SKIN INFLAMMAGING : BIOLOGICAL MECHANISMS AND CONTEMPORARY DERMATOLOGICAL AND COSMETIC APPROACHES

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Abstract: Purpose:Skin aging is a multifactorial biological process influenced by intrinsic mechanisms and extrinsic environmental factors, with chronic low-grade inflammation increasingly recognized as a central driver of age-related cutaneous changes. This review aims to analyze the role of skin inflammaging in the aging process and to examine contemporary dermatological and cosmetic approaches for its prevention and management.
Materials and Methods: A narrative literature review was conducted in February 2026 using Web of Science, Scopus, EBSCOhost, and Google Scholar. Publications from January 2010 to February 2026 were screened using keywords related to inflammaging, chronic inflammation, skin aging, oxidative stress, cellular senescence, and anti-aging dermatological and cosmetic interventions. The inclusion criteria comprised full-text articles published in English or Bulgarian in peer-reviewed journals. A total of 37 full-text publications were included in the review.
Results: The findings indicate that skin inflammaging contributes to skin aging through interconnected mechanisms such as oxidative stress, epidermal barrier dysfunction, extracellular matrix degradation, immune dysregulation, and cellular senescence. The reviewed literature also highlights the growing role of topical anti-inflammatory and antioxidant agents, retinoids, peptides, barrier-repair formulations, advanced delivery systems, and dermatological procedures in targeting these mechanisms.
Conclusions: Skin aging is a complex biological process with both local and systemic implications, in which inflammaging plays a central role. Current dermatological and cosmetic approaches show promising potential in modulating these processes. Future research should focus on biomarker identification, standardized clinical protocols, and personalized strategies for the prevention and management of skin inflammaging.
Keywords: inflammaging, skin aging, chronic inflammation, oxidative stress, cellular senescence, epidermal barrier, dermatology, anti-aging

1. INTRODUCTION

Context and Importance of the Problem

Skin aging is a complex, multifactorial process resulting from the interaction between intrinsic biological mechanisms and extrinsic environmental influences, including ultraviolet radiation, pollution, and lifestyle factors. In recent years, the concept of inflammaging has emerged as a key framework for understanding age-related changes in the skin, referring to a state of chronic, low-grade inflammation that contributes to tissue dysfunction and degeneration over time (Ferrucci & Fabbri, 2018; López-Otín et al., 2013). Within the skin, inflammaging is closely associated with immune dysregulation, increased production of pro-inflammatory cytokines, and the accumulation of senescent cells, all of which disrupt cellular homeostasis and impair regenerative capacity (Nguyen & Soulika, 2019; Tilstra et al., 2011). At the molecular level, processes such as oxidative stress, mitochondrial dysfunction, and activation of inflammatory signaling pathways, including NF-κB, further amplify tissue damage and accelerate aging (Rinnerthaler et al., 2015; Wang et al., 2019). The skin's barrier function, primarily mediated by the stratum corneum, plays a critical role in maintaining hydration and protecting against external stressors (Baroni et al., 2012). However, age-related impairment of this barrier may trigger inflammatory responses and contribute to systemic inflammation (Hu et al., 2017). Moreover, chronic exposure to ultraviolet radiation induces both oxidative stress and inflammation, leading to collagen degradation, elastin fragmentation, and pigmentation changes characteristic of photoaging (Ansary et al., 2021; Rittié & Fisher, 2015). These interconnected mechanisms emphasize the importance of understanding inflammaging not only as a driver of visible skin aging but also as a broader biological process with implications for overall health, thereby underscoring the need for integrative dermatological and cosmetic strategies aimed at prevention and intervention.

The growing significance of inflammaging in the context of skin aging reflects not only its impact on aesthetic appearance but also its broader implications for health and quality of life. As the global population ages, the prevalence of age-related skin changes and chronic inflammatory conditions continues to increase, placing a

substantial burden on healthcare systems and dermatological practice. The skin, as the largest organ and the primary barrier against environmental stressors, plays a crucial role in maintaining homeostasis; therefore, its dysfunction can contribute to systemic inflammation and the progression of chronic diseases (Ferrucci & Fabbri, 2018; Hu et al., 2017). Inflammaging has been linked to key pathological processes, including oxidative damage, immune dysregulation, and impaired tissue repair, which not only accelerate visible aging but also increase susceptibility to dermatological disorders such as atopic dermatitis, psoriasis, and delayed wound healing (Nguyen & Soulika, 2019; Tsakok et al., 2019). Furthermore, the interaction between environmental exposures, lifestyle factors, and biological aging mechanisms highlights the need for comprehensive and preventive approaches. Addressing inflammaging is therefore essential not only for improving skin health and appearance but also for mitigating its systemic consequences, making it a critical focus of contemporary dermatological and cosmetic research.

Aim

The aim of this review is to provide a comprehensive analysis of the biological mechanisms underlying skin inflammaging and to evaluate current dermatological and cosmetic approaches for its prevention and management.

Objectives

- To examine the key molecular and cellular mechanisms involved in skin inflammaging, including oxidative stress, extracellular matrix degradation, epidermal barrier dysfunction, and cellular senescence.
- To critically evaluate contemporary dermatological and cosmetic interventions targeting inflammaging, with emphasis on topical agents, advanced delivery systems, and clinical procedures.

2. MATERIALS AND METHODS

This study was designed as a narrative literature review. Scientific publications addressing the role of inflammaging in skin aging and contemporary dermatological and cosmetic approaches were analyzed. The literature search was conducted in February 2026 using the following electronic databases: Web of Science, Scopus, EBSCOhost, and Google Scholar. Two groups of keywords and search terms were applied. The first group focused on inflammaging and its underlying biological mechanisms and included the following terms: *inflammaging, chronic inflammation, skin aging, intrinsic aging, extrinsic aging, oxidative stress, reactive oxygen species, collagen degradation, elastin degradation, matrix metalloproteinases, telomere shortening, and cellular senescence*. The second group of keywords was related to dermatological and cosmetic approaches to skin aging and included the following terms: *dermatology, skin aging treatment, anti-aging skincare, topical treatments, niacinamide, antioxidants, peptides, retinoids, exosomes, drug delivery systems, dermatological procedures, laser therapy, microneedling, and skin rejuvenation*.

The search period covered publications published between January 2010 and February 2026. No geographical restrictions were applied. However, particular attention was given to studies conducted in European countries to ensure both comprehensiveness and regional relevance.

The inclusion criteria comprised: (1) availability of full-text articles; (2) publications in English or Bulgarian; (3) articles published in peer-reviewed scientific journals; and (4) studies explicitly addressing the selected keywords and the review topic.

Titles, abstracts, keywords, and reference lists of the identified publications were systematically screened. Additional relevant studies were identified through backward reference searching. Data extraction included information on study design, research objectives, study population or experimental models, main outcomes, and methodological characteristics relevant to the review objectives.

3. RESULTS

The search resulted in 37 full-text articles (Table 1).

Table 1. Publications on the topic for the period 2010-2026, included in the review

Year	Author	Design	Aim of the study	Sample
2021	Ansary et al.	Review	To examine inflammatory molecules associated with UV radiation-mediated skin aging	Not applicable
2012	Baroni et al.	Review	To discuss epidermal structure and function related to barrier properties	Not applicable
2019	Barth et al.	Comparative biological study	To identify conserved aging-related signatures of senescence and inflammation across tissues and species	Different tissues and species
2021	Bollag	Commentary/short	To discuss reduced calcium-	Aged mice and humans

		communication	sensing receptor expression in aged keratinocytes and skin	
2013	Bourguignon et al.	Experimental study	To investigate how hyaluronan-CD44 and RhoGTPase signaling affect keratinocyte function and age-related epidermal dysfunction	Keratinocytes/epidermal models
2021	Celli et al.	Original research	To investigate how reduced calcium-sensing receptor expression affects calcium signaling and adhesion in aged skin	Aged skin/cell models
2013	Dowlatshahi et al.	Systematic review and meta-analysis	To evaluate markers of systemic inflammation in psoriasis	Psoriasis studies/patients
2022	Elias	Commentary	To comment on the role of barrier function in aging and inflammaging	Not applicable
2013	Farage et al.	Review	To describe the characteristics of aging skin	Not applicable
2018	Ferrucci & Fabbri	Review	To discuss inflammageing in aging, cardiovascular disease, and frailty	Not applicable
2023	Gravel et al.	Experimental study	To investigate how PGC-1s regulate epidermal physiology, proliferation, and differentiation	Epidermal/keratinocyte models
2021	Gromkowska-Kepka et al.	Review of in vitro studies	To review in vitro evidence on UV radiation and skin photoaging	In vitro studies
2019	Ho & Kupper	Review	To review T-cell functions in skin immunity and inflammatory skin disorders	Not applicable
2022	Horiba et al.	Original research	To investigate macrophage imbalance and inflammaging in sun-exposed human skin	Human skin samples
2017	Hu et al.	Original research	To determine whether epidermal dysfunction increases serum inflammatory cytokines with age	Age-associated models/humans
2020	Jiang et al.	Review	To examine the role of keratinocytes in cutaneous immune responses	Not applicable
2023	Liu et al.	Review	To discuss oxidative stress-induced senescence, inflammation, and cancer in skin and the therapeutic role of polyphenols	Not applicable
2013	López-Otín et al.	Review	To define the hallmarks of aging	Not applicable
2023	López-Otín et al.	Review	To update and expand the hallmarks of aging	Not applicable
2019	Man & Elias	Commentary	To discuss whether inflammaging and its sequelae can be prevented or mitigated	Not applicable
2012	Menon et al.	Review	To describe the structure and function of the stratum corneum	Not applicable
2019	Nguyen & Soulika	Review	To review the dynamics of the skin immune system	Not applicable
2022	Papaccio et al.	Review	To examine the contribution of oxidative stress to skin aging	Not applicable
2015	Rinnerthaler et al.	Review	To review oxidative stress in aging human skin	Not applicable

2015	Rittie & Fisher	Review	To review natural and sun-induced aging of human skin	Not applicable
2020	Russell-Goldman & Murphy	Review	To provide new insights into the pathobiology of skin aging	Not applicable
2019	Shin et al.	Review	To review molecular mechanisms of dermal aging and antiaging approaches	Not applicable
2019	Wang et al.	Review	To review NF-kappaB signaling in skin aging	Not applicable
2023	Yang et al.	Original research	To assess the correlation between stratum corneum hydration and serum cytokines in the elderly	Elderly participants
2011	Tilstra et al.	Review	To review NF-kappaB in aging and disease	Not applicable
2019	Tsakok et al.	Review	To discuss atopic dermatitis with emphasis on the skin barrier and beyond	Not applicable
2021	Wong & Chew	Systematic review and meta-analysis	To define skin aging and its risk factors	Included studies from systematic review
2019	Ye et al.	Pilot clinical study	To test whether topical emollient application reduces circulating pro-inflammatory cytokines in aged humans	Chronically aged humans
2023	Agrawal et al.	Review	To examine the role of skin in inflamm-aging and barrier dysfunction	Not applicable
2024	Hussein et al.	Review	To discuss biological, environmental, and therapeutic influences on skin and intrinsic aging	Not applicable
2025	Naharro-Rodríguez et al.	Review	To review mechanisms, markers, and modern therapies in skin aging	Not applicable
2025	Xu et al.	In vitro experimental study	To present a novel in vitro model of skin inflammaging	In vitro model

Source: Prepared by the authors based on the reviewed publications.

The analysis of the 37 included studies demonstrates that the literature on inflammaging and skin aging published between 2010 and 2026 is dominated by review-based evidence. Narrative and integrative reviews establish the conceptual foundation in areas such as epidermal barrier biology, oxidative stress, immune dysregulation, dermal and epidermal aging mechanisms, and therapeutic strategies (Agrawal et al., 2023; Ferrucci & Fabbri, 2018; Naharro-Rodríguez et al., 2025; Shin et al., 2019). Commentaries and focused papers further emphasize epidermal barrier dysfunction, calcium signaling, and inflammaging as central mechanisms in age-related skin decline (Bollag, 2021; Elias, 2022; Man & Elias, 2019).

Original and experimental studies provide mechanistic support for the roles of keratinocytes, fibroblasts, macrophages, and epidermal signaling pathways in skin aging and inflammaging. These investigations examine senescence, calcium signaling, keratinocyte function, macrophage imbalance, epidermal physiology, and novel in vitro models (Barth et al., 2019; Bourguignon et al., 2013; Celli et al., 2021; Gravel et al., 2023; Horiba et al., 2022; Xu et al., 2025). Clinical and evidence-synthesis studies extend this evidence to systemic inflammation, psoriasis-related comorbidity, age-associated cytokine changes, and the effects of barrier-repair interventions (Dowlatshahi et al., 2013; Hu et al., 2017; Wong & Chew, 2021; Ye et al., 2019).

Higher-level evidence is represented by systematic reviews and meta-analyses that synthesize associations between inflammatory skin conditions, systemic inflammation, cardiovascular risk, and broader determinants of skin aging (Dowlatshahi et al., 2013; Wong & Chew, 2021).

Recent publications from 2023 to 2025 emphasize updated hallmarks of aging, inflammaging-specific conceptual models, contemporary therapies, and translational relevance (Agrawal et al., 2023; Hussein et al., 2024; López-Otín et al., 2023; Naharro-Rodríguez et al., 2025; Xu et al., 2025).

The distribution of study designs shows that the available evidence is broad and multidisciplinary, with review articles forming the conceptual foundation, experimental and original studies providing mechanistic depth, and clinical, epidemiological, and evidence-synthesis studies supporting the relevance of inflammaging to both dermatological science and practical skin care.

The reviewed publications addressed the following major thematic areas:

Biological Basis of Inflammaging

Inflammaging is recognized as a chronic, low-grade inflammatory state that develops with advancing age and affects both systemic and cutaneous physiology. It is characterized by increased levels of pro-inflammatory cytokines, immune system dysregulation, and the accumulation of senescent cells that secrete inflammatory mediators. In the skin, these processes are closely linked to alterations in keratinocyte and fibroblast function, as well as to impaired regenerative capacity. Key molecular pathways involved in inflammaging include NF-κB signaling, inflammasome activation, and mitochondrial dysfunction, all of which contribute to sustained inflammatory responses and tissue damage (Agrawal et al., 2023; Ferrucci & Fabbri, 2018; López-Otín et al., 2013; Tilstra et al., 2011; Wang et al., 2019).

Mechanisms Linking Inflammation to Skin Aging

Chronic Inflammation and Skin Homeostasis Disruption

Persistent inflammatory signaling disrupts skin homeostasis by altering the function of keratinocytes and dermal fibroblasts. This leads to impaired cellular communication, reduced proliferative capacity, and dysregulated extracellular matrix production, which collectively contribute to visible signs of aging such as wrinkles and loss of elasticity. Chronic inflammation also enhances the secretion of cytokines and proteolytic enzymes, further exacerbating tissue damage (Ho & Kupper, 2019; Jiang et al., 2020).

Impaired Skin Barrier Function

Inflammation plays a central role in disrupting the epidermal barrier, which is essential for maintaining hydration and protecting against environmental insults. Age-related decline in barrier function is associated with increased transepidermal water loss, altered lipid composition, and heightened susceptibility to irritation and infection. This barrier dysfunction can further amplify inflammatory responses, creating a self-perpetuating cycle that contributes to inflammaging (Baroni et al., 2012; Elias, 2022; Hu et al., 2017; Menon et al., 2012).

Oxidative Stress and Reactive Oxygen Species (ROS)

Chronic inflammation is closely associated with increased production of reactive oxygen species (ROS), which induce oxidative stress and damage cellular components such as DNA, proteins, and lipids. This oxidative burden accelerates aging processes by activating signaling pathways involved in inflammation and apoptosis. In the skin, oxidative stress is a key mediator linking environmental exposures, such as UV radiation, to structural and functional deterioration (Liu et al., 2023; Papaccio et al., 2022; Rinnerthaler et al., 2015).

Degradation of Collagen and Elastin

Inflammatory mediators stimulate the expression of matrix metalloproteinases (MMPs), which degrade collagen and elastin fibers in the dermal extracellular matrix. This degradation leads to reduced skin firmness, elasticity, and structural integrity. The imbalance between matrix synthesis and degradation is a hallmark of both intrinsic aging and photoaging, and is strongly influenced by inflammatory signaling pathways (Ansary et al., 2021; Rittié & Fisher, 2015; Shin et al., 2019).

Pigmentation and Photoaging

Ultraviolet (UV) radiation induces inflammatory responses that stimulate melanogenesis and contribute to uneven pigmentation, a characteristic feature of photoaging. Inflammation-driven signaling pathways influence melanocyte activity and pigment distribution, leading to age spots and dyschromia. These changes are often accompanied by structural damage to the skin, further highlighting the role of inflammation in photoaging processes (Gromkowska-Kepka et al., 2021; Rittié & Fisher, 2015).

Telomere Shortening and Cellular Senescence

Chronic inflammation accelerates telomere shortening and promotes cellular senescence, limiting the replicative potential of skin cells. Senescent cells accumulate in aged skin and secrete pro-inflammatory factors, reinforcing the inflammaging phenotype. This process contributes to impaired tissue repair, reduced regenerative capacity, and the progression of age-related skin changes (Barth et al., 2019; Liu et al., 2023; López-Otín et al., 2013).

Current Cosmetic Approaches Targeting Inflammaging

Topical Anti-inflammatory and Barrier-repair Agents

Topical formulations containing anti-inflammatory and barrier-repair ingredients, such as niacinamide, play a key role in mitigating inflammaging. These agents help restore epidermal integrity, reduce cytokine production, and improve skin hydration, thereby breaking the cycle of inflammation and barrier dysfunction (Man & Elias, 2019; Ye et al., 2019).

Antioxidants

Antioxidants such as vitamin C, vitamin E, and plant-derived polyphenols are widely used to counteract oxidative stress in the skin. By neutralizing ROS, these compounds protect cellular structures, reduce

inflammation, and support skin repair mechanisms, making them essential components of anti-aging skincare strategies (Liu et al., 2023; Papaccio et al., 2022).

Peptides and Growth Factors

Peptides and growth factors are increasingly incorporated into cosmetic formulations due to their ability to stimulate collagen synthesis and modulate inflammatory responses. They act as signaling molecules that enhance skin regeneration and improve dermal structure, contributing to the reduction of visible aging signs (Shin et al., 2019).

Retinoids

Retinoids are among the most well-established anti-aging agents, known for their ability to regulate cell turnover, stimulate collagen production, and reduce inflammation. Their multifaceted effects make them a cornerstone in both cosmetic and dermatological approaches to skin aging (Rittié & Fisher, 2015; Shin et al., 2019).

Emerging Delivery Systems (e.g., Exosome-based Technologies)

Innovative delivery systems, including exosome-based technologies, have emerged as promising tools for enhancing the efficacy of active ingredients. These systems improve penetration, stability, and targeted delivery, enabling more precise modulation of inflammatory pathways and skin regeneration processes (Naharro-Rodríguez et al., 2025; Xu et al., 2025).

Dermatological and Clinical Interventions

Dermatological procedures such as chemical peels, laser therapies, microneedling, and other energy-based devices are widely used to target inflammaging and promote skin rejuvenation. These interventions stimulate dermal remodeling, enhance collagen production, and reduce inflammatory mediators, thereby improving both the structural and functional properties of aging skin (Russell-Goldman & Murphy, 2020; Shin et al., 2019).

Multilevel and Personalized Approaches to Skin Aging

Contemporary approaches to skin aging emphasize multilevel and personalized strategies that integrate topical treatments, clinical procedures, and lifestyle modifications. Factors such as genetic predisposition, skin type, environmental exposures, and individual inflammatory profiles are increasingly considered in designing tailored interventions. This personalized perspective reflects a shift toward precision dermatology and more effective long-term management of skin aging (Hussein et al., 2024; Wong & Chew, 2021).

4. DISCUSSION

The findings of the present review highlight several consistent and interrelated trends in the contemporary literature on inflammaging and skin aging. First, there is a clear shift toward understanding skin aging not merely as a localized, aesthetic concern but as a complex biological process driven by chronic, low-grade inflammation with systemic implications. The concept of inflammaging has emerged as a unifying framework that integrates molecular, cellular, and clinical perspectives, linking immune dysregulation, oxidative stress, and cellular senescence to both cutaneous and systemic aging processes (Agrawal et al., 2023; Ferrucci & Fabbri, 2018; López-Otín et al., 2023). This paradigm reflects a broader movement in biomedical research toward recognizing inflammation as a central mechanism underlying age-related decline.

A second important trend is the increasing emphasis on the epidermal barrier as a critical regulator of both local and systemic inflammation. The reviewed studies consistently demonstrate that age-related impairment of barrier function contributes not only to skin dryness and increased permeability but also to elevated levels of circulating inflammatory mediators. This has led to the recognition of the skin as an active participant in systemic inflammaging, rather than a passive target of aging processes (Elias, 2022; Hu et al., 2017; Yang et al., 2023). Consequently, maintaining or restoring barrier integrity is increasingly viewed as a key therapeutic target.

Another dominant theme in the literature is the central role of oxidative stress and its interaction with inflammatory pathways. Reactive oxygen species are consistently identified as mediators that amplify inflammatory signaling, damage cellular components, and accelerate extracellular matrix degradation. This interaction is particularly evident in the context of photoaging, where ultraviolet radiation induces both oxidative stress and inflammatory responses, leading to collagen breakdown, elastin fragmentation, and pigmentation changes (Ansary et al., 2021; Papaccio et al., 2022; Rinnerthaler et al., 2015). The convergence of oxidative and inflammatory mechanisms underscores the multifactorial nature of skin aging.

The literature also reflects a growing body of mechanistic evidence derived from experimental and translational studies. These investigations provide detailed insights into the roles of keratinocytes, fibroblasts, immune cells, and signaling pathways such as NF-κB, cytokine networks, and mitochondrial dysfunction in driving inflammaging-related changes (Horiba et al., 2022; Jiang et al., 2020; Tilstra et al., 2011). Notably, recent studies have begun to explore novel models, including in vitro systems of skin inflammaging, which offer new opportunities for studying disease mechanisms and testing therapeutic interventions (Xu et al., 2025).

In parallel with advances in pathophysiological understanding, the literature demonstrates a significant expansion of therapeutic and preventive strategies. There is a strong focus on topical agents with anti-inflammatory and antioxidant properties, such as niacinamide, retinoids, peptides, and polyphenols, which target

multiple pathways involved in skin aging. At the same time, dermatological procedures, including laser therapies and microneedling, are increasingly recognized for their ability to stimulate dermal remodeling and modulate inflammatory responses (Russell-Goldman & Murphy, 2020; Shin et al., 2019). Emerging technologies, particularly advanced delivery systems and exosome-based approaches, represent a promising frontier in enhancing treatment efficacy and specificity (Naharro-Rodríguez et al., 2025).

Finally, an important trend is the movement toward integrative and personalized approaches to skin aging. The reviewed studies suggest that effective management of inflammaging requires the combination of topical, procedural, and lifestyle interventions tailored to individual characteristics, including genetic background, environmental exposures, and inflammatory status. This reflects the broader shift toward precision medicine and highlights the need for individualized strategies in dermatology and cosmetic science (Hussein et al., 2024; Wong & Chew, 2021).

Overall, the literature demonstrates a transition from descriptive observations of skin aging to a more comprehensive, mechanism-based understanding that integrates inflammation, barrier function, oxidative stress, and cellular senescence. Despite these advances, gaps remain in translating molecular insights into standardized clinical protocols, and further research is needed to validate emerging therapies and optimize personalized treatment approaches.

5. CONCLUSION

The study shows that inflammaging represents a central and integrative mechanism in skin aging, linking chronic low-grade inflammation with key structural and functional alterations such as impaired barrier integrity, oxidative stress, extracellular matrix degradation, and cellular senescence. The reviewed literature demonstrates that skin aging is not solely a superficial or cosmetic process, but rather a complex, biologically driven phenomenon with both local and systemic implications. The evidence highlights the active role of the skin as an immunological and metabolic organ that contributes to the overall inflammatory burden associated with aging.

A key trend is the growing shift toward mechanism-based and multidisciplinary approaches that combine insights from molecular biology, immunology, and clinical dermatology. The literature increasingly emphasizes the importance of targeting inflammation, restoring barrier function, and reducing oxidative stress through both cosmetic and dermatological strategies. In parallel, there is a clear movement toward personalized and multilevel care models, integrating topical treatments, procedural interventions, and lifestyle factors, as well as the development of innovative technologies such as advanced delivery systems and exosome-based therapies.

There is a need to further bridge the gap between experimental research and clinical application by developing standardized, evidence-based protocols for the prevention and management of inflammaging-related skin changes. Future research should focus on identifying reliable biomarkers, improving the understanding of individual variability in aging processes, and evaluating the long-term efficacy and safety of emerging therapies. Additionally, greater emphasis should be placed on personalized approaches that account for genetic, environmental, and lifestyle factors in order to optimize outcomes in both dermatological practice and cosmetic science.

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