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Table of Contents

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Application Effect of Cosmetic Surgery Repair Techniques in the Treatment of Facial Trauma Patients

Hangli Wu[1], Qin Yin[2], Wenjie Gao[1]*

[1]Department of Burns and Cosmetic Surgery, Shaanxi Provincial People's Hospital, Xi'an 710068, Shaanxi, China
[2]Department of Plastic Surgery, Zhen'an County People's Hospital, Shangluo 711500, Shaanxi, China

**Author to whom correspondence should be addressed.*

Abstract: *Objective*: To explore the application effect of cosmetic surgery repair techniques in the treatment of facial trauma. *Methods*: 200 patients with facial trauma who visited the hospital from January 2022 to December 2024 were selected and divided into an observation group and a control group according to the random number table method, with 100 cases in each group. The observation group was treated with cosmetic surgery repair techniques, while the control group was treated with traditional facial trauma repair techniques. The wound healing time, scar score, patient satisfaction, and complications were observed in both groups. *Results*: The average wound healing time in the observation group was 6.23 ± 1.05 days, which was significantly shorter than that in the control group (8.76 ± 1.32 days), and the difference was statistically significant ($P < 0.05$). The average score of the Vancouver Scar Scale (VSS) in the observation group was 2.85 ± 0.76, which was significantly lower than that in the control group (5.12 ± 1.08), and the difference was statistically significant ($P < 0.05$). The satisfaction rate of patients in the observation group was 90.00%, which was significantly higher than that in the control group (72.00%), and the difference was statistically significant ($P < 0.05$). The incidence of complications in the observation group was 5.00%, which was significantly lower than that in the control group (16.00%), and the difference was statistically significant ($P < 0.05$). *Conclusion*: Cosmetic surgery repair techniques have significant advantages in the treatment of facial trauma, which can effectively shorten the wound healing time, reduce scar formation, improve patient satisfaction, and reduce the incidence of complications. It is worthy of promotion and application in clinical practice.

Keywords: Cosmetic surgery repair techniques; Facial trauma; Wound healing; Scar; Satisfaction

Online publication: October 17, 2025

1. Introduction

Facial trauma is relatively common in emergency surgery, accounting for approximately 12% to 18% of emergency trauma patients. With the development of transportation and industry, the incidence of facial trauma is on the rise. It not only causes tissue damage but also affects facial aesthetics and function, imposing both physical and psychological burdens on patients. Although traditional repair techniques can close the wound surface, postoperative scars are often noticeable, affecting patients' quality of life [1]. In recent years, cosmetic repair techniques have gradually been applied to the treatment of facial trauma, balancing both functional recovery and aesthetic effects. In cosmetic repair techniques, debridement is a crucial first step [2]. Unlike traditional debridement methods, cosmetic repair techniques emphasize the precision and gentleness of debridement [3]. Gentle disinfectants such as normal saline, hydrogen peroxide solution, and povidone-iodine are used to repeatedly irrigate the wound surface, thoroughly removing foreign bodies, necrotic tissue, and bacteria while maximizing the protection of normal tissue [4]. For deep trauma, auxiliary equipment such as microscopes or magnifying glasses can be used to more precisely remove deep contaminants, avoiding unnecessary damage to surrounding healthy tissue and creating good conditions for subsequent repairs. For large facial trauma or cases involving tissue defects, skin flap transplantation and skin grafting are commonly used repair methods [5]. Skin flap transplantation includes local rotation flaps, advancement flaps, free flaps, etc. The appropriate flap type is selected based on the location, size, and shape of the trauma. The skin flap has its own blood supply, resulting in a high survival rate after transplantation. It can effectively repair tissue defects, and the color and texture of the flap are similar to the surrounding skin, resulting in a better postoperative appearance [6]. Skin grafting is suitable for cases where the skin defect is large and cannot be repaired by a skin flap. Both autologous skin grafting and allogeneic skin grafting are options, with autologous skin grafting yielding more ideal results. During the skin grafting process, emphasis is placed on the selection, fixation, and postoperative care of the skin graft to improve the survival rate and appearance quality of the graft. This study compares and analyzes the application effects of cosmetic repair techniques and traditional repair techniques in the treatment of facial trauma, providing a reference for clinical treatment.

2. Materials and methods

2.1. General information

A total of 200 patients with facial trauma who visited our hospital from January 2022 to December 2024 were selected as the research subjects. The patients were randomly divided into an observation group and a control group, with 100 patients in each group. In the observation group, there were 58 males and 42 females, aged between 18 and 62 years, with an average age of 35.62 ± 8.51 years. The causes of injury were as follows: 40 cases due to traffic accidents, 25 cases due to violent conflicts, 18 cases due to work accidents, and 17 cases due to accidents in daily life. In the control group, there were 60 males and 40 females, aged between 19 and 65 years, with an average age of 36.22 ± 9.11 years. The causes of injury were as follows: 38 cases due to traffic accidents, 27 cases due to violent conflicts, 16 cases due to work accidents, and 19 cases due to accidents in daily life. There was no statistically significant difference between the two groups in terms of gender, age, and cause of injury ($P > 0.05$), making them comparable.

Inclusion criteria: (1) Age between 18 and 65 years old; (2) Fresh facial trauma, with the time from injury to consultation within 24 hours; (3) Trauma area greater than 1cm^2; (4) Patients voluntarily signed the informed consent form.

Exclusion criteria: (1) Severe heart, liver, kidney, and other important organ diseases; (2) Coagulation dysfunction or immunocompromised state; (3) Obvious infection at the site of trauma; (4) Mental illness.

2.2. Methods

The control group was treated with traditional facial trauma repair techniques. Initially, routine wound debridement was performed, rinsing the wound with normal saline to remove foreign bodies and necrotic tissue. Then, a thicker silk suture was used for simple suturing to close the wound.

The observation group was treated with cosmetic repair techniques. The specific operations are as follows:

(1) Debridement: Gentle disinfectants such as normal saline, hydrogen peroxide solution, and povidone-iodine were used to repeatedly irrigate the wound surface, thoroughly removing foreign bodies, necrotic tissue, and bacteria. For deep wounds, a microscope or magnifying glass was used to more precisely remove deep contaminants and maximize the protection of normal tissue.

(2) Tissue reduction and reconstruction: Based on the facial anatomical structure, displaced muscles, nerves, blood vessels, and other tissues were accurately repositioned. The ruptured muscles were anastomosed end-to-end, the damaged nerves were repaired or transplanted, and the fractured sites were anatomically reduced and fixed. For tissue defects, autologous tissue transplantation was used for repair.

(3) Suturing: Minimally invasive suturing techniques were employed, using 5-0 or 6-0 absorbable sutures. Following the principle of "tension-free, layered suturing," the subcutaneous tissue was first sutured in layers to distribute skin tension, and then fine skin suturing was performed to ensure precise alignment of skin edges. Special methods such as intracutaneous continuous suturing and mattress suturing were used for specific areas like the eye corners and mouth corners.

(4) Skin flap transplantation and skin grafting: For patients with large trauma or tissue defects, appropriate skin flap transplantation or skin grafting was selected for repair based on the trauma situation.

2.3. Observation indicators

(1) Wound healing time: Record the time from the start of treatment to complete healing of the wound.

(2) Scar score: Use the Vancouver Scar Scale (VSS) to score the scars of the two groups of patients 3 months after surgery. The VSS scale evaluates scars from four dimensions: color, thickness, vascularity, and pliability. The total score ranges from 0–14, with higher scores indicating more pronounced scars.

(3) Patient satisfaction: Three months after surgery, a self-made satisfaction survey questionnaire will be used to investigate the satisfaction of the two groups of patients. The questionnaire includes evaluations of treatment effectiveness, facial appearance, functional recovery, etc., and is divided into three levels: very satisfied, satisfied, and dissatisfied. Satisfaction rate = (number of very satisfied cases + number of satisfied cases) / total number of cases × 100%.

(4) Occurrence of complications: Observe the occurrence of postoperative complications in the two groups of patients, including infection, hematoma, scar hyperplasia, etc.

2.4. Statistical methods

Data were analyzed using SPSS 22.0 statistical software. Measurement data were expressed as mean ± standard deviation (Mean ± SD) and analyzed using the t-test. Count data were expressed as rates (%) and analyzed using the x^2 test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of wound healing time

The average wound healing time in the observation group was 6.23 ± 1.05 days, while the average wound healing time in the control group was 8.76 ± 1.32 days. Comparing the two groups, the difference was statistically significant (t=11.256, *P*=0.000) (**Table 1**).

Table 1. Comparison of wound healing time between the two groups (Mean ± SD, days)

Group	Cases (n)	Wound healing time (days)
Observation Group	100	6.23 ± 1.05
Control Group	100	8.76 ± 1.32
t-value		11.256
P-value		<0.001

3.2. Comparison of scar scores

The average VSS score for patients in the observation group was 2.85 ± 0.76 points, while the average VSS score for patients in the control group was 5.12 ± 1.08 points. The difference between the two groups was statistically significant (t=15.324, *P*=0.000) (**Table 2**).

Table 2. Comparison of VSS scores between the two groups (Mean ± SD, points)

Group	Cases (n)	VSS score (mean ± SD)
Observation Group	100	2.85 ± 0.76
Control Group	100	5.12 ± 1.08
t-value		15.324
P-value		<0.001

3.3. Patient satisfaction survey

Patient satisfaction in the observation group was 90.00% compared to 72.00% in the control group. The difference between the two groups was statistically significant (x^2=12.830, *P*=0.000) (**Table 3**).

Table 3. Comparison of patient satisfaction between the two groups (n, %)

Group	Cases (n)	Very satisfied	Satisfied	Dissatisfied	Satisfaction rate
Observation Group	100	58 (58.00%)	32 (32.00%)	10 (10.00%)	90 (90.00%)
Control Group	100	32 (32.00%)	40 (40.00%)	28 (28.00%)	72 (72.00%)
x^2					12.830
P-value					<0.001

3.4. Analysis of complication rates

The incidence of complications in the observation group was 5.00% compared to 16.00% in the control group. The difference between the two groups was statistically significant (x^2=6.542, *P*=0.007) (**Table 4**).

Table 4. Comparison of complication occurrence between the two groups (cases, %)

Group	Cases (n)	Infection	Hematoma	Hypertrophic scar	Total incidence
Observation Group	100	2 (2.00%)	2 (2.00%)	1 (1.00%)	5 (5.00%)
Control Group	100	7 (7.00%)	5 (5.00%)	4 (4.00%)	16 (16.00%)
x^2					6.542
P-value					0.007

4. Discussion

The greatest advantage of cosmetic plastic surgery lies in its excellent aesthetic results. Through delicate debridement, accurate tissue reduction, and innovative suturing techniques, scar formation can be effectively reduced, allowing the appearance of facial trauma to closely approximate its pre-injury state. The rational application of methods such as skin flap transplantation and skin grafting has further improved the repair of tissue defects after large-area trauma, satisfying patients' pursuit of facial beauty [7]. While emphasizing aesthetic results, cosmetic plastic surgery does not neglect the restoration of facial function. Surgeons' precise handling of muscles, nerves, blood vessels, and other tissues during the surgical process ensures the normal recovery of facial functions such as chewing, speaking, and expressing emotions [8]. Compared with traditional repair techniques, cosmetic plastic surgery is more comprehensive and precise in functional recovery, thereby improving patients' quality of life [9]. The psychological impact of facial trauma on patients cannot be ignored. Cosmetic plastic surgery significantly reduces patients' psychological burden and helps them rebuild their confidence by improving their facial appearance [10]. Adequate communication and psychological support between doctors and patients during the treatment process also help alleviate patients' anxiety and fear, promoting their psychological recovery.

The application of cosmetic surgery repair techniques demands solid anatomical knowledge, superb surgical skills, and rich clinical experience from doctors. There are high requirements for wound assessment, tissue handling, flap design, and the precision of surgical operations, which increase doctors' learning and practical costs and limit the promotion and application of this technology in some primary medical institutions. Due to the need for special instruments and materials such as fine needles and sutures, microscopes, and complex surgical procedures like flap transplantation, the treatment cost of cosmetic surgery repair techniques is relatively high, which may become an obstacle for some patients with poor economic conditions to receive treatment [11]. Compared with traditional repair techniques, the surgical process of cosmetic surgery repair techniques is more complex and delicate, and the operation time is usually longer. Prolonged surgery not only increases the risk of anesthesia for patients but also places higher demands on equipment and staffing in the operating room.

The results of this study showed that the wound healing time in the observation group was 6.23 ± 1.05 days, shorter than that in the control group (8.76 ± 1.32 days) ($P < 0.05$). This is related to the fine debridement of cosmetic surgery repair techniques, which can completely remove foreign bodies and necrotic tissues, reduce the risk of infection, and provide a good environment for wound healing by layered suturing to disperse skin tension and ensure local blood circulation. Studies have shown that precise debridement and reasonable suturing methods can significantly accelerate the wound healing process, which is consistent with the results of this study.

The VSS score of the observation group was 2.85 ± 0.76, lower than that of the control group (5.12 ± 1.08) ($P < 0.05$). The reason is that cosmetic surgery repair techniques adopt minimally invasive suturing, using fine needles and sutures, and following the principles of tension-free and layered suturing, which can accurately align skin edges and reduce scar formation. Traditional suturing techniques are rough and have poor tension control, which can easily lead to scar hyperplasia. This is consistent with the advantages of cosmetic surgery techniques described in relevant literature regarding scar improvement.

The satisfaction rate of the observation group was 90.00%, higher than that of the control group (72.00%) ($P < 0.05$), reflecting patients' emphasis on appearance recovery. Facial aesthetics directly affects psychology and social interaction, and cosmetic repair techniques balance function and aesthetics to meet patient needs. Traditional techniques often result in noticeable scars after surgery, which can easily reduce patient satisfaction.

The incidence of complications in the observation group was 5.00%, lower than that in the control group (16.00%) ($P < 0.05$). This is because the technique involves precise operation, causes less tissue damage, reduces the occurrence of infection and hematoma, and accurate reduction also lowers the risk of scar hyperplasia. Traditional techniques are relatively rough, cause more tissue damage, and increase the probability of complications.

This study has certain limitations. The sample size was only 200 cases, and it was a single-center study, which may introduce bias. Future research should include multi-center, large-sample studies to further validate the results. Additionally, the follow-up time was relatively short, and long-term effects were not adequately observed. Follow-up time should be extended in subsequent studies to improve research quality.

5. Conclusion

In summary, cosmetic repair techniques have significant advantages in the treatment of facial trauma. However, it is also necessary to consider the high technical requirements for doctors and the higher treatment costs. In clinical applications, a reasonable selection should be made based on patient conditions and the medical institution's capabilities to achieve the best treatment effect.

Disclosure statement

The authors declare no conflict of interest.

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Application of AI in the Design of Novel Peptide-based Ingredients for Skincare Products

Youmin Zhu*, Junfeng Zhao, Yuncai Tian

Shanghai AZ Science and Technology Co., Ltd., Shanghai 201109, China

**Author to whom correspondence should be addressed.*

Abstract: This review provides a systematic review of the current applications and developmental trends of artificial intelligence (AI) in the design of novel peptide-based cosmetic ingredients. With rapid advancements in computational biology and artificial intelligence algorithms, the development paradigm for peptide-based skincare products is undergoing a revolutionary shift—from traditional trial-and-error screening to intelligent, precision-driven design. By leveraging machine learning algorithms, deep learning models, and molecular simulation techniques, artificial intelligence has significantly enhanced the efficiency and success rate of peptide ingredient development while reducing associated costs. The review highlights breakthroughs in artificial intelligence applications for peptide molecular design, stability optimization, transdermal delivery prediction, and efficacy evaluation. It also explores the integration of artificial intelligence with interdisciplinary fields such as synthetic biology and nanotechnology, and offers insights into current challenges and future development directions.

Keywords: Artificial intelligence; Peptides; Skincare

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1. Introduction

Peptide compounds, known for their high activity, strong specificity, and excellent safety profile, have become a key focus in the development of anti-aging skincare ingredients. Traditional peptide development has largely relied on trial-and-error screening, a process that is time-consuming, costly, and inefficient—typically taking 3 to 5 years to bring a new peptide ingredient to market. With the rapid advancement of computational biology and artificial intelligence (AI), the development of peptide ingredients has entered a new era of digitalization and intelligence. By leveraging machine learning algorithms, molecular simulations, and big data analytics, researchers can now rapidly predict the relationship between peptide structures and their biological activities, enabling the precise design of active peptides that target key pathways involved in skin aging [1].

2. Core technologies of AI-assisted peptide design

The application of AI technology in peptide design primarily relies on machine learning, molecular docking, and big data analysis. Machine learning builds predictive models by analyzing vast datasets of known peptides, including their sequences, structures, and biological activities. Commonly used algorithms include convolutional neural networks (CNN), recurrent neural networks (RNN), and generative adversarial networks (GAN). Molecular docking simulates, through computational methods, the interactions between peptides and target proteins—such as collagen, elastin, or inflammatory factors—to predict binding affinity and biological activity. Big data analysis involves advanced tools and techniques to process and interpret large-scale datasets, enabling the design and optimization of peptide structures. For instance, Dong et al. leveraged AI-assisted design to develop an antimicrobial peptide that demonstrated potent and selective inhibition against *Cutibacterium acnes*, achieving a minimum inhibitory concentration (MIC) of 2–4 μg/mL. These designed peptides show strong potential as promising candidates for acne treatment [2].

3. Application of AI in the development of peptide-based ingredients for skincare products

3.1. Target discovery and molecular design

AI technology can analyze vast biomedical databases to identify key targets and pathways involved in skin aging, enabling the design of targeted peptide molecules. WIS's R&D team has integrated AI-driven design with automated synthesis platforms to establish a triad system for cyclic peptide discovery—virtual screening, intelligent synthesis, and activity validation. By leveraging machine learning algorithms to simulate tens of thousands of peptide folding pathways, this system dramatically enhances the efficiency of candidate molecule selection. The Aging Science Innovation Research Center at Zhejiang Tsinghua Yangtze River Delta Research Institute utilized a computational biology platform to uncover HMGB1, a critical target in inflammatory aging, and subsequently designed cIY-8, a cyclic peptide that specifically targets inflammatory aging—the first such cyclic peptide molecule to directly address this aging mechanism [3].

3.2. Stability optimization

Peptide stability is a critical factor limiting its efficacy in practical applications. By leveraging molecular modifications and structural optimization, AI-driven approaches have effectively addressed these challenges. Cyclic peptides, with their closed-loop molecular architecture, offer enhanced stability in theory. Utilizing ADCP docking technology combined with the ADFR suite, Yang et al. identified a series of novel cyclic peptides targeting JAK1, Keap1, and TGF-β proteins. Among them, MKC1 demonstrated the most promising anti-aging activity. At a concentration of just 0.001%, MKC1 achieved a 20% reactive oxygen species (ROS) clearance rate and significantly upregulated the expression of type I collagen and elastin genes [4].

3.3. Optimization of transdermal delivery

AI enables the prediction and design of peptide molecules with enhanced skin barrier penetration through high-throughput screening, molecular simulation, and bioinformatics analysis. Furthermore, AI can simulate the distribution and transport behavior of peptides within the skin, guiding researchers in refining key physicochemical properties—such as solubility, permeability, and stability—to improve transdermal efficiency and bioavailability. For instance, Shandong Jitai Peptide Biotechnology Co., Ltd. has developed dendritic spherical peptides using an

AI-powered computational biology platform. These peptides feature a three-dimensional "tree-like" or protein-mimicking globular structure, designed to strengthen affinity with the skin's stratum corneum and significantly enhance skin penetration.

3.4. Formulation design and synergistic efficacy

AI technology is not only applied in the design of individual peptide ingredients but also plays a pivotal role in developing peptide combinations. By analyzing synergistic interactions among different peptides, AI enables optimization of formulation ratios to maximize efficacy. Studies have shown that the combination of acetyl dipeptide-1 cetyl ester, acetyl tetrapeptide-2, and Pseudoalteromonas ferment extract significantly enhances the mRNA expression of Col-I, LOXL-1, Elastin, Fibrillin-1, Fibulin-5, and TGF-β in HFF-1 cells, demonstrating strong anti-aging activity through synergistic effects [5].

4. Challenges and limitations

Although AI technology shows great promise in the design of peptide-based cosmetic ingredients, it still faces several challenges. Training AI models requires large volumes of high-quality, standardized data. However, the cosmetics industry currently lacks a unified standard for peptide activity data, and differences in testing methods and reporting practices across laboratories can compromise the accuracy and reliability of AI models. Many deep learning models function like "black boxes"—while their predictions may be accurate, they often fail to provide biologically meaningful explanations, making it difficult for researchers to fully trust AI-generated designs. This limits the broader application of AI in peptide development. Although AI can significantly shorten the initial design phase, experimental validation of peptide candidates still demands extensive in vitro and in vivo testing, which remains time-consuming and costly. Moreover, novel peptide ingredients designed by AI may encounter regulatory hurdles, especially when their mechanisms of action differ substantially from traditional ingredients, necessitating the establishment of new safety and efficacy evaluation criteria. Skin aging involves multiple signaling pathways and molecular targets, and peptides may exert effects through diverse mechanisms. This complexity makes it challenging for AI models to fully capture all relevant biological factors [6].

5. Future development directions

With continuous technological advancements, the application of AI in the design of peptide-based skincare ingredients is evolving toward the integration of multi-omics technologies, automation, high-throughput processing, personalized customization, sustainability, and cross-disciplinary technological convergence. By integrating multi-omics data—such as genomics, proteomics, and metabolomics—more comprehensive biological models of skin aging can be constructed, providing AI with a richer and more robust data foundation. When combined with automated synthesis and high-throughput screening, AI-driven design enables a closed-loop development system. Leveraging individual skin characteristics, gene expression profiles, and environmental factors, AI can tailor personalized peptide formulations. Deep integration of AI with cutting-edge fields like synthetic biology and genetic engineering will drive cosmetic ingredient innovation from single-function solutions into an era of "precision customization." Furthermore, AI can help design greener, more sustainable peptide production processes, minimizing chemical usage and energy consumption, aligning with the beauty industry's growing emphasis on environmental responsibility [7].

6. Summary and prospect

The application of AI in the design of novel peptide-based cosmetic ingredients is fundamentally transforming the research paradigm and accelerating innovation within the beauty industry. By leveraging machine learning algorithms, molecular simulations, and big data analytics, AI enables the efficient development of peptide molecules with high bioactivity, stability, and skin permeability—significantly shortening development timelines and reducing costs. Several AI-designed anti-aging peptides have already been commercialized, including dendritic sphere peptides, recombinant humanized type V collagen, and cyclic decapeptides, which demonstrate remarkable efficacy in targeted anti-aging, emotional skincare, hydration, and skin barrier repair. Nevertheless, challenges remain in data quality, algorithm interpretability, and the complex mechanisms underlying peptide functionality. Looking ahead, as multi-omics integration, automated experimental platforms, and personalized formulation strategies continue to advance, AI will play an increasingly pivotal role in cosmetic peptide development. Meanwhile, the industry must establish unified data standards, validation protocols, and regulatory frameworks to ensure the safety, effectiveness, and reliability of AI-designed ingredients. The deep integration of AI with cosmetic raw material development will drive the industry's evolution from "manufacturing" to "intelligent creation", delivering more effective, precise, and safer anti-aging solutions to consumers.

Disclosure statement

The authors declare no conflict of interest.

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Development, Classification, Application, and Research Progress of Modern Skin Photoaging Assessment Tools

Ruini Yang, Zhi Yang*

The First Affiliated Hospital of Kunming Medical University, Kunming 650000, Yunnan, China

**Author to whom correspondence should be addressed.*

Abstract: Skin photoaging, a degenerative process caused by ultraviolet radiation, plays a pivotal role in clinical diagnosis and anti-aging research. This paper systematically reviews the evolution of skin photoaging assessment tools, tracing their development from traditional clinical scoring systems to modern imaging technologies, biomarker detection, and AI-assisted analysis. It provides detailed categorization, application scenarios, and comparative evaluations of these methodologies. The study reveals that single-assessment tools have inherent limitations, while multimodal integrated evaluation has emerged as the prevailing approach. Future efforts should focus on integrating molecular biology and AI technologies to establish a more precise photoaging assessment framework.

Keywords: Skin photoaging; Evaluation tools; Imaging technology; Biomarkers; Artificial intelligence

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1. Introduction

Skin photoaging, a degenerative condition caused by prolonged exposure to ultraviolet radiation (UVR), has become a major global concern in dermatology. Characterized by visible wrinkles, uneven pigmentation, loss of elasticity leading to sagging skin, and redness from dilated capillaries, this condition not only affects appearance and causes psychological distress but also imposes significant economic burdens worldwide. Statistics indicate annual global medical expenditures exceeding tens of billions of dollars due to photoaging, with its close association to skin cancer risk further highlighting the urgency for solutions. In this context, accurate assessment of skin photoaging severity proves crucial. It serves as the foundation for personalized treatment plans tailored to individual conditions, monitors treatment efficacy in real-time, and reveals biological mechanisms underlying aging processes. Recent advancements in optical technology, molecular biology, and AI have revolutionized photoaging evaluation. Assessment methods have transitioned from subjective physician evaluations to objective quantitative analysis using advanced instruments, while parameters now encompass multimodal integration to holistically evaluate skin characteristics. This paper aims to systematically summarize the classification, application, and research progress of existing evaluation tools, deeply analyze their advantages and shortcomings, and discuss their future development direction on this basis, so as to provide a reference for promoting the further development of skin photoaging evaluation.

2. Traditional clinical evaluation methods

2.1. Descriptive scoring method

The early photoaging assessment system was established based on clinicians' empirical judgments, using descriptive language to grade characteristics such as skin wrinkles, pigmentation, and loss of elasticity. The most representative Glogau classification (1987) divides photoaging into four types: Type I presents as wrinkle-free and smooth skin, commonly seen in young adults aged 20–30; Type II shows dynamic wrinkles (e.g., crow's feet), predominantly observed in people aged 30–40; Type III features static wrinkles accompanied by rough skin texture and telangiectasia, typically seen in individuals over 50; Type IV exhibits leathery changes with only wrinkles remaining without normal skin texture. Although this method is simple to operate, its significant subjective bias remains evident. Wang et al. (2024) found in organoid model studies that inter-patient scoring variations could reach 37%, and they fail to quantify molecular changes like dermal collagen degradation and elastic fiber rupture. This qualitative assessment approach leads to poor comparability across center-based studies. For instance, when evaluating the same group of subjects, Asian physicians tend to underestimate pigmentation severity, while Western physicians may overestimate wrinkle severity.

2.2. Standardized image scoring method

To enhance evaluation objectivity, researchers developed a standardized photo-based scoring system in the 1990s. The Larnier 6-point scale categorizes severity from 1 (no visible photoaging) to 6 (severe leather-like changes) by comparing with a standard photoaging database. A longitudinal study by Marks et al. (2022) involving 140 Caucasian women using the Visual Analog Scale (VAS) assessment showed an intra-group correlation coefficient (ICC) of 0.82, significantly outperforming the traditional descriptive method's 0.59. However, image scoring remains vulnerable to limitations: photoaging conditions (e.g., color temperature variations) may introduce 5%–15% scoring errors; measurement errors in wrinkle length increase to 23% when photographic angles deviate by over 15°; and observer differences (e.g., between dermatology residents and attending physicians) reduce Kappa values from 0.71 to 0.58. Additionally, this method cannot distinguish between natural aging and photoaging, and its applicability has not been validated for Fitzpatrick IV-VI skin types.

2.3. Local analysis

The traditional evaluation system faces three core limitations that hinder its clinical application: First, the highly subjective nature of assessments leads to significant variability in results. Multicenter studies show that different evaluators may rate the same case by 30%–45%, while even the same evaluator's scores can vary by over 15% across different time periods. Second, there is a notable lack of parameter diversity. Current scoring systems primarily focus on wrinkles (78%) and pigmentation (62%), while critical indicators like skin elasticity (12%), thickness (8%), and microcirculation (5%) are often overlooked. Third, the system's dynamic monitoring capability is inadequate. Traditional methods cannot achieve real-time tracking, such as the 4–8 week interval required for evaluating photodynamic therapy responses, making it difficult to detect early molecular changes.

Wang et al. (2023) found through machine learning analysis that traditional scoring methods have a predictive accuracy rate of only 61% for treatment responses, significantly lower than the 89% achieved by imaging omics. Traditional clinical evaluation methods are shown in **Figure 1**.

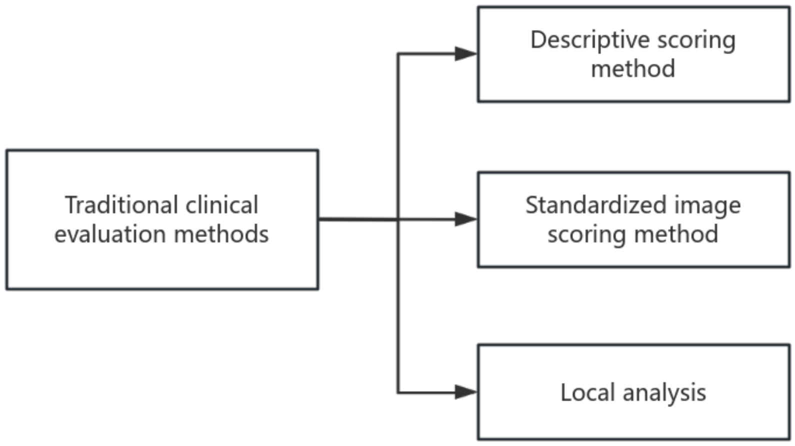

Figure 1. Traditional clinical evaluation method

3. Modern clinical evaluation methods

3.1. Skin mirror and reflected confocal microscope (RCM)

Skin microscopy utilizes polarized light to penetrate the epidermis, providing clear visualization of superficial dermal structures. Its 50–100x magnification capability detects capillary dilation as small as 0.1 mm and early-stage pigmentation, achieving 82% sensitivity in diagnosing photoaging. RCM technology enhances resolution to 1μm, dynamically monitoring collagen structure changes to assess photoaging progression. Royo et al. (2024) conducted RCM tracking on 30 hyaluronic acid-filled patients, revealing irregular honeycomb patterns (47% area increase) and dense fiber accumulation (32% density reduction) in photoaged skin. However, this technique has imaging depth limitations (limited to 150μm in the superficial dermis) and a time-consuming operation—requiring 7–10 minutes per image capture with high technical demands. The newly developed rapid scanning RCM improves imaging speed to 2 minutes per image, though it increases equipment costs by 2.3 times.

3.2. Optical coherence tomography (OCT)

OCT generates three-dimensional skin structure images based on the principle of light interference, achieving a resolution of 1–15 μm. It can display epidermal thickening (a characteristic change of photoaging) and flattened dermo-epidermal junctions in real time. Yang Rui et al. (2018) combined full open single-side MRI technology to find that photoaged skin exhibited an average epidermal thickness increase of 28 μm ($P < 0.01$) and a 67% disappearance rate of dermal papillary layers. OCT's advantages lie in being non-invasive and rapid (<1 minute per image), but its penetration depth is limited to approximately 2 mm, making it difficult to assess deep dermal changes. The latest frequency-domain OCT extends the wavelength to 1300 nm, increasing penetration depth to 3mm while causing a 40% signal attenuation rate. Clinical applications show OCT achieves 85% diagnostic accuracy for early-stage photoaging, but sensitivity drops to 62% for stage IV photoaging.

3.3. High-frequency ultrasound and shear wave elastography of skin

High-frequency ultrasound (20–50 MHz) is used to assess photoaging by measuring skin thickness and echo intensity. A 2020 study by Mataix et al. on residents in high-altitude regions found that their photoaged skin had 15% thinner layers (P = 0.003) and 28% higher echo attenuation rates compared to those in lowland areas. Shear wave elastography provides objective indicators by quantifying tissue stiffness (elastic modulus), with research showing photoaged skin's elastic modulus increased by 22% (95% CI: 18%–26%). While this technique is easy to operate, it has lower resolution (approximately 50 μm) and is significantly affected by probe pressure (each additional N of pressure increases the thickness measurement error by 7%). The newly developed acoustic radiation force pulsed imaging (ARFI) reduces pressure interference but costs 1.8 times more than traditional ultrasound equipment.

3.4. Multiphoton microscopy and Raman spectroscopy

Multiphoton microscopy utilizes two-photon excitation fluorescence technology to visualize collagen fiber arrangements in the dermis (with a resolution of 0.5 μm), demonstrating 91% sensitivity for early-stage photoaging diagnosis. Raman spectroscopy quantifies advanced glycation end products (AGEs) by detecting molecular vibration patterns. A.F.M. P et al. (2021) found that carboxymethyl lysine (CML) levels in photoaged skin were three times higher than those in naturally aged skin (P < 0.001), suggesting Raman spectroscopy could serve as a molecular biomarker for photoaging. However, this technique requires expensive equipment (over 2 million yuan per unit) and specialized operation (training period>6 months). The latest portable Raman probes can reduce detection time to 30 seconds per spot, but at the cost of a 40% decrease in spectral resolution. Modern clinical evaluation methods are shown in **Figure 2**.

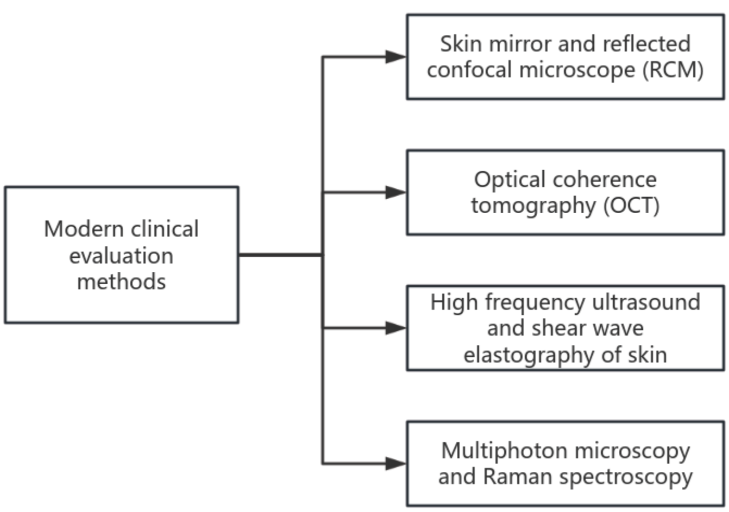

Figure 2. Modern clinical evaluation methods

4. Development and classification of skin photoaging assessment tools

4.1. Visual assessment

Visual assessment, the most intuitive method for evaluating skin photoaging, involves trained professionals observing visible changes in skin appearance to determine severity. Key indicators include skin laxity (sagging, elasticity loss), wrinkle quantity/depth (dynamic/static), pigmentation spot size/distribution, and capillary dilation visibility. Widely used in dermatology, it offers simplicity and cost-effectiveness, requiring only basic tools for rapid screening in large-scale health surveys. However, limitations persist: subjective interpretation varies with observer expertise, reducing consistency. Early-stage photoaging changes may escape detection due to low sensitivity, and the lack of quantitative data hinders precise severity tracking or treatment efficacy evaluation. Despite these drawbacks, it remains practical for preliminary assessments across healthcare levels [1–2].

4.2. Visia skin detection system

The Visia Skin Detection System, a non-invasive tool utilizing advanced optical imaging technology, plays a vital role in skin photoaging assessment. This system employs multispectral imaging to comprehensively analyze various critical skin indicators. It not only evaluates surface conditions but also captures deep-layer visual information, delivering detailed reports on spots, wrinkles, texture, pores, UV-induced pigmentation, brown spots, redness zones, and porphyrin deposits [3]. Through this comprehensive data, dermatologists can more accurately assess photoaging severity and potential issues, providing robust evidence for developing personalized treatment plans.

The Visia skin assessment system excels in four key areas: comprehensive analysis of surface imperfections and deep structural changes, objective digital evaluation minimizing human error, quantitative metrics enabling precise tracking, and visual reports enhancing provider-patient communication. This integrates holistic insights, facilitates treatment adjustments, and encourages patient engagement in skincare [4].

While the Visia skin testing system demonstrates multiple advantages, it faces notable limitations. The primary constraint lies in its high cost, with substantial upfront expenses for equipment procurement and significant ongoing investments required for maintenance and upgrades [5]. These financial burdens make it challenging for grassroots medical institutions to adopt the system, thereby limiting its widespread implementation at the primary healthcare level. Operational complexity also poses challenges, as mastering the system's interface and interpreting test results requires specialized training in optical principles and dermatological theories. This demands high professional competence from operators, which increases operational complexity. Furthermore, the system's sensitivity to ambient lighting conditions means that improper lighting environments may compromise image quality and result in inaccurate assessments. Therefore, maintaining stable and suitable lighting conditions during testing significantly elevates operational complexity and technical requirements [6].

4.3. Other evaluation methods

4.3.1. Molecular biology assessment

Molecular biology evaluation tools play a central role in the study of skin photoaging, providing a powerful means to further explore the intrinsic molecular mechanisms of skin photoaging. In recent years, many studies have made a series of breakthroughs by using advanced molecular biology techniques.

A study by Gu Y et al. (2025) focused on the substance Isovitexin. Through rigorous experiments, they discovered that Isovitexin can effectively alleviate photoaging in skin caused by oxidative stress by inhibiting cellular aging processes [1].

Wang Y et al. (2025) investigated stem cell-derived exosomes from human adipose tissue. Their study demonstrated that these exosomes can reduce mitochondrial DNA loss through the PINK1/Parkin-mediated autophagy pathway. As the powerhouses of cellular energy, mitochondria play a vital role in maintaining the normal physiological functions of skin cells [7].

4.3.2. Cell biology evaluation

Cell biology evaluation tools focus on the direct observation of skin cells under the action of ultraviolet radiation and other factors, which can directly reflect the cellular effects of skin photoaging.

Hu C et al. (2025) conducted research focusing on recombinant human collagen injections. Experiments revealed that these injections regulate the skin's local immune microenvironment through immunomodulatory mechanisms, reducing inflammation-induced skin damage. Simultaneously, they enhance collagen production and increase elastic fiber content in the skin, effectively addressing issues like skin laxity and wrinkles caused by photoaging [8].

Wu L et al. (2025) innovatively developed a thermosensitive hydrogel transdermal delivery system for salvianolic acid B to address skin photoaging. As a novel drug carrier, this hydrogel undergoes phase transition under body temperature conditions, enabling precise drug release [9].

4.3.3. Biochemical evaluation

Biochemical assessment tools mainly detect biomarkers related to skin photoaging to quantitatively assess the degree of skin photoaging. These biomarkers can reflect the physiological and pathological changes in the skin after exposure to ultraviolet radiation.

A study by Han B et al. (2025) demonstrated that spirulina polysaccharides exhibit significant protective effects against UV-induced skin photoaging. Biochemical analysis revealed that these compounds regulate intracellular redox balance, reduce oxidative stress products, and enhance antioxidant enzyme activity, thereby mitigating UV-induced oxidative damage to skin cells [10].

Ma Y et al. (2025) investigated the protective effects of carotenoids against skin photoaging. As a crucial natural antioxidant, carotenoids play a vital role in eliminating free radicals and reducing photodamage within the skin. Through biochemical evaluation methods, the study revealed that carotenoids regulate signaling pathways in skin cells and inhibit the release of inflammatory factors [11].

4.3.4. Histological evaluation

Histological evaluation tools use microscopes and other equipment to observe the skin tissue section, which can directly present the histopathological changes caused by skin photoaging, and provide an important basis for an in-depth understanding of the histological characteristics of skin photoaging.

Liu J et al. (2025) investigated the effects and mechanisms of collagen peptides and elastin peptides on UV-induced photoaging in skin cells. Through detailed histological analysis of skin tissues, they demonstrated that UV radiation causes collagen and elastic fiber damage with disordered alignment, leading to loss of skin elasticity and firmness [12].

4.3.5. Imaging evaluation

Imaging evaluation tools play an increasingly important role in skin photoaging assessment due to their non-invasive advantages. Optical coherence tomography (OCT) is a representative imaging technology.

Guida S et al. (2025) conducted a comparative study integrating OCT with other non-invasive imaging modalities to analyze atrophic and hypertrophic skin photoaging. OCT technology provides high-resolution cross-sectional images of skin tissues, clearly revealing structural changes across different layers. Through comprehensive analysis of these images alongside other imaging features, the research revealed distinct characteristic patterns in OCT-derived images for various types of photoaged skin [13].

4.3.6. Exosome biology evaluation

Exosome biology assessment tool, as an emerging research direction in recent years, has been increasingly valued in the study of skin photoaging. Exosomes are small vesicles secreted by cells, which can carry a variety of bioactive molecules and play an important role in intercellular communication.

Li K et al. (2025) demonstrated the crucial role of exosome lncRNAs in regulating apoptosis and inflammation during UV-induced skin photoaging. The study revealed that UV radiation alters the expression profiles of lncRNAs in skin exosomes. These abnormally expressed lncRNAs influence apoptosis and inflammatory responses by modulating downstream signaling pathways, thereby contributing to the development of skin photoaging [14]. This discovery provides a novel perspective for understanding the intercellular communication mechanisms underlying skin photoaging.

Liu L et al. (2025) conducted an in-depth investigation into the activation mechanism of the 5’-tiRNA-His-GTG-mediated JNK pathway in skin photoaging. The study demonstrated that 5’-tiRNA-His-GTG, as a novel small-molecule RNA, can be delivered between cells via exosomes to activate the JNK pathway, triggering a series of cellular responses that ultimately lead to skin photoaging [15]. This research further enriches the content of exosome biology evaluation in skin photoaging studies, providing theoretical support for developing novel exosome-based assessment methods and therapeutic strategies. The development framework of the skin photoaging assessment tool is shown in **Figure 3**.

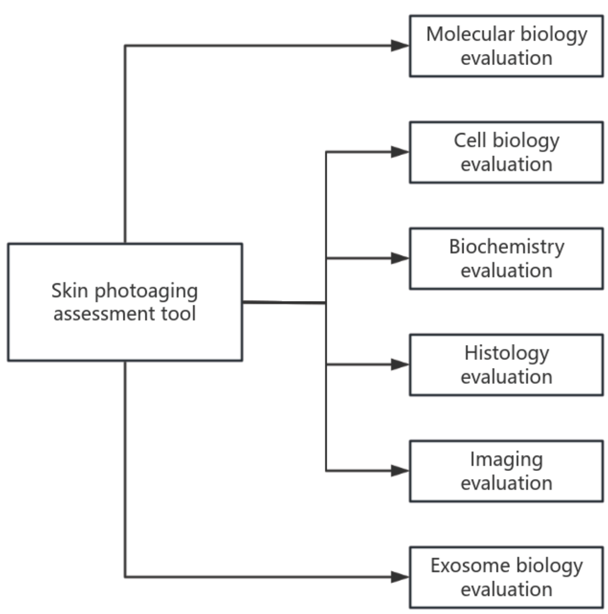

Figure 3. Development framework of skin photoaging assessment tools

5. Conclusion

The evaluation tools for skin photoaging have evolved through a developmental journey from subjective descriptions to objective quantification, and from single-parameter measurements to multimodal integration. Traditional clinical scoring methods, while easy to operate, remain highly subjective. Modern imaging technologies, though non-invasive and high-resolution, come with higher costs. Biomarker detection can reveal molecular mechanisms but requires invasive sampling. Artificial intelligence has enhanced analytical efficiency and accuracy. Moving forward, integrating molecular biology with engineering technology will enable the development of more sensitive, specific, and user-friendly assessment tools, providing scientific evidence for the prevention and treatment of photoaging.

Disclosure statement

The authors declare no conflict of interest.

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Observation on the Clinical Efficacy of Microneedle Radiofrequency Combined with Bear Bile Powder in the Treatment of 40 Cases of Moderate to Severe Acne

Yansheng Zeng, Weihua Zeng, Zhuli Chen, Suhong Liu, Xuesheng Zhang

Ganzhou Dermatosis Hospital, Ganzhou 341000, Jiangxi, China

Abstract: *Objective*: To observe the clinical efficacy of microneedle radiofrequency combined with bear bile powder in the treatment of 40 cases of moderate to severe acne. *Methods*: 80 patients with moderate to severe acne admitted from July 2020 to July 2023 were selected as the study subjects. They were divided into two groups using a random number table method. The control group (40 patients) received microneedle radiofrequency treatment alone, while the observation group (40 patients) received a combination of microneedle radiofrequency and bear bile powder treatment. The treatment effects, skin lesion conditions [Global Acne Grading System (GAGS)], and adverse reactions were compared between the two groups. *Results*: The total effective rate of the observation group was 100.00%, which was higher than 87.50% of the control group ($P < 0.05$). After 4, 8, and 12 weeks of treatment, the GAGS scores of the observation group were lower than those of the control group ($P < 0.05$). There was no difference in the incidence of adverse reactions between the two groups ($P > 0.05$). *Conclusion*: Microneedle radiofrequency combined with bear bile powder can effectively treat moderate to severe acne, improve skin lesion conditions, and ensure treatment safety.

Keywords: Moderate to severe acne; Microneedle radiofrequency; Bear bile powder

Online publication: October 17, 2025

1. Introduction

Acne vulgaris is a common skin disease and a chronic inflammatory disease of the pilosebaceous unit. Although it does not pose a threat to life safety, it can significantly affect facial aesthetics and induce psychological issues, such as long-term anxiety, feelings of inferiority, unease, and loss of self-confidence [1]. Currently, there are various treatment methods for acne, including oral or topical medications, laser therapy, and microneedle radiofrequency. For moderate to severe acne, monotherapy with oral or topical medications can achieve certain effects, but the recurrence rate is high, and the possibility of complete recovery is small. Microneedle radiofrequency is a medical aesthetic laser technology that directly targets multiple tissues, such as the sebaceous glands, destroying sebum, killing and inhibiting pathogenic bacteria such as Propionibacterium acnes, reducing skin inflammation, and achieving effective treatment [2]. Nowadays, monotherapy with medications or microneedle radiofrequency is common, while the combination of microneedle radiofrequency and medications is rare, especially studies on the combination of microneedle radiofrequency and oral bear bile powder. Based on this, this study selected 80 patients with moderate to severe acne to explore the efficacy of microneedle radiofrequency combined with bear bile powder. The report is as follows.

2. Materials and methods

2.1. General Information

The study was approved by the medical ethics committee, and patients signed informed consent forms. The sample size of the observation group and the control group was calculated using the formula n1=n2=2[(uα+uβ)/(δ/σ)]2 +0.25uα2. Based on the literature review, the estimated sample size was obtained as n1=n2=35 cases. However, considering that patients may switch to other treatment options or withdraw from the study due to various reasons during the study period, the sample size was increased to 40 cases per group, with a total sample size of 80 cases. All 80 patients were diagnosed with moderate to severe acne and were admitted to the hospital for treatment from July 2020 to July 2023. They were randomly divided into two groups using a random number table method, with 40 patients in each group.

Control group: 10 males and 30 females, aged 18–43 years old, with an average age of 30.89 ± 3.76 years old. The duration of the disease ranged from 6–42 months, with an average of 24.36 ± 4.71 months. There were 28 cases of moderate severity and 12 cases of severe severity. The skin lesion area ranged from 62–108 cm^2, with an average of 85.34 ± 6.82 cm^2. Observation group: 7 males and 33 females, aged 18–42 years old, with an average age of 30.25 ± 3.51 years old. The duration of the disease ranged from 6–44 months, with an average of 25.67 ± 4.94 months. There were 24 cases of moderate severity and 16 cases of severe severity. The skin lesion area ranged from 61–111 cm^2, with an average of 86.81 ± 6.99 cm^2. There was no difference in gender, age, or other information between the groups ($P > 0.05$).

Inclusion criteria: (1) Meet the diagnostic criteria in the "Chinese Acne Treatment Guidelines (2019 Revision)" [3]; (2) Age ≥ 18 years old; (3) No acne treatment was performed in the past month before the study; (4) Have indications for micro-needle radio frequency and bear bile powder treatment; (5) Understand the research content, treatment time, and precautions.

Exclusion criteria: (1) Have other wounds or sensitive skin on the face; (2) Have mental illness; (3) Have metal foreign bodies in the treatment area; (4) Have a history of keloid scars or hypertrophic scars; (5) Have a history of pigment loss or post-inflammatory pigmentation; (6) Have simple acne; (7) Have a pacemaker implanted in the heart; (8) Use other treatment options without permission, or give up treatment halfway.

2.2. Methods

Control group: Micro-needle radio frequency treatment was used alone. The treatment process and precautions were introduced verbally beforehand, and photos were taken before the treatment. Patients were instructed to clean their faces, apply a uniform and appropriate amount of topical anesthetic cream, which was then wiped off with a wet tissue after 30 minutes, and the face was cleaned and disinfected again. An acne needle was used for local needle cleaning, and electrode patches were attached to the patient's back. Based on the depth of the skin lesion, 2 mm/3.5mm single-needle tips were selected. The micro-needle was inserted vertically into the skin lesion until the limiter touched the skin, and radiofrequency treatment was applied. The pulse width was adjusted to 150-250 ms and the power to 4-6W based on the actual response of the treatment and pain areas. The insulated needle was removed, and the procedure was repeated on the next skin lesion. During micro-needle radiofrequency, the needle was inserted as vertically as possible, with an interval of 2–3 mm between insertion points on the skin lesion. After completing the micro-needle radiofrequency treatment, a medical repair mask was provided to fully soothe the facial skin. The treatment was administered once every 4 weeks for a total of 3 times.

Observation group: Combined treatment with bear bile powder was used. The hospital prepared the bear bile powder according to a self-developed formula. It was ground into fine powder and packaged, with 25g per bag. The patients were instructed to take 1 bag 3 times a day before meals, mixed with warm water, for a continuous treatment of 12 weeks.

2.3. Observation indicators

(1) Treatment effect [4]: The reduction rate of lesion area was calculated using the formula: (lesion area before treatment - lesion area after treatment) ÷ lesion area before treatment × 100%. Markedly effective: reduction rate of lesion area > 70%; Effective: reduction rate of lesion area 30%-70%; Ineffective: reduction rate of lesion area < 30%; Total effective rate = (markedly effective + effective) ÷ total number of cases × 100%.

(2) Skin lesion condition: The Global Acne Grading System (GAGS) was used to evaluate multiple acne-prone areas such as the forehead, left cheek, right cheek, chin, and nose [5]. The lesion score represented the specific score of the area with the most severe inflammatory reaction. No lesions: 0 points; Visible ≥1 comedones: 1 point; Visible ≥1 pustules: 2 points; Visible ≥1 papules: 3 points; Visible ≥1 nodules: 4 points. The total score of the lesion area was calculated as the factor score multiplied by the lesion score. The comprehensive score was obtained by summing the total scores of each lesion area. Acne grading was performed based on the comprehensive score: 1–18 points for mild, 19–30 points for moderate, 31-38 points for severe, and ≥39 points for very severe.

(3) Adverse reactions: Dryness, burning sensation, desquamation, and pain.

2.4. Statistical methods

Comparative analysis was performed using SPSS 26.0. Enumeration data were expressed as percentages (%) and analyzed using the x^2 test. Measurement data followed a normal distribution and were analyzed using the t-test (or F-test). A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of therapeutic effects between the two groups

The total effective rate was calculated, with the observation group showing a higher rate of 100.00% compared to the control group's 87.50% ($P < 0.05$) (**Table 1**).

Table 1. Comparison of therapeutic effects between the two groups (n/%)

Group	Markedly effective (n)	Effective (n)	Ineffective (n)	Total effective rate (%)
Observation group (*n*=40)	29	11	0	100.00
Control group (*n*=40)	17	18	5	87.50
x^2 value	-	-	-	5.333
P-value	-	-	-	0.021

3.2. Comparison of skin lesions between the two groups

After 4, 8, and 12 weeks of treatment, the GAGS score was lower in the observation group compared to the control group ($P < 0.05$) (**Table 2**).

Table 2. Comparison of skin lesions between the two groups (Mean ± SD, score)

Group	Before treatment	After 4 weeks	After 8 weeks	After 12 weeks
Observation group (n=40)	35.87 ± 4.76	26.05 ± 3.45	19.56 ± 2.85	13.42 ± 2.55
Control group (n=40)	35.21 ± 4.51	30.17 ± 3.87	24.56 ± 3.06	17.08 ± 2.84
t-value	0.637	5.026	7.562	6.065
P-value	0.526	<0.001	<0.001	<0.001

3.3. Comparison of adverse reactions between the two groups

The incidence of adverse reactions was calculated, and there was no difference between the two groups ($P > 0.05$) (**Table 3**).

Table 3. Comparison of adverse reactions between the two groups (n/%)

Group	Dryness (n)	Burning (n)	Desquamation (n)	Pain (n)	Adverse reaction rate (%)
Observation group (*n*=40)	1	1	1	1	10.00
Control group (*n*=40)	1	1	1	0	7.50
x^2 value	-	-	-	-	0.157
P-value	-	-	-	-	0.692

4. Discussion

The onset of acne is associated with excessive sebum secretion, excessive androgen secretion, infection by pathogenic bacteria such as Propionibacterium acnes, and blockage of follicular sebaceous ducts [6]. After entering puberty, androgen secretion rapidly increases, and testosterone promotes the production and secretion of large amounts of sebum. If the follicular sebaceous ducts undergo abnormal keratinization, it can lead to blockage of local sebaceous ducts, affecting the normal excretion of sebum and ultimately resulting in acne. Patients with mild acne have minor symptoms and a limited number of skin lesions, and can achieve complete recovery after appropriate treatment. However, patients with moderate to severe acne often have more pronounced acne lesions that affect facial aesthetics and have higher treatment requirements, especially female patients. Micro-needle radiofrequency has been applied in the treatment of various facial diseases in recent years, including moderate to severe acne, wrinkles, acne scars, and atrophic scars. Generally, no special treatment is required for the use of micro-needle radiofrequency in the treatment of moderate to severe acne. However, if the patient's condition is special and the skin is too sensitive, special treatments such as sedation and analgesia may be considered [7]. Accurate operation of micro-needle radiofrequency is key to ensuring efficacy. During the treatment process, it is necessary to ensure that the needle remains in the sebaceous follicles, which requires high proficiency in the operator's business skills and ion system operation abilities. Bear bile powder is mostly used in the clinical treatment of neurological diseases and is less commonly used in the treatment of skin diseases such as acne. However, the pharmacological effects of bear bile powder indicate that it has a bitter taste and cold properties, with strong heat-clearing and detoxifying effects. It can be used to treat chronic inflammatory diseases of the follicular sebaceous glands, such as acne vulgaris [8].

Zhai Hanyue et al. studied and verified the effect of microneedle radiofrequency combined with minocycline hydrochloride in the treatment of moderate to severe acne on the face, and believed that the combined treatment had a definite curative effect, high safety, and was worthy of promotion [9]. Hu Huimin et al. believed that the combination of a microneedle radiofrequency acne treatment device and collagen dressing could effectively improve the condition of moderate to severe acne, reduce skin lesion symptoms, and ensure efficacy and safety [10]. Combining the above studies, it can be seen that moderate to severe acne is mostly treated with microneedle radiofrequency and drug combination therapy nowadays, and most patients can obtain satisfactory results. In this study, 80 patients with moderate to severe acne were selected for research and analysis. Compared with microneedle radiofrequency monotherapy, the combined treatment effect of microneedle radiofrequency and bear bile powder was analyzed through a comprehensive analysis of total treatment efficiency, GAGS score, and incidence of adverse reactions. The results showed that the treatment effect and GAGS score of the observation group were better than those of the control group, and the adverse reactions of the two groups were comparable. It can be seen that the combined treatment can exert a synergistic effect, achieve internal and external treatment, so the treatment effectiveness and safety are better, and it is worthy of promotion. However, the effect of microneedle radiofrequency in the treatment of acne has been clinically confirmed, and there are few studies on bear bile powder. Bear bile powder is only effective for acne in some cases, and it is not a specific drug for acne. Therefore, the treatment effect of acne varies with different types and severity of acne, which should be fully considered in clinical practice for the rational use of bear bile powder.

This study has limitations. The observation period for patients was relatively short, and there was a lack of observation indicators, such as recurrence rate. The recent effects and prognosis of combined therapy with micro-needle radiofrequency and bear bile powder have been clinically verified, but the long-term effects of the combined therapy cannot be determined. Based on the current situation, it is necessary to increase the number of patients, extend observation indicators, and add indicators such as recurrence rate to further analyze the effectiveness of combined therapy. Since the patients in this study had moderate and severe acne, and there were individual differences in their conditions, it is recommended to further refine the inclusion criteria for clinical trials, such as comparing and analyzing the combined therapy effects of patients with moderate and severe acne, to provide more detailed data and strong support for clinical treatment options.

5. Conclusion

In summary, the combined application of micro-needle radiofrequency and bear bile powder in the treatment of moderate to severe acne can ensure the effectiveness and safety of the treatment, quickly improve the state of skin lesions, and has significant clinical application value.

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Disclosure statement

The authors declare no conflict of interest.

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Analysis of Clinical Effectiveness of Intense Pulsed Light Combined with Q-Switched Laser in Facial Skin Beauty Treatment

Xuefen Wang, Yaqi Yu, Yan Ma, Ruonan Wang, Bingbing Gao, Xuemei Ma

PLA Army Hospital 946, Yining 835000, Ili Kazakh Autonomous Prefecture, Xinjiang Uygur Autonomous Region, China

Abstract: *Objective*: To investigate and analyze the clinical effectiveness of intense pulsed light combined with Q-switched laser in facial skin beauty treatment. *Methods*: A total of 197 patients with post-acne pigmented spots and erythema seeking facial skin beauty treatment in our hospital from May 2024 to May 2025 were selected and randomly divided into observation group (99 cases) and control group (98 cases) according to the envelope method. The control group was treated with a Q-switched laser, while the observation group was treated with intense pulsed light combined with a Q-switched laser. The clinical effectiveness, Melasma Area and Severity Index (MASI) score, and skin barrier function (stratum corneum water content, transepidermal water loss, epidermal sebum content) were compared between the two groups. *Results*: The clinical effectiveness of the observation group was significantly better than that of the control group ($P < 0.05$). There was a statistically significant difference in the decrease of MASI scores between the observation group and the control group ($P < 0.05$). After treatment, the levels of transepidermal water loss and epidermal sebum content in both groups were significantly reduced, and the water content of the stratum corneum was significantly increased. The improvement of each index in the observation group was better than that in the control group ($P < 0.05$). *Conclusion*: The combination of intense pulsed light and Q-switched laser can not only improve the clearance rate of skin lesions, but also achieve an overall improvement in skin barrier function by promoting collagen regeneration, optimizing epidermal hydration function, and sebum metabolism.

Keywords: Facial skin; Intense pulsed light; Q-switched laser; Clinical effectiveness

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1. Introduction

Among facial skin problems, post-acne erythema and pigmentation are the most common concerns in the field of cosmetology, severely affecting patients' appearance and mental health [1]. With high energy and ultra-short pulse width, the Q-switched laser effectively targets pigment groups through selective photothermal action. Micro-pigment groups are cleared through the body's metabolism, showing significant effects in treating pigmented skin lesions [2]. However, the incidence of postoperative inflammatory pigmentation is relatively high, posing a risk of anti-blackening, and its solo application has limitations: it has a poor effect on stubborn vascular problems, a small treatment range, low efficiency, and easy to miss when dealing with large lesions, and its high-energy characteristics may damage the epidermal barrier with insignificant repair effects [3]. Intense Pulsed Light (IPL) is a kind of incoherent broadband spectrum light, with a wavelength range typically from visible to near-infrared. Its advantage lies in being able to simultaneously target multiple chromophores in the skin. Through photothermal action, IPL can promote the constriction and closure of dilated blood vessels, thereby effectively improving erythema. It can also gently heat melanin and inhibit its activity, promoting the catabolism of pigment particles and improving pigmentation. Furthermore, the photothermal effect of IPL can stimulate the activity of dermal fibroblasts, promoting collagen regeneration and remodeling, which potentially benefits skin texture improvement and barrier function enhancement [4]. Therefore, this study explores the intervention effect of intense pulsed laser combined with Q-switched laser on facial skin by adopting this combined therapy for patients seeking skin beauty treatment for post-acne pigmented spots and erythema at our hospital from May 2024 to May 2025. It aims to provide evidence for clinical treatment selection. The specific report is as follows.

2. Materials and methods

2.1. General information

A total of 197 patients seeking cosmetic treatment for post-acne pigmented spots and erythema on their faces, who were diagnosed and treated in our hospital from May 2024 to May 2025, were selected. They were randomly divided into an observation group and a control group using the envelope method, with 99 patients in the observation group and 98 patients in the control group. There was no statistically significant difference in basic patient information between the two groups ($P > 0.05$), as shown in **Table 1**. This study was approved by the hospital ethics committee and complied with the relevant ethical principles of the Helsinki Declaration.

Table 1. Comparison of general information between the two groups (Mean ± SD/n %)

Characteristics	Observation group (n=99)	Control group (*n*=98)	t/x^2	*P*-value
Gender (Male/Female)	9 / 90	10 / 88	0.070	0.791
Age (years)	18-41	19-43	0.103	0.918
	30.15 ± 4.66	30.22 ± 4.84		
Disease Duration (months)	8.5-15.5	8.0-15.5	0.523	0.602
	11.45 ± 1.42	11.56 ± 1.53		
Type of Lesion				
Post-acne erythema	52	55	0.257	0.612
Post-inflammatory hyperpigmentation	47	43		

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Age between 18 and 45 years old. (2) Diagnosed with post-inflammatory hyperpigmentation and/or erythema due to acne. (3) Agree to sign the informed consent form and complete the full course of treatment and follow-up. (4) Have not used any drugs that affect the skin barrier, such as vitamin

A acid and fruit acid, within one month before treatment. (5) No history of photosensitive diseases. (6) No active infection or damage in the treatment area.

Exclusion criteria: (1) Comorbidities with non-inflammatory pigmented diseases such as chloasma and nevus of Ota. (2) Scar constitution or history of hypertrophic scarring. (3) Have received facial treatments such as laser or chemical peeling within the past three months. (4) Long-term oral anticoagulant drugs or glucocorticoids. (5) Tattoos or permanent fillers in the treatment area. (6) Presence of immunodeficiency diseases or history of malignant tumors.

2.3. Methods

All enrolled patients need to thoroughly clean their facial skin before treatment and use professional eye masks to protect their eyes. For patients with low pain tolerance, compound lidocaine cream can be evenly applied to the treatment area for superficial anesthesia before treatment, with a sealing time of no less than 1 hour. The setting of treatment parameters should be adjusted according to the individual situation of the patient. Before treatment, a test spot is routinely performed in a non-obvious area, such as the front of the ear or forehead, to determine the appropriate energy density and ensure safe and effective treatment. Immediately after treatment, apply an ice pack or cold spray device to the treatment area for 15–30 minutes to reduce thermal damage reaction. For patients receiving Q-switched laser treatment, they are instructed to avoid water exposure and strict sun protection for 3–5 days after surgery, and use gentle cleansing products 2 weeks after surgery.

The control group patients received Q-switched laser treatment: a clinically commonly used Q-switched laser therapy instrument was selected, with a laser wavelength set at 532 nm (1064 nm for deep dermal pigmented spots), laser energy of 300–350 mJ, pulse width range of 6-10 ns, spot diameter of 2–3 mm, and frequency of 3–5 HZ. The energy density was personalized based on the test spot reaction and patient tolerance, typically starting at 1.0–1.5 J/cm^2 and gradually adjusted until the scanned lesion reached epidermal blasting. During the operation, the laser handle was kept perpendicular to the irradiation, and the target area was uniformly scanned once. The treatment frequency was once every 4 weeks, and a total of 3 treatments were completed based on the improvement of the patient's skin lesions.

The observation group patients received intense pulsed light combined with Q-switched laser treatment: an intense pulsed light instrument (GP666C8 model) was used with a multifunctional optical head with a wavelength range of 500–1200 nm. The parameters were selected based on the type of skin lesion — "redness removal" mode (energy density 8–10 J/cm^2) was used for post-acne erythema, and "spot removal" mode (energy density 10–12 J/cm^2) was used for pigmentation. The pulse width was set to 10–15 milliseconds (within the device's allowable range of 3–25 milliseconds), and the spot area was a 5.0cm×1.0cm rectangle. During the operation, the handpiece was kept in contact with the skin, and the spot overlap rate was controlled at 10%–15%. The endpoint of the treatment was determined by slight redness or darkening of the skin. Immediately after the intense pulsed light treatment, the cold gel was cleaned and removed, followed by Q-switched laser treatment on the same area. The instrument selection, parameter settings (laser wavelength of 532 nm (1064 nm for deep dermal pigmented spots), laser energy of 200–300 mJ, pulse width range of 6–10 ns, spot diameter of 2–3 mm, frequency of 3–5 HZ, and personalized energy density based on test spot reaction and patient tolerance), and operational specifications were exactly the same as those of the control group. The combined treatment frequency was also once every 4 weeks, with a total of 3 treatments.

After the treatment, a 4–5 °C cold air blower was immediately used to blow air on the treated area for 5–8 minutes to reduce tissue swelling and burning pain. Strict sun protection was implemented, and the treated area was kept away from water for 3–5 days. Special water-avoidance care was not required for intense pulsed light treatment as there was no epidermal damage.

2.4. Observation indices

2.4.1. Clinical effectiveness

Observe and compare the clinical effectiveness of the two patient groups, using the modified Melasma Area Severity Index (MASI) score to evaluate the improvement of pigmentation. Two dermatologists who did not participate in the treatment independently evaluated the pigment area proportion (0–6 points) and color depth (0–4 points) in four areas of the patient's face (forehead, right cheek, left cheek, chin) under standard lighting conditions. The formula for calculating the total MASI score is: forehead area × depth × 0.3 + right cheek area × depth × 0.3 + left cheek area × depth × 0.3 + chin area × depth × 0.1. Cure is defined as a ≥95% reduction in MASI score, marked effectiveness as a ≥70% reduction, effectiveness as a ≥30% reduction, and ineffectiveness as a <30% reduction.

2.4.2. MASI score

Compare the MASI scores of the two patient groups before and after treatment. The scoring criteria are as described above. The reduction rate (%) = (pre-treatment score - post-treatment score) / pre-treatment score × 100%.

2.4.3. Skin barrier function

Observe and compare the skin barrier function of the two patient groups before and after treatment, including stratum corneum water content, transepidermal water loss, and epidermal sebum content. Before treatment and one month after the last treatment, patients were asked to sit quietly for 30 minutes in a constant temperature and humidity environment (typically 25 ± 1°C, relative humidity 50 ± 5%). The Glossymeter SEM575 was used to measure the stratum corneum water content (units: %), transepidermal water loss (units: $g/h \cdot m^2$), and epidermal sebum content (units: $\mu g/cm^2$) of the patients' cheek skin in a fixed target area. The recorded values were compared between groups and within groups before and after treatment.

2.5. Statistical methods

This hospital conducted a statistical analysis using SPSS 21.0 software package. Measurement data were represented using (Mean ± SD), assuming a normal distribution. The comparison between groups was performed using the t-test. Count data were represented using relative numbers, and the comparison between groups was done using x^2 test. The comparison of clinical efficacy was performed using the rank sum test. A P-value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of clinical effectiveness between the two groups

The clinical effectiveness of the observation group was significantly better than that of the control group ($P < 0.05$) (**Table 2**).

Table 2. Comparison of clinical effectiveness between the two groups [n(%)]

Group	n	Cure	Markedly Effective	Effective	Ineffective	Total Effective
Observation	99	41 (41.41)	33 (33.33)	23 (23.23)	2 (2.02)	97 (97.98)
Control	98	26 (26.53)	37 (37.76)	25 (25.51)	10 (10.20)	88 (89.80)
x^2 value						5.766
P value						0.016

3.2. Comparison of MASI scores between the two groups

The MASI score of the observation group decreased from a baseline of 8.52 ± 1.23 to 2.15 ± 0.87, with a decrease of 75.20%. The control group decreased from 8.48 ± 1.17 to 4.36 ± 1.05, with a decrease of 48.58%. The difference in the magnitude of decrease between the groups was statistically significant ($P < 0.05$) (**Table 3**).

Table 3. Comparison of MASI scores before and after treatment between the two groups (Mean ± SD)

Group	n	Before treatment	After treatment	Reduction value	Reduction rate (%)
Observation	99	8.52 ± 1.23	2.15 ± 0.87*	6.37 ± 0.98	75.20 ± 5.12
Control	98	8.48 ± 1.17	4.36 ± 1.05*	4.12 ± 0.87	48.58 ± 4.96
t-value		0.234	16.093	16.202	37.058
P-value		0.815	<0.001	<0.001	<0.001

Note: Compared with the same group before treatment, *$P < 0.05$

3.3. Comparison of skin barrier function levels between the two groups

Before treatment, there was no significant difference in skin barrier function levels between the two groups ($P > 0.05$). After treatment, the levels of TEWL and epidermal sebum content decreased significantly, while the water content of the skin's stratum corneum increased significantly in both groups. However, the improvement in various indicators in the observation group was better than that in the control group ($P < 0.05$) (**Table 4**).

Table 4. Comparison of skin barrier function levels before and after treatment between the two groups (Mean ± SD)

Group	n	Stratum Corneum Hydration (%)		TEWL (g/h·m²)		Epidermal Sebum Content (μg/cm²)	
		Before Treatment	After Treatment	Before Treatment	After Treatment	Before Treatment	After Treatment
Observation	99	14.08 ± 1.51	16.49 ± 1.98	49.22 ± 2.11	41.93 ± 2.87	112.98 ± 8.77	104.25 ± 7.08
Control	98	14.26 ± 1.63	15.02 ± 2.04	48.94 ± 2.26	44.59 ± 3.15	112.54 ± 8.41	109.11 ± 6.45
t-value		0.804	5.132	0.899	6.197	0.359	5.035
P-value		0.422	<0.001	0.370	<0.001	0.720	<0.001

Note: Compared with the same group before treatment, *$P < 0.05$

4. Discussion

The pathological basis of post-acne erythema and pigmented patches on the face is the continuous dilation of microvessels in the dermis and abnormal melanocyte activity. Mediators such as histamine released during acne inflammation widen the gaps between capillary endothelial cells and increase permeability, leading to erythrocyte extravasation and hemosiderin deposition. Inflammatory factors also stimulate the activity of tyrosinase in melanocytes, accelerating melanin synthesis and transport, and forming erythema and pigmented patches [5].

Currently, Q-switched lasers are often used clinically to treat such problems, with the core mechanism being selective photothermolysis: the Q-switched wavelength can effectively penetrate to the deep dermis, and high-energy photons target and break up melanosomes, which are then metabolized and excreted through the lymphatic system [6]. However, research has found that the use of Q-switched lasers alone has limitations: it is not effective for stubborn redness issues; point scanning results in uneven energy distribution and easy to miss stubborn skin lesions; the thermal damage of high-energy lasers can temporarily destroy the lipid structure of the stratum corneum, potentially causing pigmentation deepening and rebound phenomenon [7]. Intense pulsed light therapy inhibits melanin activity, promotes the catabolism of pigment particles, promotes collagen contraction and closure of blood vessel walls, and improves erythema through photothermal effects; however, its depth is limited by wavelength, and it has low efficiency for deep dermal problems. Therefore, for deep pigmentation or stubborn patches, intense pulsed light combined with Q-switched laser is needed, and the synergy between the two can reduce the risk of rebound pigmentation.

This study innovatively used the MASI scoring system to quantify the degree of pigmentation improvement. The data showed that the MASI score reduction rate in the combined treatment group reached 75.20%, which was significantly higher than that in the Q-switched laser group (48.58%). This result confirms the synergistic mechanism of IPL: its broad-spectrum light energy preheats pigment targets, lowers the blasting threshold of subsequent Q-switched lasers, and simultaneously closes blood vessels to reduce the release of inflammatory factors, thereby reducing the risk of pigment rebound [8].

This study adopts sequential therapy combining intense pulsed light (IPL) and Q-switched laser, based on the complementary and synergistic effects of their photonic energy. IPL serves as a precursor, targeting hemoglobin and melanin with a broad spectrum of 540–570 nm. During treatment, the millisecond pulse width of IPL generates a thermal effect, promoting the contraction of collagen in blood vessel walls and occlusion of the lumen. In terms of pigment processing, low-energy-density IPL preheats melanin and decomposes superficial pigments, reducing pigment competition for light absorption during Q-switched laser treatment. Additionally, the thermal effect of IPL activates fibroblast TLR4 receptors, up-regulates related pathways, promotes collagen synthesis, and matrix remodeling. This explains the mechanism behind the high moisture content of the stratum corneum in the combined group: newly formed collagen enhances connectivity and improves water-holding capacity, and the repaired barrier forms a virtuous cycle of water metabolism [9].

In terms of sebum regulation, the epidermal sebum content of the combined group is further reduced compared to the control group, which may be related to the thermal effect of intense pulsed laser: local heating can temporarily inhibit PPARγ activity in sebaceous gland cells, reduce the expression of enzymes related to lipid synthesis, and promote the softening of gland duct keratinization, improving lipid excretion patency. It is worth noting that the synergistic effect of the two therapies is also reflected in the difference in clinical efficacy: the total effective rate of the combined group is significantly higher than that of the control group. This advantage stems from the dual optimization of IPL pretreatment on therapeutic targets: on the one hand, it reduces hemoglobin's competitive absorption of subsequent Q-switched laser energy by closing superficial blood vessels, allowing more energy to be focused on deep pigments; on the other hand, it lowers the threshold energy required for pigment particle explosion through preheating sensitization, enabling the Q-switched laser to achieve more thorough treatment effects at a lower safe energy level [10].

5. Conclusion

In summary, the therapeutic advantages of combining intense pulsed light and Q-switched laser are not only reflected in a higher lesion clearance rate but also in the overall improvement of skin barrier function by promoting collagen regeneration, optimizing epidermal hydration, and sebum metabolism.

Disclosure statement

The authors declare no conflict of interest.

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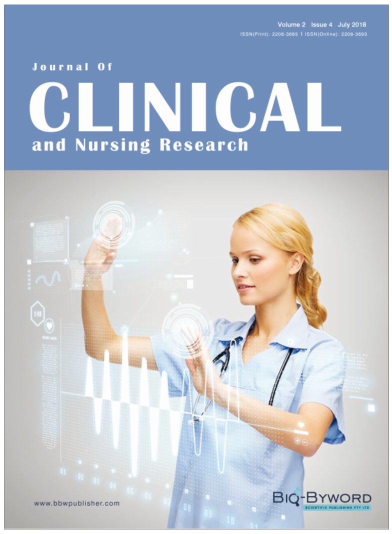

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