IFSCC 2025 full paper (IFSCC2025-752)

A New Serum for Pore Management: Efficacy Evaluation and the Application of a Precise Pore Grading Atlas

Lin Sun [1], Ying Ye [1], Mengli Sang [1], Chenlan Xu [1], Peiwen Sun [1], Xiaowei Chang [2,*], Yanan Li [1,#]

[1] Research & Innovation Center, Proya Cosmetics Co., Ltd., Hangzhou, China
[2] PROYA Shanghai R&D Center, Proya Cosmetics Co., Ltd., Shanghai, China
[*] Xiaowei Chang, Presenting Author, Email: changxiaowei@proya.com
[#] Yanan Li, Senior Author, Email: liyanan@proya.com

Introduction: Since enlarged pores represent a prevalent skin concern in contemporary society, a daily pore-care routine is a fundamental strategy for maintaining pore health and tightness. This study developed a pore-improving serum containing retinol, tocopheryl retinoate, succinic acid, azelaic acid and azelamide MEA, and investigated its tolerability and efficacy. The acidic ingredients are used for oil control, exfoliation, and acne treatment, while retinoids provide anti-wrinkle and firming benefits. A novel precise pore grading atlas ranging from 0 to 7 grades was utilized to evaluate pre- and post-product pore improvement.

Methods: In vitro tests were conducted to validate the efficacy of the active ingredients. Patch tests were conducted to ensure the product's safety. In the clinical study, 30 female volunteers with facial enlarged pores (pore grade ≥2) and an average age of 32 were recruited and advised to apply the serum once every evening for a 6-week period. The pore-refining efficacy was assessed by non-invasive instruments, subject self-assessments, and dermatologist evaluations.

Results: The efficacy of the active ingredients and their corresponding indicators were proved in vitro. The serum passed the 24-hour human patch test. After 6 weeks of use, the clinical trial revealed significant improvements in facial enlarged pores, as well as in other related parameters such as sebum production, skin elasticity, acne incidence, skin smoothness, and luminosity. Specifically, dermatologists observed an overall 22.0% improvement in pore appearance based on the grading maps (average pore grade decreased from 3.78 to 2.95).

Conclusion: This study comprehensively demonstrated that the serum is gentle and highly effective for daily use. It achieves a tightened pore appearance through multiple mechanisms, including reducing sebum production, exfoliating the stratum corneum, inhibiting acne formation, and enhancing skin firmness. The pore grading chart used in this study has subtle differences between adjacent levels, making it suitable for assessing populations with smaller pores, such as the Chinese population.

Keywords: enlarged pores, efficacy, clinical testing, pore grading atlas

1. Introduction

Enlarged facial pores are a prevalent cosmetic concern, particularly among individuals with oily or combination skin types [1]. A study involving over one million Chinese participants revealed that pore severity increases with age, with noticeable differences between genders

and facial regions [2]. In addition to affecting skin texture and luminosity, enlarged pores can influence self-perception, often prompting greater reliance on cosmetic products. The pursuit of smooth, refined skin is widely recognized not only as an aesthetic goal but also as a reflection of overall health and vitality [3]. Therefore, it is crucial to develop a skin care product that can improve enlarged pores.

The pathogenesis of enlarged pores is multifactorial, involving the interplay of excessive sebum secretion, abnormal keratinization, loss of dermal elasticity, and follicular distention [4]. Given this complexity, effective intervention strategies must address multiple biological pathways simultaneously. In response to this complexity, several multidimensional strategies have been proposed to improve enlarged pores. For example, a 56-day clinical trial demonstrated that an emulsion containing niacinamide, lentil seed extract, and white willow bark extract significantly improved acne, blackheads, and facial pore appearance in individuals with oily skin [5]. Similarly, a clinical study involving 64 Korean women showed that the application of a 4% ion-paired amino acid (IPA) emulsion for six weeks resulted in a 19.3% reduction in enlarged pores and an increase in dermal density [6]. Despite these promising advances, many existing formulations primarily act through single-target mechanisms, offering partial improvements. Common cosmetic ingredients for pore refinement predominantly focus on sebum regulation (e.g., azelaic acid, niacinamide), keratinocyte turnover (e.g., salicylic acid, succinic acid), or dermal matrix support (e.g., retinol, adapalene). Azelaic acid, for example, has been shown to inhibit 5α-reductase activity, thereby indirectly regulating excessive sebum production [7]. Retinoids, including retinol and its derivative tocopheryl retinoate (TR), are widely recognized for stimulating collagen synthesis and promoting epidermal renewal, essential for restoring dermal integrity [8,9]. However, previous research has largely focused on surface-level improvements, few studies have explored the synergistic potential of combining exfoliating acids and retinoids to simultaneously address both superficial pore congestion and deeper dermal structural deterioration.

To develop a more comprehensive intervention for enlarged pores, we formulated a multifunctional serum combining both acidic and retinoid-like components. Azelaic acid and azelamide MEA were selected to target sebaceous gland activity. Succinic acid was incorporated for its keratolytic and antimicrobial properties, aiding in the prevention of follicular obstruction and supporting overall skin smoothness [10]. Retinol and tocopheryl retinoate (TR) were included to stimulate collagen synthesis and enhance dermal elasticity, addressing the extracellular matrix degradation that contributes to pore dilation. To validate the biological efficacy of these active ingredients, a series of in vitro experiments were conducted. Additionally, a 24-hour closed patch test was performed to assess the safety and dermatological tolerance of the serum, followed by clinical trials evaluating its effectiveness in improving pore appearance among individuals with enlarged pores.

Accurate assessment of pore severity is critical for evaluating the efficacy of skincare treatments and monitoring long-term skin health. Although standardized photographic scales such as the Skin Aging Atlas have been developed for different ethnic groups—including a dedicated volume for Asian skin types [11]—existing grading systems typically use broad categories (e.g., 0—5 grades), limiting their sensitivity to detect subtle yet meaningful improvements. Given that East Asian consumers often have higher expectations for skin smoothness and more refined standards for pore appearance, there remains a need for a more sensitive and precise evaluation tool. In this study, we employed a novel 0—7 precision pore grading atlas specifically tailored to the characteristics of the Asian population, enabling a more accurate and granular assessment of treatment outcomes.

2. Materials and Methods

2.1 Efficacy verification in vitro

Determination of Lipid Droplet Content in 0.625% Azelaic Acid and Azelaicamide MEA Compositions(AZA&AZ-MEA)

Using testosterone-induced SZ95 cells as a model, after 0.625% (AZA&AZ-MEA) treatment and 24 hours incubation, lipid droplets were stained with Nile red and imaged under a fluorescence microscope. Subsequently, ImageJ analysis was employed to evaluate lipid droplet content.

Determination of Exfoliated Protein Content and Inhibition Rate of Propionibacterium acnes in 1% Succinic Acid

The sample was applied to ex vivo porcine skin slices. Then, the supernatant was collected and analyzed for exfoliated protein content using a BCA assay kit. In the antibacterial test, 1% Succinic Acid and PBS control groups were mixed with Propionibacterium acnes bacterial suspensions, incubated for 5 min, diluted, and cultured anaerobically at 37°C for 72 hours to calculate the antibacterial rate.

Determination of Collagen I Content in 0.1% Retinol, Fibrillin-1 Content in 0.4% TR

Human skin fibroblasts were irradiated to establish a model. After the 0.1% retinol addition, cells were incubated for 48 hours, and cell supernatants were collected for collagen I determination using ELISA kits. Additionally, ex vivo skin tissue was co-stimulated with methylglyoxal and combined UVA + UVB irradiation to create a damage model. 0.4% TR was applied to the tissue, which was subsequently fixed with 4% paraformaldehyde for 24 hours and subjected to immunofluorescence detection and analysis of fibrillin-1.

2.2 Safety Evaluation

Tested care product

Tested care product: a pore-improving serum containing retinol, tocopheryl retinoate, succinic acid, azelaic acid and azelamide MEA.

In order to evaluate the potential adverse reactions associated with the product, a closed patch test was conducted on a cohort of 30 healthy male and female subjects aged between 21 and 56 years. Small patches containing 20 μL of the product's essence were applied to the upper back of each subject and were removed after 24 hours. Readings were recorded at three time points: 30 minutes after patch removal, as well as 24 and 48 hours post-removal. The patch test results were assessed following the criteria established by the International Contact Dermatitis Research Group.

2.3 Assessment of Clinical Efficacy

Study design

This study was conducted at a professional third-party testing institution and was approved by the Clinical Research Ethics Committee (XMCPCH24000783-001). Before the study, each subject has fully understood the details of the trial and signed a copy of the informed consent.

Subjects

The recruitment will prioritize subjects with a sebum content on the forehead >80 μg/cm^2 and a skin type of combination-oily or oily. Subjects should self-report dull facial skin, with visibly enlarged pores on the cheeks and a clinical pore appearance grade of ≥2 (according to a novel precise pore grading atlas). Subjects should also self-report thickened facial skin with scales. Additionally, the total number of open comedones and closed comedones on the subjects' faces should exceed 10. Exclusion criteria included subjects with systemic diseases, severe skin conditions, a history of cosmetic or severe allergies, or those who had undergone skin or beauty treatments in the last six months. Ultimately, 30 healthy Chinese women aged between 23 and 40 years who met the aforementioned criteria were recruited.

Evaluation

During the first week, subjects applied the serum (mentioned above) every other evening. Subsequently, they used the serum nightly for a duration of 6 weeks, while continuing to use other conventional skincare products, with the exception of serums with similar efficacy.

Assessments were conducted at baseline (before using the product) and at 2, 4, and 6 weeks after using the product. Before each test, subjects were required to rinse their face thoroughly

with an amino acid cleanser and acclimatized to a standard constant temperature and humidity environment (temperature 20~22°C, humidity 40~60%) for at least 30 minutes before measurements. Subsequently, non-invasive instrument measurements, professional dermatologist evaluations, and subject self-assessment were carried out.

Instrument and parameter

In vivo skin parameters were evaluated as following methods: Antera 3D(Miravex) was used for capturing skin images and analyzing changes in pore parameters. Glossymeter GL200 (Courage + Khazaka Electronic GmbH) to determine skin glossiness parameter. Sebumeter SM815 (Courage + Khazaka Electronic GmbH) was used for the measurement of sebum content on the skin. Visioscan VC20plus (Courage + Khazaka Electronic GmbH) was utilized for image acquisition and analysis of smoothness.

Statistical analysis

Statistical studies carried out by SPSS 28.0 software. The Shapiro-Wilk test was used to determine the normality of the data distribution. Paired t-test method was used to detect the significance if the test data is normally distributed. Otherwise, Wilcoxon Signed-Rank test was used for statistical analysis. And $P<0.05$ was considered statistically significant in all cases.

3. Results

As shown in Figure 1, compared with the model control group (MC), the lipid droplet content in the solvent group (SC) showed no significant change, indicating that the solvent had no significant effect on the lipid droplet content. However, in the 0.625% AZA&AZ-MEA group, the lipid droplet content decreased significantly, and the inhibition rate was 19.1% (vs MC). This indicated that AZA&AZ-MEA has the potential to control sebum secretion.

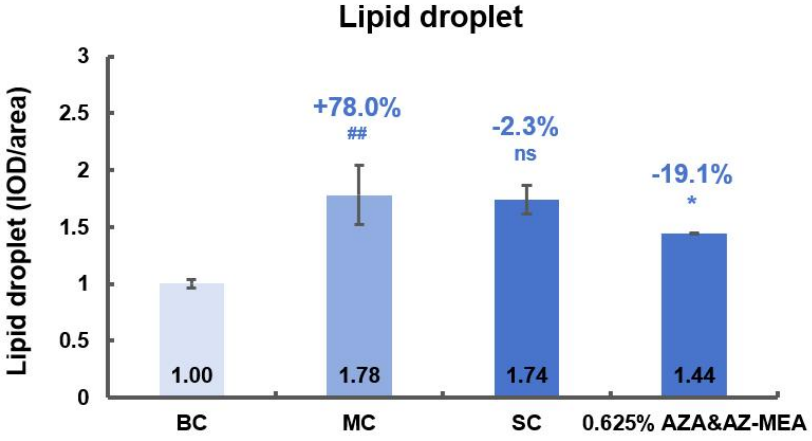


Figure 1. Lipid droplet content analysis of azelaic acid and azelamide MEA compositions. ## $P<0.01$ *vs*. BC, ns *vs*. MC ,** $P<0.01$ *vs*. MC.

As shown in Table 1, the exfoliated protein content in the 1% succinic acid group was 151.9% higher than that in the solvent control, with statistical significance, indicating the exfoliating effect of succinic acid. Table 2 showed that 1% succinic acid significantly suppressed the proliferation of Propionibacterium acnes, with an inhibition rate exceeding 90% relative to PBS.

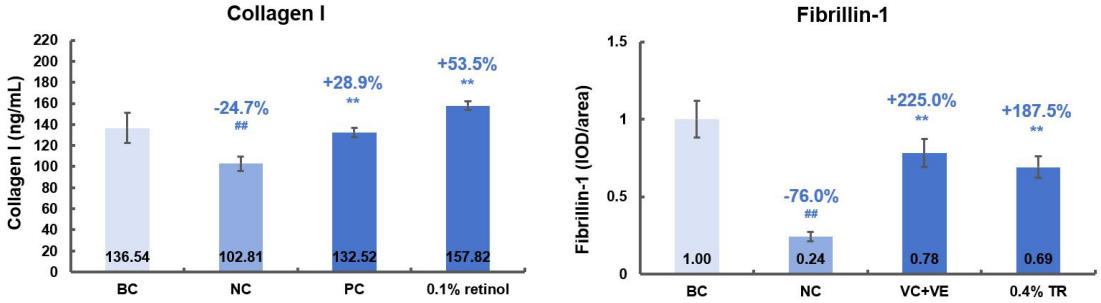
Table 1. Exfoliated protein content analysis of Succinic Acid

Group	Relative content of exfoliated protein (%)	*P* value
Solvent Control	100.0±5.60	-
1% Succinic Acid	151.9±7.47	**

Table 2. Inhibition of Propionibacterium acnes by Succinic Acid

Number	Test strain	Response time	Clump count (CFU/mL)		Inhibition(%)
			1% Succinic Acid	PBS	
1	Propionibacterium acnes	5 min	<10	1.2×10^4	99.92
2			<10	1.1×10^4	99.97
3			<1	1.2×10^4	99.99

As illustrated in Figure 2(a), 0.1% retinol significantly increased collagen I content compared to the negative control group, with enhancement rates of 53.5%. As depicted in Figure 2(b), 0.4% TR significantly enhanced the content of fibrillin-1, with an increase reaching 187.5%. Notably, our findings revealed that TR specifically regulates fibrillin-1, a core component of elastic fibers, which fills the gap in understanding how TR modulates structural proteins in the dermis.



(**a**) (**b**)

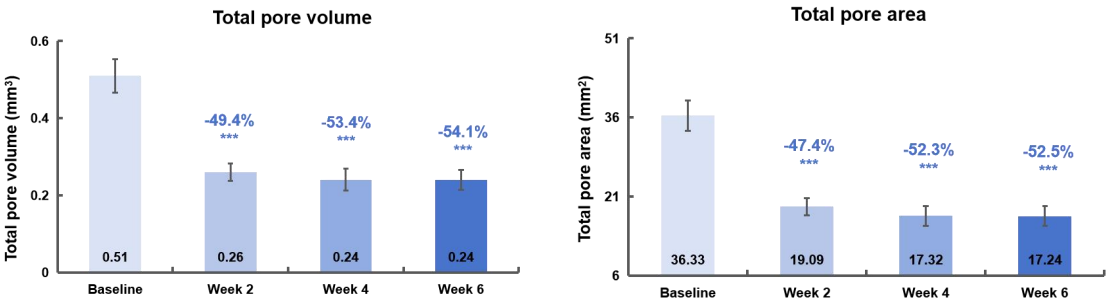
Figure 2. (a) Collage I level analysis of retinol. BC(Non-UVA). (b)Fibrillin-1 level analysis of TR. BC(Non-costimulated). ## *P*<0.01 *vs*. BC, ** *P*<0.01 *vs*. NC.

Safety Evaluation

At 0.5 hours, 24 hours, and 48 hours after the removal of the patches, none of the 30 subjects exhibited any adverse reactions (such as erythema, edema, papules, vesicles, etc.), indicating that the product is mild.

Clinical evaluation results

The study observed significant improvements in skin pore-related parameters over a 6-week period. As shown in Figure 3, total pore volume decreased by 49.4%, 53.4%, and 54.1% at weeks 2, 4, and 6, respectively, compared to baseline data. Similarly, total pore area reduced by 47.4%, 52.3%, and 52.5% at the same intervals. Pore count also showed a decrease of 36.1%, 44.2%, and 42.0%. Lastly, the pore appearance, which was determined by physicians using a novel 0 to 7 scale precision pore grading chart, improved by 7.1%, 17.2%, and 22.0%. These results highlight the effectiveness of the serum in enhancing skin quality over time. Figure 2 shows a representative example of improved pore appearance in one subject.



(**a**) (**b**)

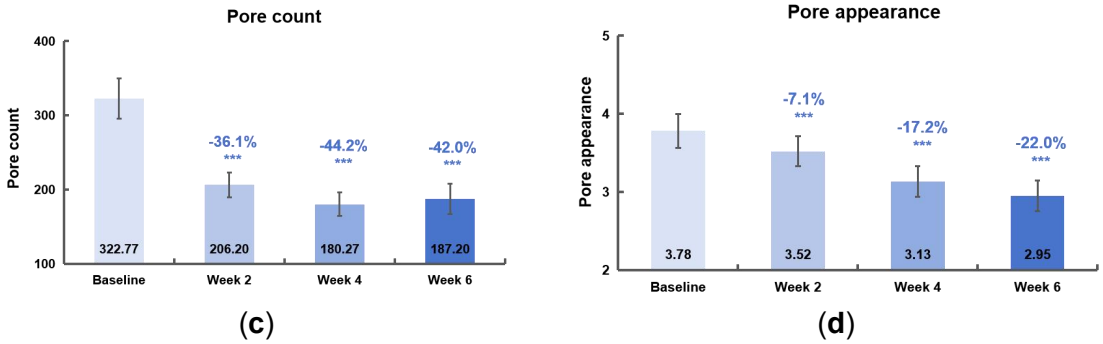


Figure 3. Observation of changes in skin pore related parameters evaluated by instruments and physician within 6 weeks. (a) Total pore volume; (b) Total pore area; (c) Pore count; (d) Pore appearance. Improvement (%) of week 2, 4, and 6 from baseline is also presented (**P*<0.05 *vs*. baseline; ***P*<0.01 *vs*. baseline; ****P*<0.001 *vs*. baseline).

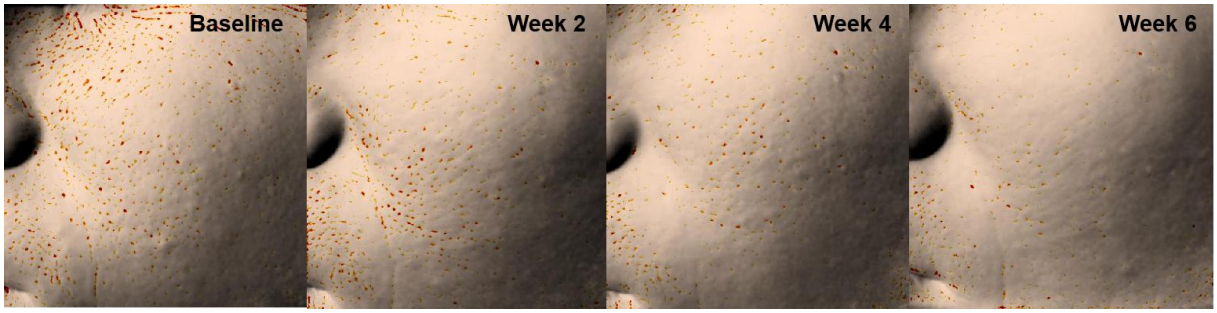


Figure 4. A serum improves facial pores by Antera 3D of analysis view. Subject serial 22, female, 33 years old, Chinese.

In addition to the significant improvements observed in facial pore appearance, other skin parameters also demonstrated notable improvements, as shown in Table 3. By the end of week 6, skin sebum content had markedly decreased by 30.3%, accompanied by substantial reductions in both open and closed comedones, indicating the product's effectiveness in managing acne-prone skin conditions. Furthermore, skin smoothness improved by 12.4%, and skin glossiness increased by 14.3%, highlighting the serum's moisturizing and nourishing capabilities. Additionally, the desquamation index decreased significantly by 37.9%, further reflecting improved skin texture and overall skin quality.

Table 3. Evaluation results of skin improvement parameters (Mean±SEM).

Parameters	Test time point			
	Baseline	Week 2	Week 4	Week 6
Skin sebum content	126.26±6.28	112.59±6.09	95.90±6.43	88.04±5.87
Open comedones	14.07±2.21	11.23±1.92	8.77±1.59	7.17±1.45
Colsed comedones	12.70±1.49	10.63±1.08	8.27±0.92	8.13±0.87
Skin glossiness	7.91±0.18	8.44±0.17	8.75±0.17	9.04±0.18
Skin smoothness	142.88±5.57	126.06±5.03	126.73±5.00	125.16±5.48
Desquamation index	24.17±0.88	18.74±0.66	16.20±0.74	15.01±0.73

The self-assessment questionnaire results indicated a high degree of participant satisfaction with the serum's performance over a six-week period, as illustrated in Figure 5. At week 6, all subjects reported moderate or marked improvements in product gentleness and non-irritation, skin elasticity, and reduced facial oiliness. Notably, by the fourth week, over 90% of participants reported moderate or marked improvements in pore size, skin texture refinement, firmness, and

skin smoothness, highlighting the serum's rapid and substantial impact on overall skin quality. Additionally, substantial satisfaction was reported regarding reductions in both blackhead and whitehead comedones, and improvement in overall skin roughness.

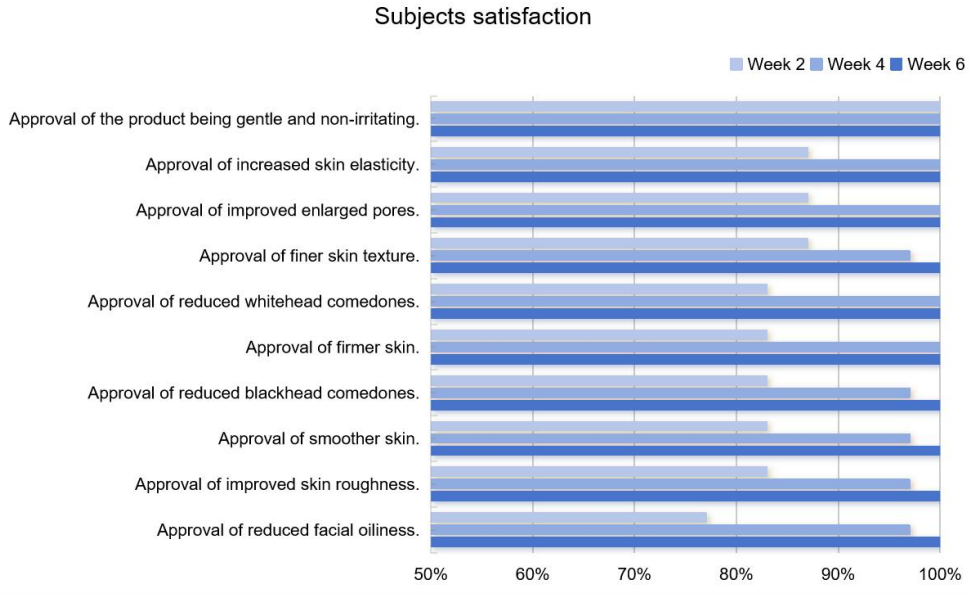


Figure 5. Results of self-assessment questionnaire. Rating scales: 1 = worse, 2 = no improvement, 3 = mild improvement, 4 = moderate improvement, and 5 = marked improvement. Satisfaction data include subjects who reported moderate or marked improvement.

4. Discussion

Pore-related skin issues, often characterized by visible pore enlargement, are frequently associated with secondary concerns such as acne, comedones, and excessive sebum secretion. To address these multifactorial issues, this study formulated a multifunctional serum comprising azelaic acid, azelamide MEA, and succinic acid—targeting sebum regulation, bacterial growth inhibition and exfoliation—alongside retinol and tocopheryl retinoate, which support dermal matrix remodeling. Results from in vitro assays, safety evaluations, and clinical studies collectively support the serum's efficacy and tolerability in improving pore-related skin parameters.

The in vitro results elucidated the mechanistic basis of the formulation. Succinic acid showed significant exfoliating activity, with a 151.93% increase in exfoliated protein content, and strongly suppressed the growth of Propionibacterium acnes, with an inhibition rate exceeding 90%. This aligns with prior research suggesting that organic acids such as succinic and salicylic acid possess both keratolytic and antimicrobial properties, which are beneficial in managing acne and preventing follicular obstruction—a key factor in pore dilation [12]. Meanwhile, the combination of azelaic acid and azelamide MEA significantly reduced lipid droplet formation by 19.1%, demonstrating their potential to downregulate sebum production, likely through the inhibition of 5α-reductase as previously reported by Stamatiadis et al. [13]. Retinoid components contributed to structural skin improvement. Retinol increased collagen I content by 53.5%, and TR markedly upregulated fibrillin-1 levels by 187.5%, indicating enhanced extracellular matrix remodeling. This is consistent with the known bioactivity of retinoids in stimulating fibroblast activity and promoting collagen and elastic fiber synthesis, which directly supports dermal structure and reduces pore visibility [14,15]. Notably, fibrillin-1 is a key structural glycoprotein involved in maintaining skin elasticity, and its targeted upregulation by TR provides a new mechanistic insight into retinoid-driven pore refinement. The serum's safety profile was affirmed through a 24-hour occlusive patch test, with no adverse reactions reported among participants. This is particularly noteworthy given the

inclusion of retinoids, such as encapsulated retinol and tocopheryl retinoate (TR), which are known for their potential to cause skin irritation, including erythema, peeling, and dryness [16]. Thus, achieving both efficacy and skin tolerability remains a key challenge in dermocosmetic product development, particularly when integrating active agents such as retinol and acidic compounds like azelaic acid and succinic acid. The ability of this formulation to maintain high bioactivity while remaining gentle underscores its clinical value.

Clinically, the serum led to noticeable improvements in multiple skin parameters related to pore visibility, including sebum regulation, texture refinement, comedone reduction, and improvements in overall skin tone and smoothness. These findings are consistent with prior studies showing that multifunctional formulations targeting both epidermal renewal and dermal remodeling pathways are more effective than monotherapy approaches [17]. Our findings further support the concept that combining exfoliating, bacteriostatic, and matrix-stimulating components offers synergistic clinical benefits for patients with enlarged pores and acne-prone skin. Additionally, a notable strength of this study is the application of a novel 0–7 precision pore grading atlas to evaluate treatment efficacy. The grading atlas developed in this study was specifically designed to capture fine-scale variation and gradual improvement in pore appearance, allowing for more sensitive and individualized assessment. Beyond serving as an evaluation tool, this atlas could contribute to the standardization of pore assessment in future cosmetic trials, particularly those targeting East Asian populations. Its application may also facilitate longitudinal tracking of treatment response, providing both clinicians and formulators with a more precise and scalable assessment framework.

Future research should consider conducting longer-term, randomized controlled trials across diverse populations to confirm the durability and universality of the observed benefits. Moreover, integrating non-invasive molecular imaging, transcriptomic profiling, or skin microbiome analysis could provide deeper mechanistic insights into how these active ingredients modulate skin biology at the cellular and microbiological levels. Longitudinal evaluation of pore improvement using the precision grading atlas would further enhance understanding of treatment dynamics and support the optimization of related skincare interventions.

5. Conclusion

This study provides evidence that a multifunctional serum incorporating exfoliating acids and retinoid derivatives offers an effective solution for addressing the aesthetic concerns related to enlarged facial pores. Importantly, the ability to achieve high efficacy without compromising skin tolerance—particularly with active ingredients known for irritation potential—underscores the formulation’s suitability for daily use. Furthermore, the introduction of a novel 0–7 precision pore grading atlas, offering a standardized and sensitive tool for tracking subtle pore improvements, especially in Asian skin types. These findings support the use of integrated, multi-targeted skincare strategies for pore refinement and set the foundation for future research into long-term outcomes, mechanistic biomarkers, and personalized treatment approaches.

References

1. Park JY, Lee JS, Lee SR, Lee DH. Combined Treatment with Micro-Focused Ultrasound with Visualization and Intradermal Incobotulinumtoxin-A for Enlarged Facial Pores: A Retrospective Study in Asians. Clin Cosmet Investig Dermatol. 2023;16:1249-1255.
2. Zhou H, Xie H, Wu L, et al. An artificial intelligence powered study of enlarged facial pore prevalence on one million Chinese from different age groups and its correlation with environmental factors. Skin Res Technol. 2024;30(9):e70025.
3. Humphrey S, Manson Brown S, Cross SJ, Mehta R. Defining Skin Quality: Clinical Relevance, Terminology, and Assessment. Dermatol Surg. 2021;47(7):974-981.
4. Lee SJ, Seok J, Jeong SY, Park KY, Li K, Seo SJ. Facial Pores: Definition, Causes, and Treatment Options. Dermatol Surg. 2016;42(3):277-285.
5. Yang F, Wang H, Guo M, Zhou Z. The clinical efficacy of a new emulsion for acne and conspicuous facial pore amelioration. J Cosmet Dermatol. 2024;23(3):958-963.
6. Kwon KC, Lee SW, Kim H, Jeon H, Park SW. Reduction of enlarged facial pore using ion-paired amino acid through enhancement in skin permeation and exfoliation: A placebo-controlled in vivo study. J Cosmet Dermatol. 2021;20(1):274-284.
7. Stamatiadis D, Bulteau-Portois MC, Mowszowicz I. Inhibition of 5 alpha-reductase activity in human skin by zinc and azelaic acid. Br J Dermatol. 1988;119(5):627-632.
8. Rossetti D, Kielmanowicz MG, Vigodman S, et al. A novel anti-ageing mechanism for retinol: induction of dermal elastin synthesis and elastin fibre formation. Int J Cosmet Sci. 2011;33(1):62-69.
9. Okano Y , Obayashi K , Yahagi S ,et al.Improvement of wrinkles by an all-trans-retinoic acid derivative, D-δ-tocopheryl retinoate. Journal of Dermatological Science Supplement, 2006; 2(1):S65-S74.
10. Guerra-Tapia A, Martínez H, Nieto C, et al. A new topical biotechnological phytocomplex for truncal mild-moderate acne restores skin microbiota balance. Skin Res Technol. 2024;30(7):e13806.
11. Flament F, et al. Skin Aging Atlas Volume 2 – Asian Type. ResearchGate. 2017.
12. Draelos ZD, Matsubara A, Smiles K. The effect of 2% niacinamide on facial sebum production. J Cosmet Laser Ther. 2006;8(2):96-101.
13. Stamatiadis D, Bulteau-Portois MC, Mowszowicz I. Inhibition of 5 alpha-reductase activity in human skin by zinc and azelaic acid. Br J Dermatol. 1988;119(5):627-32.
14. Mukherjee S, Date A, Patravale V, Korting HC, Roeder A, Weindl G. Retinoids in the treatment of skin aging: an overview of clinical efficacy and safety. Clin Interv Aging. 2006;1(4):327-48.
15. Kang S, Voorhees JJ. Photoaging therapy with topical tretinoin: an evidence-based analysis. J Am Acad Dermatol. 1998;39(2 Pt 3):S55-61.
16. Kim BH. Safety Evaluation and Anti-wrinkle Effects of Retinoids on Skin. Toxicol Res. 2010;26(1):61-66
17. Yang F, Wang H, Guo M, Zhou Z. The clinical efficacy of a new emulsion for acne and conspicuous facial pore amelioration. J Cosmet Dermatol. 2024;23(3):958-963.

Appendix: Pore Grading Atlas