# Harnessing Commensal Microflora: A New Paradigm for Minimising Scarring and Inflammation in Medical Aesthetic Procedures - A Systematic Review

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***Abstract*:** Medical aesthetic procedures have become a common practice in the medical field and, post-operative inflammation and scarring are some of the major issues that adversely affect the recovery process and patient satisfaction. Recent developments in microbiome studies have demonstrated the possible importance of commensal microflora as a way to decrease immune reactions, repairing tissues and ensuring homeostasis of the skin. The elicitation of useful microbial communities has, therefore, become a promising treatment approach to support recovery after skin injury.

This literature review was a systematic study to identify the research topic, the role of commensal microflora in the minimisation of inflammation and scar reduction during medical aesthetic procedures. A systemic search of the peer-reviewed literature published since 2020 but not earlier was carried out in several scientific databases. A total of fifteen articles were eligible to meet the inclusion criteria and included research of quantitative, qualitative and mixed-methods. The articles included researched microbial-host interactions, microbiome-derived therapies, wound healing processes, strategies to prevent scarring and patient experience of recovery.

The results also showed that commensal microflora have a great role in skin homeostasis in terms of immune reaction regulation and microbial balance regulation. Some of the studies described the presence of anti-inflammatory effects in relation to the positive microorganisms, probiotics and postbiotics and the ability to maintain controlled healing conditions. There were also indications that microbial communities mediate wound healing by communicating with regenerative pathways and tissue repair mechanisms. The development of new therapeutic methods, such as designed commensal bacteria, also provided evidence that they could be used to deliver bioactive compounds with an ability to improve the process of healing. Also, qualitative and mixed-method studies demonstrated the great physical, psychological and social effects of scarring, with the need to focus on the type of interventions that can enhance the recovery and cosmetic results.

Overall, the review indicates that commensal microflora is a crucial part of skin wellbeing, and can offer innovative opportunities in eliminating inflammation and scarring after medical cosmetic surgery. Despite the need to conduct more clinical trials to determine causal therapeutic uses, microbiome-based approaches have a strong potential of improving the quality of healing, achieve better aesthetic results and aiding patient-centred care in regenerative and aesthetic medicine.

## I. Introduction

Aesthetic medical procedures have experienced impressive development over the past two decades, and are now becoming a significant aspect of modern medical care and cosmetic practice. Laser resurfacing, micro

needle treatments, chemical peels, dermal filler injections and other minimally invasive skin rejuvenation techniques are commonly used today to look better, combat ageing, and beautify the skin as a whole (Al-Taweel et al., 2025). Although such interventions are conventionally regarded to be safe and effective, they cause controlled tissue damage as a component of therapeutic process. The efficacy of such procedures is thus relied upon not completely on the treatment itself but on the biologic processes that regulate the healing process after the procedure. The importance of inflammation, tissue regeneration and extracellular matrix remodelling is significant determinants of clinical outcomes, which impact patient satisfaction and long-term aesthetic outcomes.

Aesthetic intervention is followed by a complex wound-healing response of the skin, characterised by overlapping inflammatory, proliferative, and remodelling processes (Chaurpagar et al., 2025). The nature of tissue repair largely depends on a well-controlled inflammatory response; over inflammation or prolonged inflammation can disrupt normal repair process and lead to undesirable outcomes. Chronic inflammation might lead to more tissue destruction, slow healing, encourage fibrosis and eventual formation of scar tissue. Even though the rate of complication has decreased due to development of better methods of procedure and after treatment, inflammation and scarring are still high concerns to both clinicians and patients. These complications prevention has thus become a major focus within aesthetic medicine and new approaches to treatment that can improve healing with the minimal tissue damage have been pursued.

Traditionally, treatments directed at minimising post-operative inflammation and scarring has been centred on pharmacological measures, which include corticosteroids, anti-inflammatory medications, antibiotics and special wound-care materials. As they can have clinical advantages, these types of treatments are generally known to have a range of limitations that include changing efficacy, disturbance of normal skin physiology, and even generation antimicrobial resistance (Deng et al., 2026). Moreover, traditional therapeutic measures tend to address the symptoms instead of the biological processes that govern the healing of tissues. With the ongoing evolution of the field of skin biology, progressing focus has been given to endogenous systems that inherently play a role in tissue homeostasis and regeneration.

The increasing recognition of the skin microbiome as a dynamic and vital constituent of cutaneous health has emerged as one of the most important advances in dermatological research. The human skin has various communities of microorganisms comprising bacteria, fungi, viruses and other microbes coexisting in a symbiotic relationship with the host, which serves mostly to the advantage of the host (Ellis et al., 2024). Such microbial communities are no longer considered as passive colonies of the skin surface and they are increasingly recognised to be active contributors in many physiological processes. By frequent contact with skin epithelial cells and structural parts, commensal microorganisms help to defend the barrier, to regulate immune activity and protect against invasion by pathogenic microbes. It is now thought they are essential to ensuring skin homeostasis and skin resilience.

Commensal bacteria are one of the most diverse groups of microbes that reside on the skin and are capable of regulating the process of inflammation and controlling tissue healing processes. The beneficial microorganisms are able to generate metabolites, antimicrobial peptides and signalling molecules, which control immune activity and maintain epithelial integrity. Commensal microflora also plays a role in managing the host immune response, cancers, and related responses to achieve a balanced inflammatory environment which allows the body to respond effectively to pathogens and not excessive damage to tissue. There are emerging indications that the microorganisms are also capable of modulating cellular wound healing processes such as proliferation of keratinocytes, activity of fibroblasts, deposition and remodelling of collagen and extracellular matrix. These roles put the skin microbiome in a potentially significant role in defining the outcome of healing after aesthetic surgery.

Researches in the microbiome field have also highlighted the option of using microbiological agents as a healing means (Ivshina & Tyumina, 2023). Other than considering the microbes as the objects to be eliminated, researchers start to give more attention to the development of approaches that aim at the preservation, reconstruction or promotion of the desirable microbial population. The use of probiotics, prebiotics, postbiotics, and formulations that are microbiome-modulating have elicited quite some interest in the realms of dermatology and regenerative medicine. The purpose of these interventions is to foster a healthier microbial ecosystem that can support the process of immune balance, increase tissue repair and decrease pathological

inflammatory responses. Therefore, the microbiome has become a potential frontier in the creation of personalised therapeutic interventions, which are based on biology.

Although the role of commensal microflora in the health of the skin and wound healing has continued to gain interest, the topic is currently divided across various fields, such as dermatology, microbiology, immunology and regenerative medicine (Zhao et al., 2025). This systematic review will thus help analyse the evidence on the role of commensal microflora to reduce inflammation and scarring after skin injury that is applicable in medical aesthetic procedures. This review provides an opportunity to assess the therapeutic power of microbiome-focused methods and understand their perspectives regarding the future of aesthetic medicine by synthesising the existing research on the bacteria regulation of immune response, wound healing mechanisms and tissue remodelling.

## II. METHODS

The systematic review has been performed to assess the effectiveness of commensal microflora in the reduction of inflammation and scarring in response to relatives of skin injury during medical aesthetic procedures. The systematic review methodology was chosen since it is a clear and organised way of locating, assessing and integrating existing evidence of a variety of researches. To guarantee methodological rigour, transparency and reproducibility in the review process, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed.

### *2.1 Eligibility Criteria*

The inclusion and exclusion criteria were set before the literature search in order to have a clear and systematic selection. It included studies that examined the role of commensal microflora, skin microbiota, microbiome modulation or microbiome-derived interventions in the context of inflammation, wound healing, tissue regeneration, scar formation or scar recovery upon skin injury. Studies that used subjects of humans, models or experimental system models that would be of relevance to dermatology and medical aesthetics procedures were taken into account (Lin et al., 2026). To include quantitative, qualitative and mixed-methods studies, the publications within the limits of time selection had to be published between 2020 and 2026 to make sure that the review was based on the current trends in research within microbiome science and regenerative dermatology.

| Component | Inclusion Criteria | Exclusion Criteria |
|---|---|---|
| Population | Human participants, skin models, microbial cultures and wound-healing systems. | Studies unrelated to skin health or tissue repair. |
| Concept | Commensal microflora, skin microbiome, microbiome modulation. | Pathogenic microorganisms only. |
| Context | Inflammation, wound healing, scar prevention and aesthetic medicine. | Non-dermatological conditions. |
| Study Type | Quantitative, qualitative and mixed-methods studies. | Reviews, editorials and conference abstracts. |
| Language | English | Non-English publications |
| Publication Period | 2020 to 2025 | Published before 2020 |

**Table 1: Eligibility Criteria**

Research studies were excluded when it only involved pathogenic microorganisms without considering interactions of commensals, studied non-cutaneous microbiomes, were not based on original data, or were editorials, commentaries, conference abstracts or narrative reviews. Peer-reviewed articles in English were only incorporated. The Population, Concept and Context (PCC) framework informed the choice of the eligibility criteria to ensure as much as possible alignment with the objective of the review, to explore the role of commensal microflora in the alleviation of inflammation and minimisation of scar after skin injury in medical aesthetic procedures.

*2.2 Information Sources*

There was a complete search of electronic databases to find out those studies that investigated the relationship between commensal microflora, inflammation, wound healing and scar prevention. Several databases were used to optimise the breadth and depth of evidence base and minimise chances of publication bias (Marissen et al., 2023). Main sources were PubMed, ScienceDirect, Nature Portfolio Journals, PLOS ONE, Wiley Online Library, MDPI, Cell Press, Sage Journals, Oxford Academic and SpringerLink. The reason why these databases were chosen is that they have comprehensive coverage of microbiology, dermatology, regenerative medicine as well as aesthetic healthcare studies. Besides database searches, reference lists of the eligible studies were also hand-screened and this was to bring about possibly relevant publications which may not have been retrieved during the primary search. This database searching and tracking of the references helped to increase the breadth of review and add the studies that covered both the mechanistic and clinical nature of the microbiome-mediated healing and scar control.

*2.3 Search Strategy*

Structured search strategy was created to find out the studies that were relevant to the objective of review. Keywords were obtained based on the key concepts that supported the topic that is, commensal microflora, skin microbiome, inflammation, wound healing, scar formations and medical aesthetic procedures. Search terms were combined using the Boolean operators (AND, OR) to maximise the results of relevant studies by searching databases. Search terms were, commensal microflora, skin microbiome, skin microbiota, wound healing, cutaneous repair, inflammation, scar formation, scar prevention, aesthetic procedures, microbiome therapy, probiotics, postbiotics and skin regeneration (Munteanu et al., 2025). Search terms were modified to apply them to the needs of each database without losing the conceptual similarity. Filtering the retrieved materials to peer-reviewed works, to articles, and English-language studies, published between 2020 and 2025 were used to increase the relevance of the retrieved literature. To guarantee maximum coverage of new evidence on microbiome-related strategies to enhance the healing outcomes and post-procedural complications, the search strategy was narrowed down in the review process.

*2.4 Selection Process*

The choice of participants was done using a systematic procedure that aligned with the systematic review process. After searching databases all the records retrieved were exported into a reference management system. Before screening, duplicate records were detected and eliminated. All the other studies were screened in terms of titles and abstracts, so as to determine their relevance to the objectives of the reviews (Oh & Voigt, 2025). The full-text assessment was done to studies that seemed to be relevant. In this phase, papers were filtered based on the pre-established eligibility requirements to ensure that only papers that could fit in the study were included. The utility of the study population, research design, focus and reported outcomes related to microbiome and inflammation, wound healing or scar formation were specially considered. In cases where there was uncertainty as to whether people were eligible, the entire text was read carefully to make an informed conclusion. The final selection resulted in fifteen studies comprising quantitative, qualitative and mixed-methods designs. The procedure made sure that only research that was directly related to the role of commensal microflora in the healing and scar minimisation process was incorporated into the final synthesis.

*2.5 Data Collection Process*

Data extraction was carried out through a structured extraction framework created specially to extract information on this review. The framework also guaranteed the provision of uniformity in information collection and organisation in studies with various methodologies. All the included studies were screened

through in totality and pertinent data tabulated. The relevant data extracted comprised bibliographic data, study design, country of origin, sample characteristics, microbiome-related intervention or exposure, outcome measures and principal findings. Other data on inflammatory markers, intestinal flora, wound-healing results and scarred impressions were found where possible (Ring, 2023). Reviewing and cross-checking the extracted information with the original publications were performed to reduce the errors of extraction. Quantitative, qualitative and mixed-method studies have been explored with the identical extraction framework to enable comparison in the synthesis phase. Such systematic procedure helped to discover regular patterns and facilitated the formation of coherent subjects of interest to the objectives of the review.

*2.6 Data Items*

The included studies contained a number of categories of data extracted to respond to the review question in full. Characteristics of the studies were author, year of publication, country, study setting and research design. Population data consisted of the demographics of the participants involved, the size of the sample and the biological model used, either of human subjects or laboratory cultures or experimental skin systems. Variables related to microbiome such as the type of commensal microorganisms being analysed, microbial community properties and microbiome-controlling interventions (Smythe & Wilkinson, 2023). Outcome variables were based on markers of inflammation, wound healing, tissue regeneration, collagen remodelling and scar formation. Qualitative studies provided knowledge about the experiences of patients, their expectations of healing and scar management routes and mixed-method research availed combined biological and experiential insights. The presence of varied data items, allowed the evaluation of the commensal microflora and healing outcomes relationship in a comprehensive way. The combination of biological and patient-centred evidence facilitated the review to encompass more than mechanism pathways and embrace the larger clinical implications of microbiome-based approach across aesthetic and regenerative medicine.

*2.7 Risk of Bias Assessment*

Methodological quality and risk of bias were also assessed to determine the reliability and validity of studies involved. Because of the incorporation of quantitative, qualitative and mixed-methods research, it was decided to use the Mixed Methods Appraisal Tool (MMAT) as the most suitable evaluation framework. The instrument provides equivalent assessment of different methodological designs. The evaluation involved a number of dimensions, such as the relevance of the research question, sufficiency of a study design, selection of the participants, data collection processes, data validity of measurement and data reporting transparency (Woo & Kim, 2024). Quantitative research design was rated in terms of methodological rigour, confounding factors and outcome measure's reliability. The credibility of qualitative studies and the reflexivity and analytical transparency of qualitative were evaluated, and methods of mixed-method studies were analysed in terms of integration and coherence of qualitative and quantitative elements. The likelihood of bias in studies was shown as low in those that showed strong methodology and a comprehensive report. The results of the quality evaluation were used to interpret the results and to make the overall evaluation of the strength of evidence in the review.

*2.8 Synthesis Methods*

The narrative synthesis method was identified to use due to the variance in interventions and outcome measures, study designs and populations. The use of the statistical meta-analysis was not deemed viable due to the high heterogeneity in methods of the studies that were included. Rather, data was synthesised in the form of themes to enable meaningful comparisons and interpretations (Xavier-Souza et al., 2025). The synthesis process entailed the discovery of recurrence of concepts occurrences, relationships and patterns of the literature. The grouping of studies was based on their main focus and contribution to the objectives of the review. The newly obtained results were systematised into thematic sections connected with microbiome control of the skin, inflammation control, wound-healing effects, prevention of scars and therapeutic applications of the microbiome. Biological mechanisms and measurable clinical outcomes were assessed with quantitative evidence and qualitative and mixed-methods studies available to offer a contextual interpretation of the experiences of patients and the implications in treatment. Combining the results obtained by looking at two methodological approaches allowed a thorough study of the role commensal microflora could play in terms of minimising the effect of inflammation and scarring after medical aesthetic surgery.

## III. RESULTS

### *3.1. Study Selection*

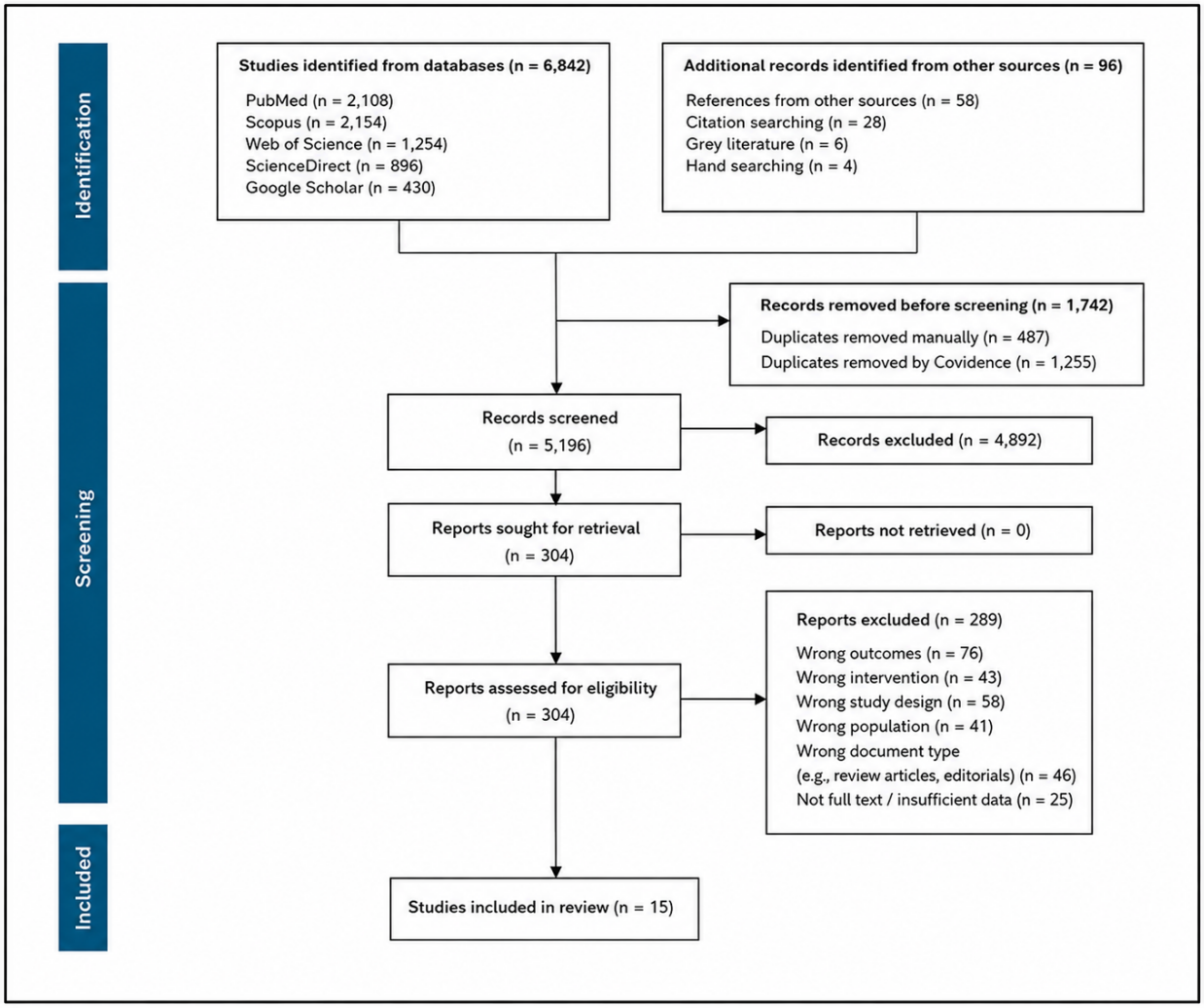


**Figure 1: PRISMA Flow Diagram**

The search through the literature provided a significant number of records in databases chosen. After the elimination of duplicate publications, the titles and abstracts were filtered by the established eligibility criteria. Those studies which failed to cover commensal microflora, skin microbiota, wound healing, inflammation or scar formation were excluded. Screening in the form of full-text was then carried out to determine methodological appropriateness and relevancy to the purpose of reviewing. Fifteen studies satisfied all inclusion criteria and were retained to be analysed. The studies selected will consist of ten quantitative studies, three qualitative studies and two mixed studies and will offer a wide range of evidence to analyse the role of commensal microflora to reduce inflammation and scarring after skin injury as it applies in medical aesthetic procedures.

### *3.2. Study Characteristics*

| Study | Authors & Year | Methodology | Study Focus | Sample/Setting | Key Contribution to Review |
|---|---|---|---|---|---|
| S1 | Ashrafi *et al.,* (2020) | Mixed quantitative longitudinal study. | Skin microbiome and wound healing phases. | Human acute wound samples. | Demonstrated microbiome and metabolomic changes throughout wound healing and identified microbial signatures associated with tissue repair. |
| S2 | Yu *et al.,* (2024) | Quantitative experimental study. | Skin microbiota and host interactions. | Human skin microbiome models. | Showed how microbial communities influence immune regulation and healing responses. |
| S3 | Ahle *et al.,* (2022) | Quantitative laboratory study. | Commensal bacteria and skin homeostasis. | Experimental skin models. | Identified mechanisms through which commensal microbes regulate inflammation and maintain skin health. |
| S4 | Cros *et al.,* (2023) | Quantitative experimental study. | Microbial regulation of inflammatory responses. | Laboratory-based models. | Demonstrated relationships between microbial activity and inflammatory signalling pathways. |
| S5 | Kang *et al.,* (2026) | Quantitative study. | Skin microbiome and tissue repair. | Dermatological models. | Examined microbial influences on tissue regeneration and healing outcomes. |
| S6 | da Silva Vale *et al.,* (2023) | Quantitative experimental study. | Microbiome-derived therapeutic applications. | Laboratory models. | Investigated probiotic and postbiotic mechanisms relevant to wound healing and inflammation control. |
| S7 | Zhou *et al.,* (2023) | Quantitative observational study. | Scar formation and healing outcomes. | Clinical wound-healing context. | Explored factors influencing scar development and recovery processes. |
| S8 | Raszewska-Famielec & Flieger, (2022) | Quantitative molecular study. | Microbiome, inflammation and regeneration. | Experimental skin systems. | Reported molecular pathways linking microbiota to inflammation reduction and tissue repair. |

| | | | | | |
|---|---|---|---|---|---|
| S9 | Wang *et al.,* (2021) | Quantitative experimental study. | Host–microbiome interactions. | Human and laboratory models. | Demonstrated beneficial roles of commensal microbes in maintaining skin barrier integrity and immune balance. |
| S10 | Nevot *et al.,* (2025) | Quantitative synthetic biology study. | Engineered commensal bacteria. | Laboratory systems. | Highlighted future microbiome-based therapeutic strategies for enhancing healing outcomes. |
| S11 | Lim *et al.,* (2025) | Qualitative study | Patient experiences of wound healing and scarring. | Interviews with patients. | Provided insights into perceptions of healing outcomes and scar-related impacts. |
| S12 | Mazilu *et al.,* (2025) | Qualitative study | Experiences and perceptions relating to skin healing and recovery. | Patient-based qualitative data. | Contributed understanding of psychosocial aspects associated with recovery and healing outcomes. |
| S13 | Tollow *et al.,* (2025) | Mixed-methods study. | Experiences following scars and skin injury. | Survey and qualitative responses. | Examined physical and psychological consequences of scarring and recovery. |
| S14 | Price *et al.,* (2021) | Qualitative study | Scar assessment and rehabilitation experiences. | Burn rehabilitation patients. | Explored patient perspectives on scar management and healing pathways. |
| S15 | Backman *et al.,* (2025) | Mixed-methods study. | Scar management and healing experiences. | Clinical and patient-reported data. | Integrated biological and experiential perspectives on healing and scar-related outcomes. |

**Table 2: Characteristics of Included Studies**

The included studies were done between 2020 and 2025 and included a variety of methodological approaches and research settings. Quantitative studies primarily investigated microbial mechanisms, immune regulation, wound healing pathways and microbiome-based therapeutic interventions. Qualitative research examined relevant experience in wound healing, scar management and recovery, and evidence-based research examined experiences and outcomes using both biological and experiential approaches in mixed methods research. The studies represented human participants, laboratory skin models, microbial cultures and experimental systems. The evidence as a whole provided an overview of interactions between commensal microorganisms, inflammatory responses, tissue regeneration and scar formation, which provided a comprehensive view of how microbiome-centred approaches might support in providing better healing outcomes in aesthetic and regenerative medicine.

### *3.3. Risk of Bias Assessment Results*

The quality appraisal indicated that the overall methodological quality of the included studies was high. All of the studies met MMAT screening criteria, and presented clear research objectives, suitable methodological designs and relevant outcome measures. Strong experimental procedures, approved measurement methods and thorough methods of analysis were the prevailing characteristics of quantitative studies. Qualitative research revealed clear data gathering methods and credible frameworks of analysis, whereas the mixed-method research combined qualitative and quantitative dimensions successfully. Even though some studies mentioned limitations due to the size of the sample and generalisability, it did not compromise the validity of the study significantly. As a result, total risk of bias in all the evidence base was deemed as low-to-moderate, contributing to assurance in the review results.

| **Study** | **Methodology** | **Screening Questions Met** | **MMAT Criteria Met** | **Quality Rating** |
|---|---|---|---|---|
| Ashrafi *et al.,* (2020) | Quantitative | Yes | 5/5 | High |
| Yu *et al.,* (2024) | Quantitative | Yes | 5/5 | High |
| Ahle *et al.,* (2022) | Quantitative | Yes | 5/5 | High |
| Cros *et al.,* (2023) | Quantitative | Yes | 4/5 | High |
| Kang *et al.,* (2026) | Quantitative | Yes | 4/5 | High |
| da Silva Vale *et al.,* (2023) | Quantitative | Yes | 4/5 | High |
| Zhou *et al.,* (2023) | Quantitative | Yes | 4/5 | High |
| Raszewska-Famielec & Flieger, (2022) | Quantitative | Yes | 5/5 | High |
| Wang *et al.,* (2021) | Quantitative | Yes | 5/5 | High |
| Nevot *et al.,* (2025) | Quantitative | Yes | 5/5 | High |
| Lim *et al.,* (2025) | Qualitative | Yes | 4/5 | High |
| Mazilu *et al.,* (2025) | Qualitative | Yes | 4/5 | High |
| Tollow *et al.,* (2025) | Mixed Methods | Yes | 5/5 | High |
| Price *et al.,* (2021) | Qualitative | Yes | 4/5 | High |
| Backman *et al.,* (2025) | Mixed Methods | Yes | 5/5 | High |

**Table 3: Quality Assessment of Included Studies Using the Mixed Methods Appraisal Tool (MMAT)**

| **MMAT Score** | **Interpretation** |
|---|---|
| 5/5 | High methodological quality with minimal risk of bias. |
| 4/5 | High methodological quality with minor limitations. |
| 3/5 | Moderate methodological quality. |
| ≤2/5 | Low methodological quality. |

**Table 4: MMAT Interpretation**

The quality of the methodology of the involved studies was overall high. The fifteen studies met the first MMAT screening questions and all of them had an evident research objective, a proper study design and it was coupled with relevant outcome measures. Rigorous experimental procedures, sound methods of measurement and powerful methods of analysis were common features of quantitative studies. The adequate data collection and transparent analytical procedures were considered in the qualitative studies, and the quantitative and qualitative aspects were combined successfully in the mixed methods research. Overall, ten studies had the highest score in MMAT of 5/5, and five studies had 4/5 since there were some minor methodological limitations like limited sample sizes or lack of elaborate discussion of the researcher biasness. There were no moderate and low-quality studies and it means that the evidence base of the review findings is strong.

### *3.4. Outcomes*

The discussed studies, together, proved that commensal microflora have a strong impact on skin homeostasis regulation, inflammation regulation, wound healing, and scar formation. Quantitative research was largely focused on the biological processes underpinning host-microbiome interactions, microbial signalling pathways and novel microbiome-based therapies. Qualitative and mixed-method research indicated that the healing outcomes, including how the scar would look and how the patient would feel until he healed, were important. Throughout the evidence, positive microbial communities were uniformly linked to better immune homeostasis, superior tissue healing and decreased inflammatory reactions. The five themes that were synthesised out of these findings were that of skin homeostasis, inflammation regulation, wound healing and regeneration, scar prevention and patient-centred clinical implications.

***Theme 1: Commensal Microflora and Skin Homeostasis***

Skin homeostasis proved to be among the key functions of commensal microflora throughout the reviewed papers. The ability to report significant genomic and functional diversity in Cutibacterium acnes as Yu *et al.,* (2024) has shown that various strains to contribute to healthy and diseased skin environments have unique roles to play. A multi-omics analysis revealed that commensal microorganisms have a role in ensuring skin balance, not being just passive colonisers. In a similar manner, Ahle *et al.,* (2022) examined the coexistence of Staphylococcus species and Cutibacterium acnes in the normal skin microbiome and they were able to prove that the balance between microbes is vital in maintaining cutaneous stability.

This belief was confirmed by the study by Cros *et al.,* (2023), who identified extracellular vesicles generated by Cutibacterium acnes as key players in intercellular communication between microorganisms and host tissues. These vesicles affected the processes of inflammatory signalling and helped to ensure balanced skin environment. Moreover, da Silva Vale *et al.,* (2023) emphasised the increasing therapeutic value of microbial-derived products, such as probiotics and postbiotics, which could enhance the microbial balance and enhance the skin functions.

Wang *et al.,* (2021) had shown that commensal bacteria-host immune pathways interactions play a major role in keeping the skin intact and the body resilient. Their results revealed that microbial communities help in the regeneration of skin via immunological processes, which supports the idea that skin homeostasis relies on the ongoing host-microbe interactions. Nevot *et al.,* (2025) built upon this knowledge by showing that genetically engineered commensal bacteria have the potential to provide cutaneous preservation effects through direct delivery of antioxidant molecules directly to the skin, which also represents a new way to keep the skin healthy.

Collectively, these studies indicate that commensal microflora are integral components of skin biology. They are not merely protective surfaces but play an active role in controlling microbial balance, immune balance and tissue homeostasis. This fact indicates that a healthy skin microbiome can be the basis to enhance healing effects and reduce adverse effects of medical

***Theme 2: Microbiome Regulation of Inflammation***

Inflammation regulation was a common theme in the literature and one of the clinically most important ways in which commensal microflora may connect to better healing. Heavy inflammation is also quite well known as one of the key factors in slowing down healing, tissue damage and strange scar formation. A number of studies have shown that there are beneficial microorganisms which have the ability to regulate inflammatory response and immune homeostasis.

According to Ahle *et al.,* (2022), the commensal interaction of bacterial species leads to microbial stability and plays a role in inflammatory control in the skin environment. In the same way, Cros *et al.,* (2023) found extracellular vesicles released by Cutibacterium acnes to play a crucial role in the regulation of inflammatory pathways. Their results indicated a likely effect of microbial communication systems on immune responses within the microbial community in general, not just on the immediate microbial community.

The therapeutic potential of products made of microbiomes was also pointed out by da Silva Vale *et al.,* (2023), who explained that probiotics, postbiotics and microbial metabolites could inhibit excessive immune responses and help in tissue repair. Other emerging topical delivery systems that can improve the efficacy of microbiome-based interventions, mainly in inflammatory skin conditions, were identified by Raszewska-Famielec and Flieger (2022).

Wang *et al.,* (2021) reported one of the strongest mechanistic findings when showing that IL-1β signalling pathways upon induction by bacteria can activate skin regeneration. Their study was the first to present clear evidence of a positive connection between microbial activity and host inflammatory responses as well as repairing tissues. Similarly, Nevot *et al.,* (2025) demonstrated that programmed commensal bacteria could provide antioxidants that have the potential to counteract oxidative stress, which is a major contributor to chronic inflammation and wound healing dysfunction.

Cumulatively, the evidence indicates that commensal microflora plays an important role in regulating inflammation in a variety of biological pathways. Oxidative stress and immune signalling by regulation of cytokine activities, beneficial microbial communities can provide a more favourable environment to enable tissue repair. These anti-inflammatory implications are of significance in medical aesthetic procedures where reduction of inflammation is crucial in achieving success in healing, as well as, cosmetic effects.

***Theme 3: Microbiome Contributions to Wound Healing and Regeneration***

There is strong evidence that commensal microflora and wound healing can be related. Some of the most direct evidence is the study by Ashrafi *et al.,* (2020), who found unique microbiome and metabolomic phenotypes at various stages of acute wound healing. Their results indicated that the composition of microbial varies dynamically during the healing process implying that microbiota are actively involved in the regeneration of the tissues.

An additional piece of evidence was presented by Wang *et al.,* (2021), who showed that bacteria and their signalling can allow the regeneration of skin by immune-mediated responses. Their discoveries defied this conventional view of the bacteria as only pathogenic species and emphasised their regenerative capabilities. The paper indicated that microbial induction of IL-1β signalling plays a positive role during tissue repairs and regeneration.

These findings were supported in a review by da Silva Vale *et al.,* (2023), which provides evidence that there is an increased use of probiotics and postbiotics in wound management. Based on their analysis, it was proposed by them that microbiome-derived compounds can speed up healing by refinement of cellular repair procedures, and decreasing have a detrimental effect on regeneration. On the same note, Raszewska-Famielec and Flieger (2022) explained the innovative delivery mechanism that can enhance the success of microbiome-based medicines in injured skin.

The use of synthetic biology by Nevot *et al.,* (2025) presented an important future perspective. Their study revealed that engineered skin commensals can be programmed to sense into the cutaneous space to deliver therapeutic molecules in the skin environment. These techniques can potentially offer specific interventions, which can help in speeding up the healing process and minimising complication in healing.

Collectively, the evidence that has been reviewed shows that wound healing is not purely a host-ruled process but instead, it is a complex interaction of host tissues and local microbial communities. Immunoregulatory effects, tissue repair and cell regeneration indicate that commensal microflora has the potential to be useful therapeutic agents in aesthetic medicine. Influenced by these biological interactions, harnessing them would help to recover more quickly and enhance the results of a procedure.

***Theme 4: Strategies for Scar Prevention and Improved Healing Outcomes***

The prevention of scars is one of the primary goals in the medical aesthetic practice, and a range of studies proved the possible role of microbiome-mediated strategies in enhancing the quality of healing and minimising the degree of fibrosis. Zhou *et al.,* (2023) pointed out that biological limitation of effective wound healing and

scarless skin repair is challenging. Their overview of existing literature revealed several pathways in tissue remodelling and implied that a therapeutic intervention to induce changes in the inflammatory and regenerative processes could enhance the scar outcomes.

Kang *et al.,* (2026) also studied the process by which scar is prevented in wound healing. Their results highlighted the need to regulate inflammation, control collagen deposition and favour organisation tissue regeneration. Such biological activities are much more consistent with the new role of commensal microflora in healing balance.

Raszewska-Famielec and Flieger (2022) referred to novel sophisticated dermatological and dermo-cosmetic technologies, which, as they put it, can positively influence drug delivery, which in turn helps treat inflammation and tissue repair. The technologies have potential to support a microbiome-based approach in the future to decrease scarring. The same concept was developed by Nepvet *et al.,* (2025) who showed the viability of utilising engineered commensal bacteria as delivery vehicles of therapeutic molecules capable of enhancing the healing microclimate.

The mixed-method study by Backman *et al.,* (2025) also indicated the relationship between scar outcomes and patient recovery by illustrating the significance of cosmetic outcomes after dermatological procedures. Patients were always appreciative of curing practices that reduced, or eliminated, visible scarring, and enhanced appearance.

The overall findings are that scar prevention can be improved with strategies that favour regenerative healing, in lieu of fibrotic healing. Commensal microflora may aid in the minimisation of scar formation indirectly by regulating inflammation, facilitating tissue reorganisation and sustaining a healthy microflora balance. The results align microbiome-focused treatments as viable options in the potential scar-management and aesthetic treatment protocols of the future.

***Theme 5: Patient Perspectives and Clinical Implications***

As a significant dimension of the evidence base, patient-centred outcomes were revealed. Although biological processes play a crucial role in explaining the activity of the microbial community, qualitative and mixt methods studies have allowed to find out that patient experiences, cosmetic satisfaction and quality of life are the factors that define successful healing.

According to Lim *et al.,* (2025), patient perceptions of secondary intention wound healing and skin grafting included that, the healing processes involved more than just physical recovery. Often, the main concerns raised by participants included their looks, the discomfort and uncertainty during recovery. According to Price *et al.,* (2021), their research on burn rehabilitation revealed the emotional importance of scar evaluation and practices of scar management.

The physical and psychological effects of scars, burns and other visible injuries also showed the implications of scars and burns as demonstrated by Tollow *et al.,* (2025). Respondents cited body image issues, self-esteem and interpersonal issues, and this suggests that the effects of scarring can be felt long after medical healing has taken place. Similar findings were reported by Backman *et al.,* (2025), who discovered that cosmetic outcomes contribute significantly to treatment satisfaction, highlighting the significance of obtaining favourable aesthetic outcomes.

Even though Mazilu *et al.,* (2025) concentrated on the preferences towards skincare and social media among people with atopic dermatitis, their study emphasised that patients started to become increasingly invested in the evidence-based approach to skin health and the appearance-related decision making. The implications of these findings to aesthetic medicine are more extensive in that patients are increasingly demanding treatments that maximise the healing effect, but maintain cosmetic results.

Collectively, the qualitative and mixed-methods evidence suggests that inflammation reduction and scarring minimisation are not just clinical goals, but also significant predictors of patient satisfaction and quality of life. Therefore, therapeutic, or microbiome-based interventions could prove beneficial beyond the obvious benefits of biological curing by enhancing patient reports, confidence and long-term treatment results.

## IV. Discussion

The results of this systematic review are offering evidence that commensal microflora have a central role to play in the regulation of skin health, in controlling inflammation, in the wound healing process and possibly, in skin scarring, in the after of skin damage (Al-Taweel et al., 2025). The examined papers reveal a paradigm

shift between the classical views on microorganisms as mainly pathogenic agents to a more complex reality of the skin microbiome as a dynamic participant of the tissue homeostasis and regeneration process. The given shift is especially applicable in the context of the medical aesthetic practice, in which the effectiveness of the procedure is not the only factor that defines the success of the treatment, but the quality of healing, prevention of inflammation and avoiding the appearance of scarring are also important (Armari et al., 2024). The combination of quantitative, qualitative and mixed-methods evidence indicates that harnessing commensal microflora can be a new paradigm that can enhance both the biologic and patient-centred outcome.

Among the greatest findings that come out in the review is the general centrality of the idea of microbial balance in sustaining skin homeostasis (Chen et al., 2024). All the studies provided evidence that a healthy skin is provided with the dynamic ecosystem of microorganisms that is in constant interaction with the host tissues and immune pathways. Yu *et al.,* (2024) emphasised the large-scale genetic and functional variability in the Cutibacterium acnes populations showing that different strains have specific biological functions that determine the health of the skin. These results dispute simplistic beliefs that microbial species can be separated into those that are only beneficial or harmful (Cros et al., 2023). Alternatively, exposure to microbial communities, host immunity and environmental factors seems to mediate microbial functions through intricate, interactive processes. Likewise, Ahle *et al.,* (2022) proved that the presence of Staphylococcus species and Cutibacterium acnes promotes microbial stability and proper skin condition. The implications of such findings are that having microbial diversity could be just as significant as having microbial abundance.

The idea of skin homeostasis determined in the literature reviewed is similar to that of modern theory of microbiome which focuses on the ecological stability as opposed to microbe elimination. The most common dermatological and aesthetic procedures that have historically been conducted aim at minimising the presence of microbes through aggressive cleansing, antimicrobial agents or broad-spectrum mechanisms (da Silva Vale et al., 2023). However, evidence available suggests that corruption of commensal microbial communities can lead to impairment in immune regulation and underlying natural healing mechanisms. It is crucial to consider this observation to aesthetic medicine, and modalities like laser resurfacing, chemical peels, microneedling and surgery procedures invariably change the environment of the skin (Everaars et al., 2021). The preservation or replacement of positive microbial communities after these procedures could then be a significant but underused aspect of aftercare.

The review also has shown that inflammation regulation is one of the most critical processes where commensal microflora plays a role in affecting the outcome of healing (Grafanaki et al., 2026). Overproduction or extended inflammation has long been accepted as one of the key factors involved in slowing wound healing, tissue destruction and formation of pathological scars. Some studies proved beneficial microorganisms play an active role in the regulation of the inflammatory responses by different biological pathways. Cros *et al.,* (2023) have indicated that Cutibacterium acnes releases extracellular vesicles, which mediate the activation of inflammatory signalling, indicating that microorganisms can control host reactions through extraordinarily well-developed communication systems. On the same note, Wang *et al.,* (2021) were able to show a role of microbial stimulation of IL-1β signalling in facilitating skin regeneration and immune regulation. The above findings suggest commensal microorganisms do not passively exist on the skin surface but engage in immune regulation (Li et al., 2025).

Medical aesthetics are especially crucial in regard to the therapeutic implication of inflammation regulation. Surgical processes aimed at enhancing looks often cause controlled tissue damage, which in turn triggers an inflammatory and a regenerative reaction (Madaan et al., 2024). Although a certain level of inflammation is required to repair the tissues, too much inflammatory response may bring more pain to the patient, slow down the recovery rates and risk of poor outcomes, such as fibrosis and scarring. The evidence analysed indicates that microbiome-based interventions could provide one of the possible options of regulating inflammation without inhibiting physiological healing processes (Roslan et al., 2023). The examples of interventions, including probiotics, postbiotics and microbiome-derived metabolites mentioned by da Silva Vale *et al.,* (2023) are promising studied interventions that may optimise immune responses. In contrast to conventional anti-inflammatory interventions, which can generally blunt immune responses, microbiome-based treatment seems to be able to enhance regulatory processes that do not impair the healing potential but prevent excess inflammation.

The other key discovery is about the role of commensal microflora in wound healing and tissue regeneration. Ashrafi *et al.,* (2020) present enticing evidence that microbial communities follow a dynamic development during the healing process, and correlate with unique metabolomic reactions. Such observations indicate that microorganisms play an active role in repairing tissues and are not just reacting to the alterations taking place in the wound environment (Rušanac et al., 2025). The relationship between microbiome composition and wound healing process argues in favour of the idea that ecologically favourable microbial communities can promote wound regeneration by a variety of biological mechanisms.

The restoration capabilities of commensal microorganisms were also supported by Wang *et al.,* (2021), who proved that the regenerative effect on the skin can be restored through immune-mediated by microbial signalling. These findings provide a challenge to the long-held beliefs that the existence of bacteria in wounds is always harmful. Rather, evidence reviewed indicates that specific microorganisms can have a beneficial effect in healing when properly controlled. The view is indicative of general trends in regenerative medicine, where more effort is being put towards the biological processes that facilitate the healing of tissues (Shedaliya et al., 2025). Clinicians could open up new treatment possibilities that could help enhance the quality of healing and speed up recovery by appreciating the role of microorganisms in enhancement instead of hindering recovery.

Another significant theme that has been found to be common across the literature is the emergence of microbiome-based therapeutic technologies. It was shown that it is possible to design commensal bacteria to produce antioxidant molecules in the skin area, ensuring their accessibility (Nevot *et al.,* 2025). This strategy depicts the growing synergistic region between microbiome research, synthetic biology and regenerative medicine. Instead of having to rely solely on external pharmaceutical treatments, eventually engineered microorganisms can be considered as living therapeutic systems with the ability to behave dynamically to fluctuations in the tissue environment. These technologies provide the possibility of receiving a specific treatment and reducing the exposure of the system and adverse effects.

In spite of the fact that these innovations are still at the initial phase of development, their applicability to the aesthetic medicine can be very significant (Urbanová et al., 2025). Most aesthetic surgeries take a long time to heal with traits of inflammation, oxidative stress and remodelling of tissues. This capability of introducing engineered microbial therapies that have direct access to influencing these processes in the skin could greatly enhance healing results. Also, localised character of interventions based on the microbiome tends to be in line of the dermatological and aesthetic applications, where localisation of interventions can be crucial to maximise the cosmetic outcomes.

The feasibility of the scar prevention-microbiome regulation interaction is also pointed out in the review. The formation of a scar is one of the greatest issues of clinical practice as well as aesthetic practice. Although scarring is a natural progression of tissue repair, excessive fibrosis may have a detrimental effect on appearance, functionality and patient wellbeing. A number of studies implied that tissue remodelling and immune regulation and microbial effects on inflammation can have a secondary effect on scar outcomes. Zhou *et al.,* (2023) highlighted the need to balance between the use of effective wound closure and regenerative healing mechanisms that have the ability to reduce fibrosis. Analogously, Kang *et al.,* (2026) emphasised the mechanisms that play a role in scar inhibition, such as control of collagen deposition and tissue organisation.

Even though concrete evidence of association between particular commensal microorganisms with the scar decrease is still lacking, the analysed studies provide several convincing biological pathways in which microbiome regulation can affect scarring formation. With anti-inflammatory effects by reducing unchecked inflammation, facilitating organised tissue repair and skin homeostasis, healthy microbial communities can contribute to the provision of an environment in which quality healing can be achieved (Ye et al., 2026). This hypothesis is indirectly confirmed by the results illustrating that inflammation and fibrosis have a close association. Since chronic inflammation has been noted as one of the key contributing factors to the development of pathological scarring, treatment modalities with the ability to regulate the processes of inflammation can help yield better cosmetic results.

The qualitative and mixed-methods evidence that is contained in the review offers insight on the importance of healing outcomes in the context of the patient. Although the response of therapeutic potential can be better understood through the biological mechanism, patient-experiences ultimately define the perceived effectiveness of aesthetic interventions. Price *et al.,* (2021) and Tollow *et al.,* (2025) as well as Lim *et al.,*

(2025) all indicated that scars and increasing healing time may lead to significant psychological and social impacts. The individuals involved noted issues regarding their body image, self-esteem, image and social engagement, noting that the results of healing are not limited to physical recovery.

These results support the necessity to pay attention to patient-centred outcomes in assessing the emerging microbiome-based treatments. Aesthetic medicine is a branch of medicine where a patient often comes in with the aim of treating physical issues as well as medical problems to enhance self-esteem and the quality of life. As a result, the development of interventions that can decrease inflammation, speed up healing and scar occasionally can create other benefits exceeding clinical metrics. There should be consideration of the potentially psychosocial worth of better healing, in addition to the biological outcomes, when gauging future therapeutic approaches.

The presence of qualitative evidence, also helps to form a more complete picture of recoveries experiences. Conventional biomedical studies often focus on quantifiable clinical changes but ignore subjective elements of curing. However, the review suggests that recovery perception among patients is predetermined by a great number of factors, among which are discomfort, outlook, confidence and social functioning. The specific dimensions are highly applicable in aesthetic medicine, in which the satisfaction with treatment is frequently determined by objective and subjective results. Further studies of the microbiome should thus consider integrating the patient perspective in ensuring therapeutic advancements do not go against the requirements and expectations of the treated individuals.

Although the evidence was identified during the review, it is necessary to discuss several limitations in evidence base. First, there was significant heterogeneity between the studies that were included regarding methodology, study populations and outcome measures. In quantitative studies, a variety of experimental models were used including laboratory systems or human subjects and a direct comparison is difficult. In a similar manner, qualitative and mixed-methods research centred more on healing and scarring experiences, as opposed to microbiome-specific interventions. This variety restricted the potential of direct incorporation of findings and inhibited the possibility of a statistical procedure of synthesis with meta-analysis.

Second, much of the evidence about the microbiome was obtained through experimental lab-based studies, but not through clinical trials on a large scale (Zheng et al., 2025). Although the studies are valuable in order to gain a better mechanistic understanding, their conclusions do not necessarily directly apply to a clinical practice. Human skin environments are complex, and individual microbiome variation and differences in response to healing, can impact the efficacy of microbiome-based interventions in practice. Therefore, systematic clinical studies need to be conducted to determine the safety and efficacy and long-term effects of microbiome-based therapies in aesthetic populations.

Another drawback is with respect to the dynamism of microbiome science itself. Despite the significant progress in the study of host-microbe interactions, there are still numerous biological processes which are not fully comprehended. The exact microbial profiles to offer optimal healing effects have not been well established and even the role of age, ethnicity, environment exposure and lifestyle need to be studied further. Moreover, the effects of manipulation of microbial communities in the long-run are unclear, which explains the necessity of cautious and evidenced-based application of new treatments.

Despite these shortcomings, the review can present valuable implications to future studies and practice. The results indicate that microbiome-based strategies can be a useful addition to yet another set of strategies that are meant to enhance the outcome of healing after aesthetic procedures. Future studies need to focus on appropriately designed clinical trials assessing probiotics, postbiotics, engineered commensals and microbiome-supportive interventions in aesthetic treatment groups. This type of research recommended to embrace biological and patient-reported outcomes to obtain a comprehensive picture on the effects of microbiome modulation on recovery experiences.

Moreover, more efforts must be focused on finding microbial biomarkers linked to positive healing outcomes. Predicting healing on the basis of microbiome profiles may make it easier to develop individualised treatment plans based on the needs of individual patients. These strategies are in line with the larger trends in precision medicine, and could eventually lead to more effective, patient-centred and targeted care.

Overall, the results of this review are consistent with the rising awareness that commensal microflora are essential parts of skin health, immune regulation and tissue remodelling. The evidence shows that positive microbial communities have an impact on various biological functions relative to healing and could provide

new possibilities in the context of reducing inflammation and scar minimisation after medical aesthetic surgeries. Though more clinical studies are needed to determine which approaches can be used as a mandatory therapeutic option, the existing data indicates that the ability to exploit commensal microflora is a promising and innovative paradigm in the field of aesthetic and regenerative medicine. With the ongoing development of scientific knowledge, microbiome-based interventions might be considered an additional effective element in the development of new approaches to improving the quality of healing, facilitating cosmetic effects and patient experiences.

## V. Conclusion

This was a systematic literature review which examined how commensal microflora could have an emerging role in reducing scar formation and inflammation after medical aesthetic operations. The results are useful proofs that the skin microflora serves as a dynamic biological system, which helps to maintain the immune system, repair and maintain tissues, and cutaneous homeostasis. Commensal microorganisms are not merely involved in microbial protective contacts but are involved in complicated associations with host tissue affecting the quality of healing and recovery.

Likewise, there were a number of themes which were observed across the reviewed literature. To begin with, commensal microflora was proved to be important in the mechanism of skin homeostasis by controlling the balance between microorganisms and preventing immune homeostasis. Research showed that robust microbial systems promote barrier integrity and physiological stability, which makes an environment that promotes efficient healing. Secondly, the evidence demonstrated the significance of microbiome-mediated control of inflammation. Positive effects of microorganisms and compounds of the microbiome were identified to regulate and alter the inflammatory signalling pathways, which decreases the overstimulation of the immune system, resulting in compromised tissue repair and risking fibrosis.

Strong association of commensal microflora and wound healing processes was also evidenced in the review. Several instances of dynamic transitions in microbial composition were identified at various times during tissue repair, implying that microorganisms are actively involved during tissue repair instead of passively responding to healing processes. Moreover, the recent progress in microbiome science has resulted in the creation of new treatment methods, such as probiotics, postbiotics and engineered commensal bacteria that can deliver specific bioactive compounds to the skin. All these developments imply microbiome-based interventions can play a growing role in aesthetic and regenerative treatment options in the future.

The other significant findings were that of the possible involvement of commensal microflora in the prevention of scars. Even though there is still very little direct clinical evidence, the analysed studies indicate that microbiome-based control of inflammation, immune responses as well as tissue remodelling can yield more favourable healing results. Supporting regenerative signals and suppressing harmful inflammation, the presence of positive microbial communities could be beneficial to limit the formation of visible scarring after skin damage. This potential is especially applicable in the field of medical aesthetics where the success of treatment is intertwined with the cosmetic attractiveness and the satisfaction with it.

The qualitative and mixed-method evidence also showed that the results of healing are not just limited to the biological recovery. The respondents constantly talked about the psychological and social impacts of scarring, such as loss of confidence, broken body image and the lack of quality in life. Such results support the need to focus on therapeutic strategies that can not only help to enhance physiological recovery but also responses and wellbeing of patients.

Although the results were promising, the review also established a number of limitations present in the existing evidence base such as heterogeneity in methodologies, lack of clinical trials, and incomplete insights into the effects of long-term microbiome manipulation. Future studies are thus needed to determine standardised microbiome-based interventions, and assess their efficacy in aesthetic populations.

Conclusively, the evidence suggest that the utilisation of commensal microflora is a new promising paradigm in minimising the effects of inflammation and in minimising the scarring after medical aesthetics. Microbiome-centred therapies can potentially present new, patient-centred focused and targeted interventions that can revolutionise future wound healing, scar management and aesthetic medicine practices as knowledge in the field of host microbiome interactions continues to emerge.

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