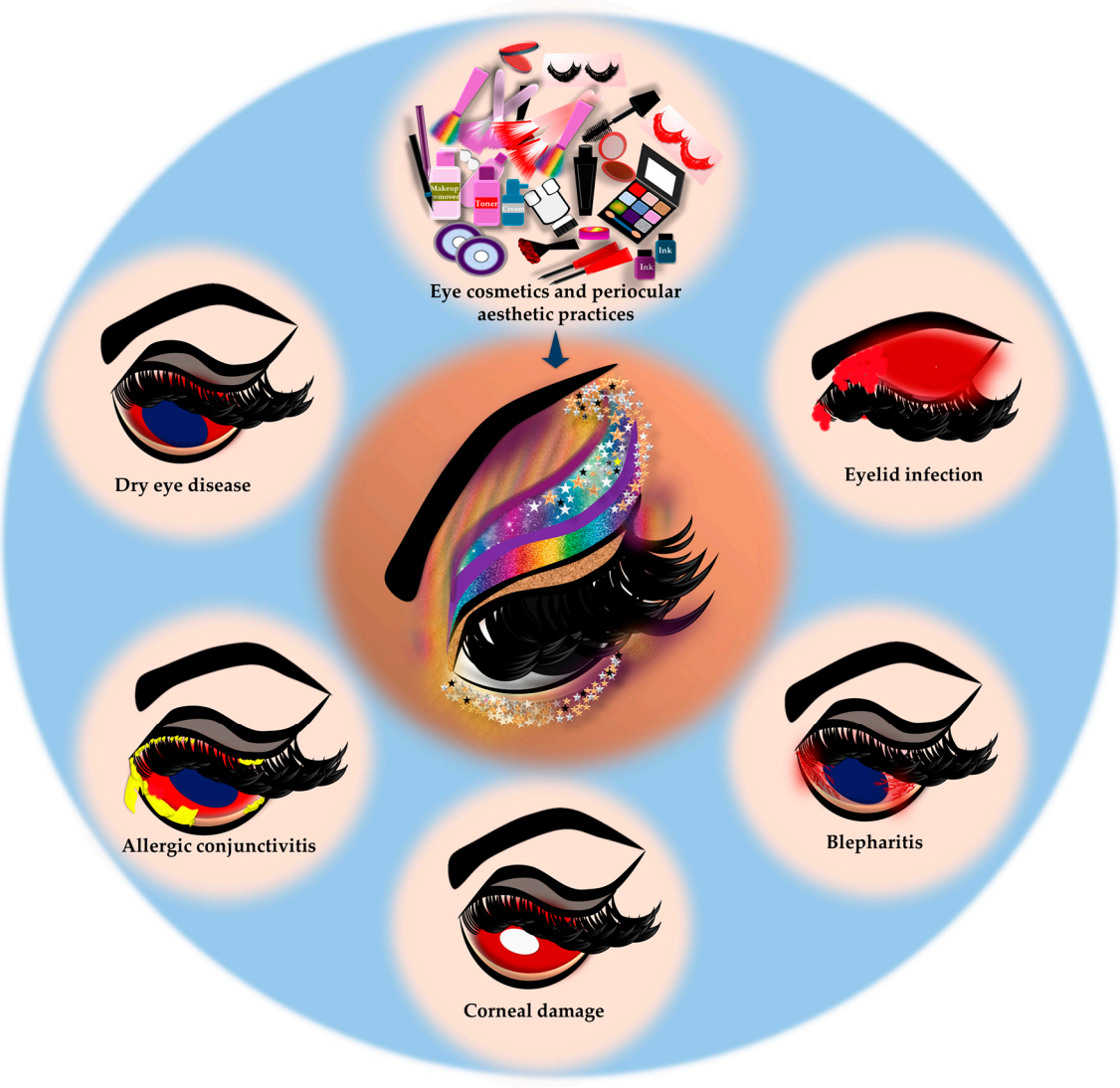


Figure 3. Ocular surface disorders potentially associated with eye cosmetics and periocular aesthetic practices. Illustration summarizing possible adverse ocular outcomes linked to the use of eye cosmetics. Products applied to the eyelids and periocular region may enter the tear film or accumulate along the eyelid margin, disrupting ocular surface homeostasis and contributing to conditions such as dry eye disease, blepharitis, eyelid infection, allergic conjunctivitis, and corneal damage.

Growing evidence indicates that eye cosmetic use is associated with an increased prevalence and severity of DED [149,171,173]. It has been suggested that the migration of cosmetic products across the eyelid margin may contribute to increased debris within the tear film lipid layer, meibomian gland blockage, and meibum contamination. The resulting destabilization of the lipid layer can lead to increased tear evaporation and reduced tear film stability [44,172,190].

Furthermore, cosmetic users report significantly higher symptom scores than non-users, with the greatest burden observed among individuals using internal eyeliner and

mascara. In contrast, lower symptom severity and ocular surface disease index (OSDI) scores have been reported in individuals who consistently remove eye makeup before sleep and use appropriate cleansing products, highlighting the protective role of proper cosmetic hygiene [191].

The association between eye cosmetics and DED is particularly relevant in women, who exhibit both higher cosmetic use and a greater prevalence of DED. In a cross-sectional study of 207 adult female eye-cosmetic users, a high prevalence of DED symptoms of 71.6% was reported, exceeding rates observed in the general population. Severe, moderate, and mild DED were observed in 40.5%, 13.5%, and 17.6% of participants, respectively. Mascara was the most commonly used cosmetic at 98.6%, although it showed no significant association with DED. In contrast, daily inner eyeliner application was significantly associated with increased DED prevalence at approximately 75%, suggesting disruption of tear film stability and meibomian gland function [192]. Additionally, lack of cosmetic cleanser use was linked to greater DED severity, highlighting the role of periocular hygiene in ocular surface health. In a study involving 1344 participants, eyeliner use was associated with a higher prevalence of DED, with users showing significantly increased OSDI scores compared to non-users. Application along the lid margin and inner lash line further elevated dry eye symptoms, likely due to tear film disruption and meibomian gland obstruction, leading to ocular surface instability and inflammation. Increased frequency and prolonged eyeliner use were also associated with greater symptom severity, identifying cosmetic application practices as a modifiable risk factor for DED [193].

Likewise, a recent cross-sectional study involving 1741 women reported ocular adverse reactions in about 85% of eye makeup users, with dry eye-related symptoms including foreign body sensation in 47.5% and burning sensation in 39.4%. These symptoms were linked to tear film instability and ocular surface inflammation, primarily associated with frequent cosmetic use, allergic predisposition, and improper application or removal practices. The findings suggest that prolonged and unsafe eye makeup use contributes to evaporative DED and ocular surface dysfunction.

Similarly, a cross-sectional study involving 220 healthy women demonstrated that eyeliner and mascara use were associated with reduced tear film stability and increased meibomian gland loss compared with non-users, despite no significant effect on tear production. All cosmetic user groups showed a significantly lower noninvasive tear break-up time, suggesting lipid layer disruption. Meibomian gland structural loss was significantly higher among cosmetic users, likely due to pigment and cosmetic residue accumulation obstructing gland orifices and impairing meibum secretion. These findings indicate that eyeliner and mascara use contribute to evaporative DED through tear film instability and meibomian gland dysfunction [194].

The “inside liner” technique, which involves applying eyeliner directly along the lid margin overlying the meibomian gland orifices, poses a particular risk. Makeup products can mix with tears and sweat, migrate onto the ocular surface during blinking or eye drop instillation, and contribute to gland obstruction. Consequently, individuals requiring frequent topical ocular medications are generally advised to avoid eye cosmetics [12].

In addition, artificial eyelash extensions further exacerbate ocular surface disruption through multiple mechanisms, including altered blink dynamics, incomplete eyelid closure, impaired lid hygiene, gland blockage, allergen exposure, and mechanical trauma. A prospective study in 32 women showed that eyelash extensions cause short-term tear film instability and ocular surface disturbance, relevant to DED. Most participants (84%) reported acute symptoms (mainly foreign body sensation). Tear meniscus height and tear break-up time significantly decreased within 1 week, indicating increased tear evaporation and reduced tear film stability, while corneal staining increased shortly after application.

Meibomian gland structure and lipid layer thickness were unchanged, suggesting DED symptoms were driven mainly by tear film imbalance and epithelial irritation, likely related to lash length, glue volatility, and altered blink/evaporation dynamics rather than gland dysfunction [195].

Furthermore, topically applied periocular cosmetics can migrate across the eyelid margin and reach the ocular surface, with a higher contamination risk in individuals using eye drops simultaneously [172,173]. In the tear film, accumulation of hydrophilic components may promote tear hyperosmolarity and inflammation, although this mechanism was mainly described for BAK, which is now largely excluded from modern cosmetic formulations. Deposited cosmetic materials can irritate the cornea and conjunctiva, potentially through membrane disruption, saponification, protein coagulation, and macromolecular interactions [196]. Additionally, migrated cosmetic ingredients may exacerbate DED by activating ocular surface inflammatory pathways [197].

Further, ocular and periocular tattooing may also contribute to tear film instability through chronic periocular inflammation and structural disruption. Eyelid tattooing has been linked to meibomian gland dysfunction, tear film instability, and dry eye symptoms, likely due to pigment deposition or inflammatory obstruction of gland orifices, which impairs lipid secretion and promotes evaporative dry eye.

In addition, a randomized crossover study of 24 participants demonstrated that 7-day pencil eyeliner application at the mucocutaneous junction increased tear film lipid layer thickness but worsened ocular comfort without improving tear stability [198]. OSDI scores were significantly higher compared with periocular application. The findings suggest that migration of lipophilic eyeliner components into the tear film elevates lipid content but disrupts ocular surface homeostasis, leading to increased symptom burden.

Clinical evidence also indicates that eye makeup removers can adversely affect tear film integrity. An in vivo study confirmed that removal solutions applied over closed eyelids can infiltrate the tear film [53]. A prospective study involving 20 participants compared three remover types, including oil and alcohol free, oil-based microemulsion, and hyaluronic acid micellar solution, and found that all formulations increased tear evaporation [199]. Notably, the oil-based microemulsion produced the most pronounced deterioration in lipid layer quality and tear film stability.

DED induced by BoNT is highly dependent on the anatomical site of administration and may result from impaired eyelid closure, diminished lacrimal secretion, or dysfunction of the meibomian glands, all of which compromise tear film stability [68,69]. Direct diffusion of the toxin to the lacrimal gland disrupts parasympathetic innervation, leading to a marked reduction in aqueous tear production and consequent aqueous-deficient dry eye. Multiple clinical investigations have consistently demonstrated objective evidence of reduced tear secretion, including significantly decreased Schirmer test measurements, following aesthetic botulinum toxin injections in the lateral canthal region [200–202].

7.2. Allergic and Contact Hypersensitivity Reactions

The ocular surface is protected by a highly regulated immune defense network comprising innate, adaptive, and mucosal immune components. This system maintains immune homeostasis while remaining capable of mounting appropriate responses to external stimuli. Cosmetic exposure in the periocular region can disrupt this balance, primarily affecting the eyelids, tear film, conjunctiva, and cornea [203]. Like other cutaneous tissues, the eyelid is particularly susceptible to contact allergy, most commonly presenting as a delayed-type (Type IV) hypersensitivity reaction following sufficient allergen exposure [204].

Users of eye cosmetics may develop irritant or allergic contact dermatitis, characterized by erythema, pruritus, burning sensations, vesiculation, or urticaria, typically emerging

within 24–72 h of exposure. Allergens may originate directly from cosmetic products or be transferred indirectly from the hands. In addition to delayed hypersensitivity, the eyelids may also exhibit immediate (Type I) hypersensitivity reactions, manifesting as immunologic contact urticaria. These reactions are mediated by histamine release and can lead to rapid-onset eyelid swelling, redness, and conjunctivitis within minutes to an hour after exposure. Individuals with underlying atopic conditions are particularly vulnerable to such responses [205,206].

Eyelash tinting has been increasingly recognized as a potential cause of periocular allergic and inflammatory ocular surface disorders, primarily attributed to PPD, a well-known contact sensitizer frequently present in tinting formulations. Clinical reports have demonstrated that exposure to PPD-containing eyelash dyes can precipitate acute allergic conjunctivitis, characterized by conjunctival hyperemia, excessive discharge, recurrent conjunctival inflammation, and associated periorbital dermatitis. Additional manifestations, including bilateral eyelid edema, erythema, and ocular discomfort, have also been documented. Patch testing in affected individuals consistently confirms PPD hypersensitivity, supporting its role as a key immunologic trigger [207].

A case report described severe allergic blepharoconjunctivitis following eyelash and eyebrow dye application in a 38-year-old woman. The patient developed acute ocular allergy characterized by intense itching, conjunctival hyperemia, chemosis, epiphora, and eyelid edema shortly after dye exposure. Visual acuity was transiently reduced but improved following topical corticosteroid and lubricating therapy. The findings demonstrate that eyelash dyes, including commercially approved products, can trigger significant allergic ocular surface inflammation [208].

Across different eyelash dye products, allergic reactions remain the most frequently reported complication. A case–control study involving 544 patients reported a significant association between eyelash dye use and allergic ocular disease. Eyelash dye exposure was observed in 63.2% of allergic eye disease cases compared with 40.4% of controls, with 82.6% of users reporting worsening ocular symptoms after dye application. These findings suggest that chemical constituents and traditional dye formulations may trigger ocular surface inflammation and hypersensitivity reactions, contributing to allergic eye disorders [209].

Similarly, tattoo pigments used in ocular and periocular tattooing may contain heavy metals, dyes, or allergenic compounds capable of triggering hypersensitivity reactions. These reactions may manifest as localized eyelid dermatitis, conjunctival inflammation, and chronic periocular irritation. In some cases, persistent foreign body reactions to tattoo pigments may result in granuloma formation or prolonged inflammatory responses affecting periocular tissues and the ocular surface [210,211].

7.3. Infectious Ocular Complications

Microbial contamination of cosmetic products represents a significant safety concern, arising both during manufacturing and throughout storage and use. Most cosmetics are produced under non-sterile conditions and formulated with non-sterile raw materials. In addition, many products contain water, lipids, and organic nutrients that readily support microbial proliferation. As a result, inadequate manufacturing hygiene, insufficient preservative systems, suboptimal microbiological testing, and poorly defined microbial acceptance limits can lead to contamination, product degradation, and economic loss. Microbial growth may also compromise product quality by altering color, texture, viscosity, and odor [212].

Studies have demonstrated that microbial contamination can occur even in unused cosmetic products, with higher contamination rates and greater microbial diversity observed in

lower-quality formulations [213,214]. These differences are likely influenced by ingredient composition, preservative efficacy, and conditions encountered during transportation and storage. Although cosmetic products are not required to be sterile, regulatory standards in the United States mandate withdrawal of eye-area products containing bacterial loads exceeding 100 CFU/g or mL [215].

Beyond manufacturing-related factors, user behavior substantially contributes to contamination risk. Poor hygiene practices, prolonged product use, dilution of cosmetics with water, and sharing products among multiple users markedly increase microbial exposure [212]. Repeated use of a single cosmetic item facilitates the introduction and accumulation of microorganisms within its container. Notably, studies have reported microbial contamination in over one-third of mascaras after three months of personal use, with high prevalence of pathogenic species such as *Staphylococcus aureus* and *Pseudomonas aeruginosa* [216]. The extent of contamination correlates with product age, frequency of use, and the number of users [217].

Sharing eye cosmetics and applicators poses an additional risk by enabling the transmission of bacteria, fungi, mites such as *Demodex*, and viruses [218]. Surveys indicate limited public awareness of this risk, despite evidence that makeup brushes and sponges used in beauty salons are frequently contaminated with pathogenic bacteria and fungi. Even powder-based products, including eyeshadows, are susceptible to microbial colonization. Consequently, the use of communal cosmetic testers is strongly discouraged [219,220].

Similarly, ocular and periocular tattooing carries infection risks due to direct breach of the ocular or periocular barrier during needle penetration. Non-sterile instruments, contaminated pigments, or inadequate post-procedure hygiene may introduce pathogens into periocular tissues or ocular structures [221,222]. Tattoo-associated infections have been reported to cause conjunctivitis, blepharitis, episcleritis, and severe intraocular infections such as endophthalmitis. Additionally, chronic inflammatory reactions or foreign body responses to tattoo pigments may predispose individuals to secondary microbial colonization, further increasing the risk of infectious ocular surface disease [223–225].

To reduce cross-contamination and infection risk, the use of disposable, single-use applicators is recommended, particularly in professional settings. Effective disinfection strategies for reusable tools include cleaning with 60–80% ethanol or isopropyl alcohol and the use of UV or UVC sanitation systems. Application techniques also influence contamination risk; for example, eyeliners or brushes that contact the lid margin or mucocutaneous junction are more likely to become contaminated. Liquid eyeliners showing signs of contamination should be discarded, whereas pencil eyeliners may be sharpened to remove exposed material [28].

Routine hygiene practices are essential for minimizing microbial growth. Makeup sponges should be washed after each use with a mild cleanser and stored in a dry environment, while makeup brushes should be cleaned at least weekly using gentle cleansing agents. Adherence to these practices is critical for reducing cosmetic-related ocular infections, particularly in individuals with pre-existing ocular surface disorders such as DED [226,227].

7.4. Mechanical and Chemical Ocular Surface Injury

Mechanical ocular trauma refers to eye injury caused by direct physical impact, ranging from minor irritation to significant structural damage. Among cosmetic users, a well-recognized example is accidental corneal injury from inadvertent contact with a mascara applicator wand [197]. Using pins to separate clumped eyelashes after mascara application can cause mechanical eye injury and create entry points for infection. Additionally, loose nylon fibers from lash-lengthening mascaras may detach and irritate the ocular surface [44].

Applying eyeliner directly along the lid margin can obstruct meibomian gland openings, potentially disrupting tear film stability [228]. Moreover, rigid or sharply pointed eyeliner pencils may cause ocular surface abrasions, although wooden casings generally exert less pressure than plastic alternatives [26]. Modification of eyelash volume, length, or curvature can disrupt their protective function, impairing debris deflection and tear film stability. Excessive elongation from mascara or artificial lashes may redirect airflow toward the ocular surface, increasing mechanical strain and tear evaporation [229]. Similarly, ocular and periocular tattooing introduces additional mechanical risks due to needle penetration and pigment injection. Improper tattoo depth or technique may result in tissue trauma, corneal or scleral perforation, inadvertent pigment deposition within intraocular structures, or damage to adjacent ocular tissues. Such injuries may lead to severe complications, including visual impairment, intraocular inflammation, or structural damage to the cornea and retina [89].

Cosmetic application around the eyes inherently carries a risk of mechanical trauma due to the use of applicators. Ocular injury was reported when powdered eyeshadow was displaced beneath a laser-assisted in situ keratomileusis (LASIK) flap created over six years earlier after accidental impact during makeup application, necessitating flap elevation and foreign material removal [74]. Direct corneal trauma has also been documented following inadvertent contact with mascara wands, and post-application manipulation of clumped lashes using sharp objects, such as pins, further increases the risk of epithelial injury and secondary infection [25]. Certain cosmetic products, including fiber-based mascaras, contain fine nylon filaments that may detach and irritate the ocular surface upon contact [17]. More severe injuries, including penetrating ocular trauma and traumatic cataract, have been associated with improper use of eyelash curlers [75]. To minimize such risks, the FDA advises against applying eye cosmetics in moving vehicles [43]. Artificial eyelashes are additionally linked to mechanical complications, such as incomplete eyelid closure during sleep, lash-base calcification causing corneal abrasion, and eyelid malposition, including entropion [1,76]. Moreover, magnetic or metallic cosmetic accessories can contribute to eyelash loss due to excessive weight and may induce corneal abrasions when displaced.

Case reports have shown that periocular hyaluronic acid dermal filler injections can result in globe penetration with subconjunctival, vitreous, and subretinal hemorrhages, as well as retinal tears, highlighting the risk of inadvertent intraocular trauma [230]. Similarly, cosmetic PRP injections have been associated with retrobulbar pain, conjunctival chemosis, corneal edema, and segmental ischemia, likely due to inadvertent intravascular injection and embolization, with severe cases progressing to orbital ischemia and phthisis bulbi [231].

7.5. Pigment Deposition and Structural Ocular Changes

Chronic and repeated use of eye cosmetics has increasingly been recognized as a potential source of pigment deposition and structural ocular changes. Several cosmetic products, including eyeliners, mascaras, and eye shadows, contain metallic compounds that function as colorants or arise as contaminants during production. Heavy metals such as lead, mercury, arsenic, cadmium, chromium, nickel, and cobalt have been consistently identified in commercially available cosmetic formulations, raising concerns regarding their ocular safety [232]. These metals are capable of penetrating ocular surface tissues and may accumulate within the conjunctival and corneal epithelium following prolonged exposure. Such accumulation can disrupt epithelial integrity, induce oxidative stress, and trigger inflammatory signaling pathways, thereby contributing to tear film instability, conjunctival irritation, and the progression of ocular surface disease [12,232].

Cosmetic tattooing represents another clinically significant source of exogenous pigment deposition within ocular tissues. Multiple studies on ocular and periocular tattoo

complications have demonstrated that injected pigments can migrate beyond their intended anatomical location and infiltrate adjacent ocular structures [233]. Histopathological analyses have confirmed the presence of pigment particles in multiple ocular compartments, including the conjunctiva, corneal endothelium, iridocorneal angle, lens capsule, and vitreous cavity [234]. These deposited pigments frequently induce foreign body granulomatous reactions characterized by macrophage infiltration containing pigment granules, suggesting persistent immune activation and chronic inflammation. Clinically, such pigment deposition has been associated with the development of chronic ocular inflammatory disorders, including uveitis, secondary glaucoma, tear film dysfunction, and progressive corneal structural damage, which may ultimately result in significant visual impairment [235].

Exposure to silver-containing cosmetic preparations has been linked to corneal argyria, a condition characterized by pigment deposition within the Descemet membrane and corneal stromal layers [236]. Cosmetic pigments and preservatives may also obstruct lacrimal drainage pathways, alter tear film composition, and disrupt normal ocular surface homeostasis, thereby amplifying inflammatory responses. Collectively, these findings demonstrate that long-term cosmetic use may result in exogenous pigment deposition within ocular and periocular tissues, contributing to conjunctival and periocular discoloration [12,236].

7.6. Ocular Toxicity

The eyelid epithelium is exceptionally delicate and highly permeable, facilitating the transdermal entry of exogenous chemical substances [33]. Traditional eye cosmetics such as kohl are frequently formulated using lead-based ingredients [176]. Chronic application of these products has been associated with substantial increases in systemic lead burden and corresponding reductions in hemoglobin levels [237]. Epidemiological evidence indicates that infants aged 6–16 months exposed to kohl demonstrate approximately 62% higher blood lead concentrations compared with unexposed infants. Similarly, individuals using surma have been reported to exhibit mean blood lead levels exceeding those of non-users by more than 80% [237]. Moreover, accumulation of lead and other heavy metals within the epidermal layer has been implicated in the development of periocular hyperpigmentation among habitual kohl users [238].

A clinical case report described the development of toxic keratitis following the continuous daily use of a traditionally prepared kohl eyeliner applied to the inner eyelid for two weeks [239]. This kohl, produced by a local herbal practitioner in the Riyadh region of Saudi Arabia, was later analyzed using gas chromatography–mass spectrometry, which revealed hazardous concentrations of cadmium in addition to lead. Cadmium, a heavy metal widely utilized in battery manufacturing, was detected despite its unclear source; however, reports have suggested that certain traditional practitioners in the region may incorporate materials such as ground paint or dried battery components into kohl formulations [239].

While direct evidence of lead-induced corneal toxicity in humans remains limited, experimental animal studies have demonstrated that cadmium exposure can induce significant structural injury to corneal endothelial cells. Furthermore, cadmium has been shown to promote mitochondrial damage, leading to impairment of the endothelial ion pump function and subsequent disruption of corneal homeostasis [44].

In an in vitro study by Chen et al., commonly used cosmetic preservatives, including BAK and formaldehyde-releasing compounds, demonstrated dose-dependent cytotoxic effects on human corneal, conjunctival, and meibomian gland epithelial cells, impairing cellular morphology, proliferation, lipid production, and intracellular signaling [7].

7.7. Ocular Discomfort and Sensory Disturbances

Eye cosmetic application has been increasingly linked to heightened ocular surface discomfort and irritation, likely due to repeated exposure of delicate periocular tissues to chemical constituents and mechanical stress [171,173,190,198]. The frequent application and removal of cosmetic products may alter the periocular microenvironment, potentially sensitizing ocular surface structures. Moreover, routine eyelid hygiene practices and repeated digital manipulation during cosmetic removal may further contribute to surface irritation, representing important confounding factors that should be considered when interpreting these associations [240].

A cross-sectional questionnaire-based study involving 1360 female participants investigated the association between periocular cosmetic use and subjective ocular comfort [240]. Cosmetic users demonstrated slightly higher OSDI scores compared with non-users; however, this difference did not reach statistical significance. Within the cosmetic-user cohort, participants reported significantly greater ocular discomfort on days when cosmetic products were applied. No significant associations were identified between symptom severity and either the frequency of cosmetic use or the specific product type. Nevertheless, the interpretation of these findings may be limited by potential self-selection bias, as individuals predisposed to ocular irritation may intentionally restrict cosmetic use to mitigate symptom exacerbation.

A randomized crossover trial involving 20 female participants demonstrated that 7-day pencil eyeliner application reduced subjective ocular comfort regardless of whether the product was applied to the periocular skin or directly along the mucocutaneous junction [198]. Notably, application at the mucocutaneous junction resulted in significantly worse OSDI scores compared with periocular application. The authors suggested that this effect was likely due to increased migration of cosmetic material toward the ocular surface when applied in closer proximity to the eyelid margin.

Moreover, a prospective study including 410 participants evaluated both subjective and clinical indicators of ocular irritation following deliberate exposure of the inferior fornix to undiluted cosmetic formulations, including mascara, powder eye shadow, liquid cosmetics, and eye makeup remover [177]. Designed to simulate accidental ocular contamination, the study identified powder eye shadow as producing the highest sodium fluorescein staining scores. Subjective irritation responses occurred rapidly, typically peaking within 30 s after exposure, and generally subsided within approximately 15 min.

In a study investigating the ocular effects of eye cosmetic use, increased subjective ocular discomfort was reported, suggesting that cosmetic application may contribute to tear film disturbance and ocular surface irritation [240].

Studies have shown that periocular dermal filler injections have been reported to cause periocular or retrobulbar pain, numbness in the maxillary (V2) dermatome, and floaters, sometimes preceding more severe complications [241,242]. Similarly, BoNT-A injections may result in periocular discomfort, ocular fatigue, transient mydriasis, and ptosis, reflecting sensory and functional disturbances of ocular tissues [243].

In the same context, studies demonstrated that cosmetic PRP injections in periocular areas can cause retrobulbar/periocular pain, numbness or tingling, ptosis, restricted eye movement, and ocular fatigue [244,245].

7.8. Contact Lens-Related Ocular Surface Complications

The concurrent use of eye cosmetics and contact lenses has been proposed to contribute to ocular dryness and discomfort; however, consistent clinical evidence remains limited [246,247]. Experimental observations by Tsukiyama et al. demonstrated that cosmetic materials readily adhere to contact lens surfaces [248]. Reported cases included

contamination of rigid gas-permeable lenses following inner eyelid application of liquid eyeliner, mascara deposition on soft hydrogel lenses, and adherence of hand cream to silicone hydrogel lenses. Notably, some contaminants were resistant to removal despite routine rubbing and rinsing with multipurpose solutions. Additionally, exposure to cosmetic cleansing agents resulted in structural deformation of certain silicone hydrogel lenses, particularly those lacking surface plasma treatment. Such lens alterations were proposed as a potential contributor to patient-reported discomfort.

Lens deformation and impaired optical performance resulting from cosmetic contamination of silicone hydrogel contact lenses have also been reported by Luensmann et al. [249]. Their findings demonstrated that eye cosmetic removers exerted the most significant alterations in lens parameters, including increases in base curve and lens diameter, while waterproof mascaras produced the greatest deterioration in optical quality. Importantly, these optical changes persisted even after routine lens cleansing, suggesting potential long-term effects on lens integrity.

Collectively, findings from both Tsukiyama et al. and Luensmann et al. emphasize the importance of removing contact lenses before applying cosmetic removal products [248,249]. The use of cleansing agents with cotton pads over closed eyelids may introduce contaminants into the preocular tear film [53]. Furthermore, cosmetic removers may induce persistent modifications in lens structure and optical performance. Proper hand hygiene is also essential, as residual lotions or creams may transfer to the lens surface during handling, potentially compromising lens function and ocular comfort.

Table 3. Different studies utilizing eye cosmetics and aesthetic practices and their major findings.

Cosmetic Product/Aesthetic Practice	Detailed Findings	Study Design	References
Internal eyeliner, mascara, external eyeliner, eye shadow, false eyelashes	-Internal eyeliner and mascara users have greater symptomatic DED prevalence/severity than non-users. -Daily inner eyeliner and mascara users show highest DED incidence. -Removing makeup with cleansing creams before bed significantly reduces DED.	Population-based cross-sectional study	[191]
Eyeliner, mascara	-No synergistic detrimental effect on the ocular surface was observed with combined eyeliner and mascara use. -All cosmetic groups showed significant NTBUT reduction and meibomian gland loss. -Schirmer test showed no differences across groups.	Cross-sectional study	[194]
Artificial eyelashes	-Foreign body sensation peaks 1 h after artificial eyelash application. -Tear breakup time and tear meniscus height reach their lowest levels 1 week after artificial eyelash application.	Prospective study	[195]
Artificial eyelash	-Four weeks after artificial eyelash removal, OSDI, TBUT, corneal staining, and blink frequency show significant improvement.	Prospective study	[250]
Eyelash dyeing	-Allergic reactions represent the primary complication following eyelash dyeing.	Case–control study	[208]
Contact lens use	-Symptomatic contact lens wearers had poorer meibomian gland function (reduced expressibility and poorer secretion quality). -Higher tear evaporation rate and thinner lipid layer were strongly associated with discomfort. -Shorter tear breakup time correlated with increased symptoms. -Meibomian gland morphological changes were significantly linked to contact lens discomfort.	Cross-sectional study	[251]

Table 3. *Cont.*

Cosmetic Product/Aesthetic Practice	Detailed Findings	Study Design	References
Eyeliner cosmetic products	-One eyeliner significantly increased meibum lipid phase transition temperature (+4.2 °C). -Increased lipid order (from 30% to 49%), indicating higher viscosity. -Significant reduction in enthalpy and entropy of meibum phase transition. -Another eyeliner showed no significant effect. -Increased lipid order may impair tear film stability and contribute to dry eye symptoms.	Pilot in vitro experimental study	[149]
Eye pencil	-Eyeliner applied to the mucocutaneous junction (inner lid margin) increased tear film lipid layer thickness compared to application on the periorbital skin. -Ocular comfort slightly decreased with inner lid application. -No significant differences were observed in tear breakup time, redness, or staining between application methods. -Application closer to the lid margin likely increases cosmetic migration into the tear film, potentially disrupting ocular surface homeostasis.	Randomized crossover clinical study	[198]
Mascara, eyeliner, multiple products	-Eye cosmetic use was highly prevalent, with most participants using products regularly. -Overall OSDI scores were similar between users and non-users. -Participants reported better ocular comfort when not wearing cosmetics. -Occasional users frequently reported reduced comfort when using cosmetics. -Trend toward reduced comfort among eyeliner users. -Use of multiple products was associated with perceived ocular discomfort.	Cross-sectional study	[240]
Direct ocular instillation of cosmetic and consumer products (liquid make-up, shampoo, baby wash, mascara, eye make-up remover, powder eye shadow, facial cleanser)	-Ocular irritation levels varied markedly depending on product category. -Both subjective irritation symptoms and objective signs (inflammation and fluorescein staining) differed across products. -Different ocular tissues showed varying susceptibility to irritation. -Product type and category are important predictors of ocular irritancy potential.	Prospective human experimental ocular instillation study	[177]
Application of cosmetic product material (CPM) at different eyelid locations ± eyedrop instillation	-CPM migration onto the ocular surface was significantly higher when applied at the inner eyelash line compared to outer locations. -Migration increased over time, particularly when applied near the lash line. -Eyedrop instillation significantly exacerbated CPM migration and ocular surface contamination. -Application closer to the lid margin increases risk of ocular surface contamination.	Randomized controlled experimental study	[173]
Lipid-containing lubricant eye drop vs. phospholipid liposomal spray after eyeliner application	-Both lipid-based treatments increased tear film lipid layer thickness. -Both treatments increased tear film contamination in eyeliner users. -Neither treatment improved tear film stability or reduced tear evaporation. -No significant difference in efficacy between the two treatments.	Prospective, randomized, investigator-masked paired-eye trial	[190]

Table 3. *Cont.*

Cosmetic Product/Aesthetic Practice	Detailed Findings	Study Design	References
Natural eyelash morphology and mascara preference patterns	-Eyelash length, thickness, and curl were measured and classified into six groups. -Short/thin lashes preferred long-lash effects and reported staining complaints. -Long/thick lashes preferred volume effects and reported clumping. -Eyelash morphology strongly influenced mascara preference and complaints.	Cross-sectional observational study	[252]
Nickel-containing eye pencil	-Palpebral eczematous dermatitis was associated with eye pencil use. -Nickel was identified as the responsible allergen. -Chemical analysis confirmed the presence of metal contamination in the product. -Findings underscore the risk of allergic contact dermatitis from contaminated eye cosmetics.	Case report	[253]
Chronic kohl (lead-containing eyeliner) use treated with oral D-penicillamine	-Kohl use was associated with elevated conjunctival and serum lead levels and periocular hyperpigmentation. -Findings support lead-induced toxicity as a cause of periocular hyperpigmentation.	Single-group, non-randomized clinical trial	[238]
Silicone hydrogel contact lenses exposed to hand creams, makeup removers, and mascaras	-Makeup removers caused the greatest changes in lens diameter, sagittal depth, and base curve. -Waterproof mascaras reduced optical performance in several lens types. -Lens power remained unchanged. -Cleaning partially restored lens parameters, with variable effectiveness depending on cosmetic type.	In vitro experimental study	[249]
Twelve cosmetic make-up removers	-Corneal opacity and permeability test scores were not predictive of clinical signs and were mainly related to glycol and sodium lactate concentration. -The epithelial cell cytotoxicity assay correlated with the presence of surfactants. -Interleukin-8 release showed the strongest correlation with clinical irritation signs and appeared most sensitive for predicting mild irritancy.	Experimental in vitro study with clinical correlation	[53]
High-quality vs. low-quality cosmetic products, particularly mascara	-Most cosmetic samples showed microbial contamination. -Low-quality products demonstrated higher frequency and greater diversity of bacterial and fungal contamination than high-quality brands. Common bacteria included *Staphylococcus aureus*, *E. coli*, and other pathogenic species. -Fungal contamination was detected primarily in low-quality products.	In vitro study	[254]
Powdered eyeshadow use in a post-laser in situ keratomileusis (LASIK) patient	-Accidental mechanical trauma ("bumping") during eyeshadow application led to migration of cosmetic particles beneath the LASIK flap. -Cosmetic material entered the flap interface several years after surgery. -Highlights long-term vulnerability of the LASIK flap interface to external mechanical forces and cosmetic contamination.	Case report	[255]
Dermal filler	-Unilateral blindness occurred immediately after injection. -Permanent ocular tissue damage risk from inadvertent intravascular filler injection.	Case report	[256]
Periocular botulinum toxin A (BoNT-A) injections	-BoNT-A injections significantly worsened ocular surface parameters including tear break-up time (TBUT) and meibum expression, indicating worsened dry eye status.	Prospective clinical study	[257]

8. Discussion

The growing popularity of eye cosmetics reflects broader societal shifts toward aesthetic enhancement, personal expression, and evolving beauty standards. The periocular region plays a central role in facial communication and emotional expression, making it a primary focus of cosmetic application. The increased reliance on digital communication platforms and social media has further amplified attention to eye appearance, particularly during and following the COVID-19 pandemic, when facial masking accentuated the visual prominence of the eyes [258,259]. While cosmetic products provide important psychological, cultural, and aesthetic benefits, the evidence synthesized in this review highlights the complex relationship between cosmetic practices and ocular surface health. Importantly, this relationship now extends beyond topical products to include periocular aesthetic practices, which are increasingly integrated into modern beauty routines. The widespread use of eye cosmetics has made cosmetic-related ocular complications an increasingly important clinical issue [240]. Survey data from the United States indicate that approximately 65% of women are regular users of mascara and 62% regularly use eyeliner, reflecting the extensive daily exposure of the ocular surface to cosmetic products. Coupled with a 38% increase in eye cosmetic sales since 2004, these findings underscore that cosmetic-associated ocular surface complications represent a growing global concern affecting a large population of consumers [260].

Economic and industry trends further illustrate the growing importance of eye cosmetics. The global cosmetics market, valued in the hundreds of billions of US dollars, continues to grow steadily, with eye-focused products, including mascara, eyeliner, eyeshadow, and brow enhancers, accounting for approximately 15–20% of color cosmetic sales worldwide [261]. Fashion trends, digital marketing, and social media influence have further driven the demand for eye-enhancing products.

The ocular surface represents a uniquely delicate anatomical and physiological system that relies on the integrity of epithelial barriers, stable tear film dynamics, and coordinated eyelid and meibomian gland function. Unlike other skin surfaces, the eyelid margin and conjunctiva are directly exposed to both environmental stressors and cosmetic application, making them particularly susceptible to mechanical, chemical, and microbial insults. The collective literature demonstrates that ocular surface complications associated with cosmetic use rarely arise from a single factor but instead result from cumulative and multifactorial mechanisms. These include repeated mechanical irritation from cosmetic particles and applicators, direct epithelial toxicity from preservatives and pigments, and microbial contamination facilitated by prolonged product use and inadequate hygiene practices.

Importantly, modern cosmetic practices frequently involve application directly along or within the lid margin, an area critical for tear film stability and meibomian gland function. Disruption of this anatomical interface can interfere with lipid secretion, increase tear evaporation, and promote chronic inflammation, ultimately contributing to DED and blepharitis [1,262,263]. The widespread use of preservatives such as BAK and formaldehyde-releasing compounds further compounds this risk. Although these agents are essential for preventing microbial growth in non-sterile cosmetic products, substantial experimental evidence demonstrates their cytotoxic effects on corneal and conjunctival epithelial cells, as well as their potential to induce meibomian gland dysfunction even at low concentrations. Chronic exposure, therefore, represents a significant concern, particularly among individuals with pre-existing ocular surface disease or those using multiple cosmetic products simultaneously [264–266].

Another emerging issue involves the presence of trace heavy metals and particulate contaminants in cosmetic formulations. Several heavy metals have been detected in eye cosmetic formulations, including lead, arsenic, cadmium, mercury, nickel, chromium, and

cobalt. These substances may accumulate within periocular tissues over time, contributing to allergic sensitization, epithelial toxicity, and chronic inflammatory responses. In addition, cosmetic applicators and shared makeup products have been identified as reservoirs for microbial colonization, potentially altering the ocular microbiome and increasing susceptibility to infectious or parasitic conditions, including *Demodex* infestation [267,268]. The increasing popularity of cosmetic procedures such as eyelash extensions and periocular tattooing introduces additional mechanical and toxicological risks, with reported complications ranging from allergic dermatitis to severe infectious keratitis [269]. Notably, a nationwide Japanese survey reported ocular complications in 26.8% of women following eyelash extension procedures [270], whereas another clinical study found that 54% of users experienced ocular adverse effects, including itching (38%), eyelid swelling (6%), red eyes (34%), burning sensation (24%), and heavy eyelids (34%). Furthermore, a literature review demonstrated that allergic blepharitis accounted for approximately 79% of reported eyelash extension-related complications, highlighting that these adverse events are relatively common rather than isolated occurrences.

In parallel with these cosmetic trends, surgical and minimally invasive periocular aesthetic procedures, including upper and lower eyelid blepharoplasty, eyelid tightening procedures, cosmetic ptosis correction, canthoplasty, and lower eyelid fat repositioning, have gained substantial global popularity as part of facial rejuvenation strategies [271–273]. While these interventions aim to improve periocular appearance and restore youthful eyelid contour, they may inadvertently alter eyelid anatomy, blink dynamics, eyelid closure, and tear distribution, potentially predisposing individuals to lagophthalmos, exposure keratopathy, meibomian gland dysfunction, and exacerbation of pre-existing DED [274,275]. Additionally, the growing demand for non-surgical aesthetic treatments such as BoNT injections, periocular dermal fillers, PRP-based rejuvenation, lash lifting and perming, and semi-permanent cosmetic microblading has expanded patient exposure to chemical agents, adhesives, and injectable biomaterials around the ocular surface [276]. Although widely perceived as safe and convenient, these procedures have been associated with impaired lacrimal pump function, mechanical obstruction of meibomian gland orifices, inflammatory responses, and alterations in tear film stability [17,61]. According to the International Society of Aesthetic Plastic Surgery (ISAPS), BoNT injections remain the most frequently performed non-surgical cosmetic procedure worldwide, with more than 8.8 million treatments performed annually, while hyaluronic acid filler injections exceed 5.5 million procedures each year. Although serious ophthalmic complications are uncommon, the enormous procedural volume means that even rare adverse events translate into a considerable number of affected patients worldwide, emphasizing the need for greater clinician awareness and preventive strategies [56,277,278]. The increasing integration of combination aesthetic procedures further highlights the need for comprehensive ocular surface evaluation and multidisciplinary collaboration to balance cosmetic outcomes with functional ocular safety [279].

Regional market dynamics further emphasize the importance of eye cosmetics in contemporary consumer behavior. The Korean beauty (K-beauty) industry has emerged as a global trendsetter, strongly influencing international cosmetic preferences through innovation, product diversification, and targeted marketing strategies. South Korea represents one of the most advanced cosmetic markets in Asia, characterized by rapid product development and strong consumer demand for eye-enhancing products. K-beauty trends emphasize long-lasting, waterproof, and multifunctional eye cosmetic formulations designed to withstand humid environmental conditions and prolonged mask usage, which may increase cumulative ocular surface exposure to cosmetic ingredients. The global popularity of K-beauty products has contributed to increased adoption of elaborate eye

makeup routines worldwide, further reinforcing the need to evaluate ocular safety in the context of evolving cosmetic technologies and usage patterns [280].

From a clinical perspective, cosmetic periocular aesthetic practices represent an under-recognized yet modifiable contributor to ocular surface disease. Many patients may not volunteer information regarding cosmetic practices unless specifically questioned. Incorporating detailed cosmetic history into routine ocular surface evaluation can provide valuable diagnostic insights and improve treatment outcomes. Furthermore, effective management of cosmetic-related ocular complications requires interdisciplinary collaboration among ophthalmologists, dermatologists, and cosmetic specialists to address both medical and aesthetic concerns [17,271]. In addition, patient education regarding safe application techniques, adherence to product hygiene, routine replacement of cosmetics, and avoidance of high-risk practices should be systematically integrated into ocular surface disease management protocols. Figure 4 illustrates practical hygiene and preventive measures designed to reduce ocular surface complications associated with eye cosmetic use, including proper cleaning of applicators, avoiding shared products, discarding expired cosmetics, and minimizing periocular contamination [281]. Collectively, these measures provide a structured framework to balance aesthetic goals with ocular safety.



Figure 4. Safety recommendations for the hygienic use of eye cosmetics and aesthetic practices. Illustration outlining important hygiene and preventive measures to reduce ocular complications related to periocular cosmetic use.

Beyond potential adverse effects, it is important to acknowledge the significant aesthetic, psychological, and social value of eye cosmetics. Cosmetic enhancement of the periocular region has long been associated with cultural identity, self-expression, and improved self-confidence [282]. Modern eye cosmetic products, including mascaras, eyeliners, eyeshadows, brow enhancers, and eyelash extensions, allow individuals to emphasize eye shape, improve symmetry, and create a more youthful and expressive appearance. Several studies have demonstrated that cosmetic use can positively influence self-esteem, social perception, and overall quality of life, particularly among individuals who perceive periocular aging or facial asymmetry [61,283]. Additionally, in certain clinical settings, cosmetic products may provide psychosocial benefits for patients recovering from ocular or facial disorders by helping restore appearance and emotional well-being. Therefore, eye cosmetics should not be viewed solely as potential risk factors but rather as tools that contribute to personal identity and aesthetic satisfaction when used appropriately and safely [282–284].

Overall, while eye cosmetics offer clear aesthetic benefits, their frequent and long-term use can pose meaningful risks to ocular health. Managing cosmetic-related eye complications requires collaboration between ophthalmologists and dermatologists. Greater consumer awareness, stricter ingredient regulation, and improved product safety standards are essential to reduce avoidable ocular surface damage while maintaining cosmetic use as a safe daily practice [271].

9. Conclusions and Future Perspectives

Eye cosmetics have become an integral component of modern self-care, cultural expression, and aesthetic enhancement. Products such as mascara, eyeliner, eyeshadow, eyelash extensions, cosmetic tattoos, and makeup removal products are widely used to improve periocular appearance and self-confidence. In parallel, periocular aesthetic practices, including minimally invasive procedures such as Botox injections, dermal fillers, and PRP, have further expanded the landscape of eye enhancement. The evidence summarized in this review demonstrates that, while these products provide substantial psychosocial and aesthetic benefits, their repeated and prolonged use can influence ocular surface homeostasis through mechanical, chemical, and microbiological pathways. Cosmetic application near the lid margin, chronic exposure to preservatives and pigments, and evolving aesthetic procedures collectively represent modifiable contributors to ocular surface disorders [285].

A critical observation emerging from current literature is the disparity between the widespread use of eye cosmetics and periocular aesthetic practices and the relatively limited consumer awareness of potential ocular health implications. Cosmetic selection is frequently influenced by aesthetic appeal, cost, and social media trends rather than safety considerations or ingredient transparency. This highlights the need for improved public education and more active engagement from eye care professionals in counseling patients regarding safe cosmetic practices. Routine clinical evaluation should increasingly incorporate detailed cosmetic history-taking, as identification of cosmetic-related exposures may improve diagnostic accuracy and support individualized management of ocular surface disease.

Future research should focus on strengthening the scientific foundation guiding cosmetic safety and periocular aesthetic practices. Long-term clinical studies evaluating cumulative exposure, dose–response relationships, and interactions with pre-existing ocular surface conditions are essential to better define risk profiles. The development of advanced in vitro, ex vivo, and translational models that accurately simulate the corneal, conjunctival, and meibomian gland microenvironment will further enhance preclinical safety testing and facilitate mechanistic understanding of cosmetic-induced ocular changes.

Regulatory frameworks governing eye cosmetics and periocular aesthetic practices may also benefit from reassessment. Given the unique vulnerability of the ocular surface and the frequent application of cosmetic products near the lid margin, stronger regulatory oversight, clearer labeling standards, and improved ingredient disclosure are warranted. Establishing ocular-specific safety thresholds and encouraging the development of preservative-minimized or biocompatible formulations may significantly reduce preventable ocular complications [61,283].

Innovation within the cosmetic industry presents an important opportunity to enhance product safety without compromising performance or consumer satisfaction. Advances in formulation chemistry, alternative preservation strategies, safer pigment technologies, and contamination-resistant packaging systems hold promise for improving ocular tolerability. Collaboration between academic researchers, clinicians, regulatory agencies, and cosmetic manufacturers will be essential for translating scientific evidence into safer consumer products [1,286–288].

In summary, eye cosmetics represent a dynamic intersection between modern aesthetic practice and ocular health. Promoting safer cosmetic use requires coordinated efforts in research, regulation, clinical awareness, and consumer education. By integrating these approaches, it is possible to support aesthetic expression while preserving long-term ocular surface integrity and visual well-being.

Author Contributions: Conceptualization and methodology, J.-Y.K. and B.B.; writing, B.B.; data acquisition B.B., K.S.E., H.S.C., S.S.K., H.L. and J.-Y.K. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science, and Technology (MEST) (NRF-2022R1F1A1073895), and by a grant (2026IF0010) from the Asan Institute for Life Sciences, Seoul, Republic of Korea.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Acknowledgments: During the preparation of this manuscript, the authors used ChatGPT (OpenAI, version GPT-4) for language editing and grammatical improvement. The authors have carefully reviewed and edited the output and take full responsibility for the content of this publication. No AI tools were used for the creation or generation of any figure in this manuscript.

Conflicts of Interest: The authors declares no conflicts of interest.

Abbreviations

PRP	Platelet-rich plasma
EEs	Eyelash extensions
EC	European commission
PGAs	Prostaglandin analogs
BoNT	Botulinum toxin
BAK	Benzalkonium chloride
PMMA	Polymethyl methacrylate
HEMA	Hydroxyethyl methacrylate
DED	Dry eye diseases
OSDI	Ocular surface disease index
MMPs	Matrix metalloproteinases

TBUT	Tear break-up time
PPD	P-phenylenediamine
CPM	Cosmetic product material
LASIK	Laser-assisted in situ keratomileusis

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