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Instrumental and Patient-Reported Assessment of Skin Changes During a 90-Day Dermocosmetic Regimen: A Prospective Single-Arm Observational Study

Zoran Golušin [1,2], Bojana Spasić [2], Nemanja Maletin [1,3,*], Nikola Denda [1,4], Marija Ranđelović [2], Maša Golubović [5], Iva Binić [6] and Ivana Binić [5,7]

1 Faculty of Medicine, University of Novi Sad, 21000 Novi Sad, Serbia; zoran.golusin@mf.uns.ac.rs (Z.G.); nikola.denda@mf.uns.ac.rs (N.D.)
2 Clinic for Dermatovenerology, University Clinical Center of Vojvodina, 21102 Novi Sad, Serbia; k2diagnostic@gmail.com (B.S.); marijarandjelovic99@gmail.com (M.R.)
3 Clinic of Internal Oncology, Oncology Institute of Vojvodina, 21204 Novi Sad, Serbia
4 Clinic for Eye Diseases, University Clinical Center of Vojvodina, 21000 Novi Sad, Serbia
5 Clinic for Dermatovenerology, University Clinical Center Niš, 18000 Niš, Serbia; masabinic@gmail.com (M.G.); ivanabinic@gmail.com (I.B.)
6 Department of Psychiatry, Medical Faculty, University of Niš, 18000 Niš, Serbia; drivabinic@gmail.com
7 Department of Dermatovenerology, Medical Faculty, University of Niš, 18000 Niš, Serbia
* Correspondence: nemanja.maletin@mf.uns.ac.rs

Abstract

Background: Skin aging is influenced by intrinsic and extrinsic factors that alter skin texture and microrelief. Non-invasive imaging techniques enable objective longitudinal assessment of these characteristics. This study aimed to instrumentally and subjectively evaluate skin surface changes during a standardized 90-day dermocosmetic regimen containing multiple active ingredients. Methods: This prospective, single-arm observational study included 47 women aged 30–60 years with visible signs of facial skin aging. Participants applied a standardized anti-age serum and cream regimen twice daily for 90 days. Skin surface morphology was assessed at baseline and after 30, 60, and 90 days using Visioscan® VC 20plus imaging with SELS® software. Subjective outcomes were evaluated using a structured product questionnaire and the validated Skindex-16 instrument. Results: Significant temporal changes were observed across objective skin surface parameters. From baseline to day 90, mean skin roughness decreased from 4.99 ± 2.29 to 1.66 ± 0.67, while the wrinkle-related parameter decreased from 191.08 ± 87.26 to 74.27 ± 15.25. Reductions were also observed in scaliness, contrast, entropy, variance, and anisotropy, whereas smoothness, homogeneity, and energy increased over time. Skindex-16 scores decreased across Symptoms, Emotions, and Functioning domains, indicating lower participant-reported dermatology-related burden. The regimen was well tolerated, with no serious adverse events reported. Conclusions: In this exploratory single-arm observational study, the standardized dermocosmetic regimen was associated with measurable longitudinal changes in Visioscan-derived skin surface parameters and patient-reported outcomes over 90 days. Because the study included no control group, the findings cannot establish causality or isolate the contribution of individual regimen components.

Keywords: dermocosmetic regimen; patient-reported outcomes; skin aging; skin imaging; Visioscan

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1. Introduction

Skin aging is a multifactorial biological process influenced by intrinsic factors, including genetic, hormonal, and metabolic changes, as well as extrinsic factors, such as ultraviolet (UV) radiation, environmental pollution, and lifestyle habits [1]. Intrinsic (chronological) aging is characterized by epidermal thinning, progressive loss of collagen and elastin, and reduced moisture retention, leading to fine wrinkles and decreased skin firmness [1]. In contrast, extrinsic aging (photoaging), largely driven by cumulative UV exposure, results in coarse wrinkles, pigmentary alterations, and dermal elastosis [2]. Collectively, these mechanisms contribute to degradation of the extracellular matrix, including depletion of collagen, elastin, and hyaluronic acid (HA), which clinically manifests as dryness, roughness, laxity, and surface textural irregularities [3].

A wide range of bioactive ingredients has been incorporated into dermocosmetic products to target pathways involved in skin aging. HA plays a central role in maintaining skin hydration and dermal viscoelasticity; however, endogenous HA levels decline with age, contributing to dehydration and wrinkle formation [4]. Both topical and injectable HA formulations have been shown to improve skin hydration, turgor, and the visible appearance of wrinkles [5]. Niacinamide (vitamin B_3) is another well-established dermocosmetic active that enhances epidermal barrier function by increasing ceramide and protein synthesis, reduces transepidermal water loss, and exhibits antioxidant and anti-inflammatory properties. Clinical studies have reported improvements in fine lines, uneven skin tone, and sallowness following regular topical application [6,7].

Peptides represent an additional class of ingredients frequently used in anti-aging formulations. Signal peptides and matrikines have been shown to stimulate fibroblast activity and promote collagen and elastin synthesis, whereas neurotransmitter-inhibiting peptides (e.g., acetyl hexapeptide-3) act by modulating facial muscle microcontractions, thereby softening expression lines [8]. Controlled clinical trials have reported improvements in the appearance of periorbital wrinkles with topical peptide formulations, including palmitoyl pentapeptide-4 and acetylhexapeptide-3 [9]. Recent randomized studies suggest that bakuchiol-containing formulations may improve facial photoaging-related parameters while maintaining a favorable tolerability profile [10].

Thermal mineral waters are often used in dermocosmetic formulations as vehicles with specific physicochemical properties. Prolom thermal water is classified as sodium-hydrogencarbonate, alkaline, oligomineral, and hypothermal water, with a pH of 8.7–9.2 and the presence of metasilicic acid [11]. Its dermatological use mainly stems from balneotherapy, where it has been applied alongside mineral baths and peloids for inflammatory skin conditions. However, these findings cannot be directly applied to leave-on cosmetic products or interpreted as evidence of an independent effect of the water itself [11]. A recent study of a 10% urea lotion formulated with Prolom thermal water showed improvements in skin parameters, but the specific contribution of the water could not be distinguished from other ingredients [12]. Therefore, in this study, Prolom thermal water was considered a supportive vehicle rather than an independent active component.

Evaluating the complete formulation is relevant because dermocosmetic products are used as integrated systems rather than as isolated ingredients. The tested serum-and-cream regimen combined multiple components targeting different aspects of skin appearance and microrelief. This approach provides practical insight into changes observed during standardized use, although it does not allow attribution of effects to individual ingredients or to Prolom thermal water.

Previous studies have mainly focused on individual ingredients, short-term outcomes, or limited parameters. Less is known about longitudinal changes during use of complete multi-ingredient regimens, especially when combining instrumental measurements with

validated patient-reported outcomes. Therefore, this study aimed to assess changes in skin texture, microrelief, wrinkle-related parameters, and participant-reported outcomes during a 90-day dermocosmetic regimen under observational conditions.

2. Materials and Methods

2.1. Study Design

This was a pragmatic, prospective, single-arm observational longitudinal study designed to characterize temporal changes in skin surface characteristics during standardized use of a complete dermocosmetic regimen. A control or placebo arm was not incorporated because the study was conceived as an exploratory, formulation-level evaluation under routine-use conditions rather than as a confirmatory efficacy trial. Accordingly, the study was not intended to establish causal treatment effects or to distinguish the contribution of individual product components.

Several procedural measures were implemented to reduce avoidable variability, including predefined eligibility criteria, standardized twice-daily application instructions, avoidance of newly introduced facial skincare products or cosmetic procedures during follow-up, a standardized daytime photoprotection recommendation, repeated within-participant assessments, and uniform imaging conditions. Nevertheless, these measures cannot eliminate expectation effects, observer-related bias, seasonal influences, or other time-dependent confounding factors inherent to an uncontrolled observational design.

The study was conducted between May and October 2025 and included a 90-day observation period with four scheduled assessments: baseline (T0), day 30 (T1), day 60 (T2), and day 90 (T3). All procedures were performed in a clinical dermatology setting under standardized measurement conditions.

No formal a priori sample size or statistical power calculation was performed because the study was designed as an exploratory observational evaluation without a predefined comparative efficacy endpoint. The sample size was determined pragmatically on the basis of feasibility and the number of eligible participants recruited during the study period.

2.2. Participants

A total of 47 female participants, aged 30–60 years, were consecutively enrolled. All participants presented with visible clinical signs of facial skin aging, including fine lines, reduced elasticity, uneven texture, or dryness.

Inclusion criteria were:

- female sex;
- age between 30 and 60 years;
- visible signs of facial skin aging;
- good general health without active dermatological disease;
- willingness to comply with study procedures and scheduled visits.

Exclusion criteria included:

- known hypersensitivity to any component of the tested products;
- pregnancy or breastfeeding;
- active inflammatory or infectious dermatoses of the face;
- use of systemic retinoids, corticosteroids, or other medications known to affect skin physiology within the preceding three months.

Baseline demographic data, Fitzpatrick skin phototypes, and lifestyle characteristics (smoking status, alcohol consumption, sun exposure habits, tanning bed use, and occupational UV exposure) were recorded using a structured questionnaire.

2.3. Dermocosmetic Regimen

Participants followed a standardized dermocosmetic regimen consisting of an anti-age serum and an anti-age cream. The anti-age cream contained Prolom thermal water as 10.0% of the finished formulation, incorporated within the aqueous phase.

Quantitative composition data were available for the anti-age cream. The finished cream contained apricot kernel oil (15.0%), propylene glycol (5.0%), glyceryl stearate/potassium stearate (3.0%), cetyl palmitate (3.0%), squalane (2.0%), niacinamide (1.5%), a peptide filler complex (1.5%), panthenol (1.2%), caprylic/capric triglycerides (1.0%), sweet almond oil (1.0%), urea (1.0%), tocopheryl acetate (1.0%), sodium hyaluronate (0.99%), Psoralea corylifolia (bakuchi) seed oil (0.88%), cetearyl alcohol (0.50%), and polysorbate 60 (1.0%). The formulation additionally contained an acetyl octapeptide-3 preparation providing 0.003% acetyl octapeptide-3 in the finished cream, together with other peptide derivatives, allantoin, antioxidant components, preservatives, stabilizers, and fragrance constituents.

The regimen was designed as a multimodal leave-on system combining humectant and emollient components, barrier-supportive ingredients, antioxidants, peptide-based ingredients, and a retinoid-like botanical active. The rationale was to evaluate the complete formulation as it is intended to be used in practice, rather than to test isolated compounds under experimental conditions. Accordingly, the present study cannot determine the independent contribution of any individual ingredient or of the Prolom thermal water component. During stability testing, the pH of the anti-age serum ranged from 5.20 to 5.70 when measured internally using a WTW 3110 pH meter (WTW GmbH, Weilheim, Germany) and from 5.30 to 5.70 when measured by an independent external laboratory (IHTM). For the anti-age cream, the corresponding pH ranges were 5.60–6.20 internally and 6.00–6.50 in the external laboratory. Minor interlaboratory variation was considered attributable to differences in measurement instruments and analytical procedures.

Product safety, microbiological quality, preservative efficacy, and physicochemical stability of the anti-age cream were evaluated as part of the Cosmetic Product Safety Report. The microbiological examination fulfilled Category 1 criteria, and the preservative challenge test met criterion A. Stability and packaging compatibility tests were performed using an accelerated-aging protocol, with monitoring of organoleptic properties, pH, refractive index, and mass loss. Based on these assessments, the estimated shelf life was up to 24 months.

2.4. Application Protocol and Standardization

Participants were instructed to apply the serum and cream twice daily for 90 consecutive days.

- Morning application: serum was applied to cleansed facial skin, followed by the cream after approximately 5 min. Participants were instructed to follow the standardized study skincare routine throughout the observation period.
- Evening application: serum and cream applied in the same sequence to cleansed skin.

During follow-up, participants were permitted to use a mild facial cleanser and routine makeup, provided that makeup and leave-on products were removed before each instrumental assessment. Broad-spectrum SPF 50 sunscreen was recommended during daytime exposure to sunlight. Participants were instructed not to introduce additional leave-on facial products, including other moisturizers, serums, exfoliating products, retinoid-containing products, or prescription topical treatments, and not to undergo facial cosmetic procedures during the study period. The use of the study serum and cream constituted the standardized leave-on dermocosmetic regimen. Adherence to the study regimen was

assessed at each scheduled visit by verbal inquiry, review of participant product-use diaries, and monitoring of product consumption.

2.5. Measurement Conditions and Imaging Protocol

All objective assessments were performed by the same trained examiner using the same Visioscan® VC 20plus device (Courage + Khazaka electronic GmbH, Cologne, Germany) and a standardized acquisition protocol. The device was operated in accordance with the manufacturer's instructions. Before imaging, participants removed makeup and leave-on facial products using a mild, alcohol-free cleanser, rinsed their face with lukewarm water, gently dried the skin, and rested for 15 min in a controlled examination environment with a target temperature of 21–23 °C and a relative humidity of 40–60%. Objective imaging was performed at four predefined facial sites identified using stable anatomical landmarks: the central glabellar region, the left lateral canthal region, the right lateral canthal region, and the mental region. Participants were positioned in a standardized manner, and identical lighting, device-to-skin distance, and acquisition settings were used at each visit. For statistical analysis, subject-level values were calculated as the mean of the four assessment sites for each parameter at each scheduled visit.

2.6. Objective Skin Surface Analysis

Skin surface morphology and microrelief were analyzed using SELS® (Surface Evaluation of the Living Skin) software. The following parameters were quantified:

- skin roughness (SEr);
- skin smoothness (SEsm);
- scaliness (SEsc);
- wrinkle parameter (SEw);
- gray-level texture parameters (contrast, energy, entropy, homogeneity, variance);
- anisotropy index.

These metrics characterize surface irregularity, optical texture, and microrelief-related characteristics of the stratum corneum.

2.7. Subjective Outcome Measures

Subjective evaluation was performed using:

1. a structured product evaluation questionnaire assessing participant-perceived changes in skin hydration, elasticity, smoothness, wrinkle visibility, skin tone uniformity, overall satisfaction, and tolerability, recorded on a five-point scale;
2. the validated Skindex-16 questionnaire, assessing dermatology-related quality of life across Symptoms, Emotions, and Functioning domains.

The structured product evaluation questionnaire was developed for this study to capture exploratory participant-perceived changes and was not subjected to formal psychometric validation. Accordingly, its item-level findings were interpreted as exploratory and were considered alongside the validated Skindex-16 measure.

2.8. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice (GCP) guidelines. Ethical approval was obtained from the Ethics Committee of the University Clinical Centre of Vojvodina (Approval No. 00-156/2025) and the Ethics Committee of the Faculty of Medicine, University of Niš (Approval No. 12-3102-1/2-6). All participants provided written informed consent prior to enrollment. Written informed consent for publication of the potentially identifiable clinical images in Figure 1 was obtained from the participant(s) depicted.

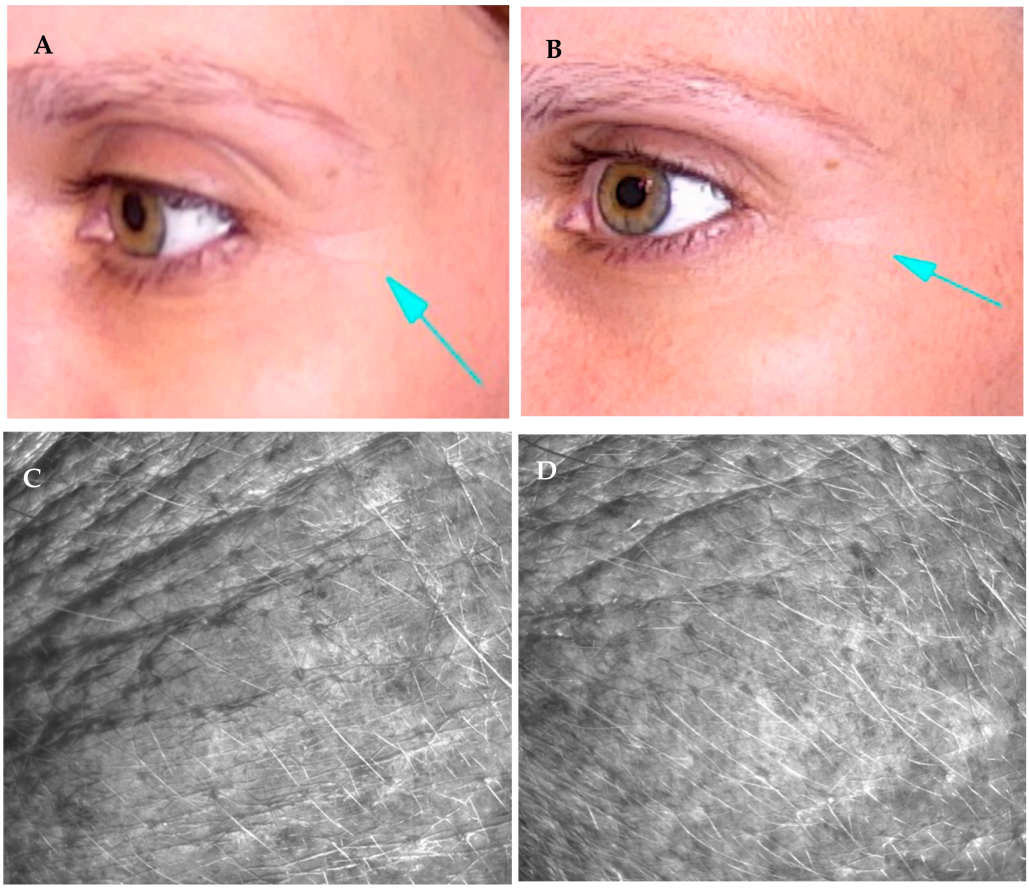

Figure 1. Representative clinical and Visioscan® images of the lateral canthal region obtained under standardized conditions at baseline (T0) and day 90 (T3). (**A**) Clinical photograph at baseline. (**B**) Clinical photograph at day 90. (**C**) Visioscan® image at baseline. (**D**) Visioscan® image at day 90. The images are provided as representative illustrations of the longitudinal changes in skin surface appearance and microrelief observed during the study period.

2.9. Statistical Analysis

Statistical analyses were performed using Jamovi version 2.5.0. Continuous variables are presented as mean ± standard deviation (SD). For objective Visioscan® parameters, subject-level values were calculated as the mean across the four predefined facial assessment sites at each scheduled visit. Median and interquartile range values are additionally provided in Supplementary Table S1 for descriptive completeness.

Changes in individual ordinal questionnaire items across follow-up visits were analyzed using the Friedman test, with Kendall's W reported as the corresponding effect size. Changes in Skindex-16 domain and overall scores across baseline and follow-up visits were analyzed using the Friedman test because the assumptions required for repeated-measures analysis of variance were not satisfied. Kendall's W was reported as the corresponding effect-size measure. Skindex-16 analyses were based on participants with complete repeated data at baseline and at days 30, 60, and 90.

Longitudinal changes in objective Visioscan® parameters were evaluated using linear mixed-effects models, with study visit entered as a categorical fixed effect and participant entered as a random intercept. Descriptive data are presented as observed mean ± SD at each scheduled visit. Observed mean changes from baseline to day 90 were calculated directly as the difference between the unadjusted mean values at T3 and T0. Model-based pairwise contrasts between baseline and each follow-up visit, with 95% confidence intervals and Holm-adjusted *p* values, are reported in Supplementary Table S2.

2.10. Use of Generative Artificial Intelligence

During manuscript preparation, ChatGPT (GPT-5.5 Thinking model; OpenAI, San Francisco, CA, USA; accessed July 2026) was used to assist with language editing, sentence restructuring, and improvement of clarity. It was not used for study design, participant recruitment, data collection, statistical analysis, generation or manipulation of data or images, or interpretation of the findings. All AI-assisted text was critically reviewed, revised, and verified by the authors, who take full responsibility for the final content.

3. Results

All 47 enrolled participants attended the scheduled baseline and follow-up visits through day 90. Retention was supported by the relatively short observation period, provision of the study products, scheduled follow-up assessments, participant product-use diaries, and a review of returned products and product consumption at follow-up visits.

Table 1 presents the demographic and baseline characteristics of the 47 participants. The mean age was 43.6 ± 9.7 years (range: 30–60 years). Most participants were classified as Fitzpatrick skin phototype II (59.6%) or phototype III (25.5%), reflecting the predominant skin phototypes in the study population. Lifestyle characteristics were relatively homogeneous: the majority of participants were non-smokers and reported moderate habitual sun exposure, while only a small proportion reported tanning bed use or high occupational ultraviolet exposure.

Table 1. Demographic and Lifestyle Characteristics of the Study Participants.

Characteristic	Category	n (%)
Sex	Female	47 (100%)
Age (years)	Mean ± SD (Min–Max)	43.6 ± 9.7 (30–60)
Age group	30–35 years	13 (27.7)
	36–45 years	15 (31.9)
	46–55 years	15 (31.9)
	56–60 years	4 (8.5)
Fitzpatrick skin phototypes	I	5 (10.6)
	II	28 (59.6)
	III	12 (25.5)
	IV	2 (4.3)
Smoking status	No	30 (63.8)
	Occasionally	4 (8.5)
	Yes	13 (27.7)
Alcohol consumption	No	24 (51.1)
	Occasionally	23 (48.9)
Sun exposure	Rarely	12 (25.5)
	Moderately	33 (70.2)
	Frequently	2 (4.3)
Tanning bed use	Yes	3 (6.4)
	No	44 (93.6)
Occupational sun exposure	Yes	1 (2.1)
	No	46 (97.9)

Table 2 summarizes participants' exploratory evaluations of the dermocosmetic regimen across the follow-up visits. Significant overall time effects were observed for perceived skin firmness and elasticity and a reduction in wrinkles (both $p < 0.001$), evenness of skin tone ($p = 0.015$), satisfaction with product effects ($p = 0.028$), and intention for continued use ($p = 0.004$). Changes in perceived skin texture and willingness to recommend the product were not statistically significant ($p = 0.549$ and $p = 0.135$, respectively). As the structured

product evaluation questionnaire was developed specifically for this study and was not formally psychometrically validated, these findings should be interpreted as exploratory participant-reported trends rather than validated clinical outcome measures. No serious adverse events were reported during the 90-day follow-up period.

Table 2. Subjective Evaluation of Perceived Product Effects Over the 90-Day Study Period.

Assessment Item/Evaluation Aspect	T1 Mean ± SD	T2 Mean ± SD	T3 Mean ± SD	*p* (Friedman)	Kendall's W
Skin firmness and elasticity	3.31 ± 1.03	3.31 ± 1.06	3.67 ± 0.91	<0.001	0.235
Reduction in wrinkles	2.31 ± 1.13	2.29 ± 1.11	2.69 ± 1.07	<0.001	0.153
Evenness of skin tone	2.69 ± 0.99	2.42 ± 0.87	2.67 ± 0.86	0.015	0.087
Skin texture (smoothness, softness)	2.98 ± 1.25	2.90 ± 1.21	2.98 ± 1.14	0.549	0.012
Satisfaction with product effects	3.65 ± 0.98	3.62 ± 0.96	3.75 ± 0.89	0.028	0.074
Intention for continued use	1.94 ± 1.00	1.88 ± 0.98	1.67 ± 0.66	0.004	0.116
Willingness to recommend the product	1.44 ± 0.58	1.50 ± 0.62	1.54 ± 0.65	0.135	0.042

Note: Values are presented as mean ± standard deviation. Friedman-test analyses were based on 47 participants with complete repeated questionnaire data at T1, T2, and T3. Responses were recorded on item-specific 5-point Likert scales. For perceived skin firmness and elasticity, reduction in wrinkles, evenness of skin tone, skin texture, and satisfaction with product effects, higher scores indicate more favorable perceived outcomes. For intention for continued use and willingness to recommend the product, lower scores indicate more favorable responses. Kendall's W is reported as the effect size.

All 47 participants attended the scheduled study visits; however, complete repeated Skindex-16 data at baseline and all follow-up visits were available for 41 participants and were included in the complete-case longitudinal analysis. Table 3 presents longitudinal changes in Skindex-16 domain and overall scores over the 90-day study period. Significant overall time effects were observed for Symptoms ($p = 0.015$), Emotions ($p < 0.001$), Functioning ($p < 0.001$), and the Overall Skindex-16 score ($p < 0.001$). The greatest relative reduction was observed in the Symptoms domain (−35.1%), followed by Functioning (−31.4%) and the Overall Skindex-16 score (−30.3%). Kendall's W values indicated small-to-moderate within-participant effect sizes across domains.

Table 3. Skindex-16 scores Across the 90-Day Assessment Period in the Anti-Age Cohort.

Domain	T0 Mean ± SD	T1 Mean ± SD	T2 Mean ± SD	T3 Mean ± SD	Change (T0 → T3)	Friedman χ^2 (*p*)	Kendall's W
Symptoms (items 1–4)	2.03 ± 1.17	1.57 ± 1.16	1.40 ± 1.13	1.32 ± 1.17	−35.1%	10.47 (0.015)	0.085
Emotions (items 5–11)	1.33 ± 1.20	1.29 ± 1.19	1.03 ± 1.10	1.00 ± 1.10	−25.1%	18.22 (<0.001)	0.148
Functioning (items 12–16)	1.85 ± 1.27	1.62 ± 1.31	1.29 ± 1.08	1.27 ± 1.09	−31.4%	18.04 (<0.001)	0.147
Overall Skindex-16 (items 1–16)	1.67 ± 1.07	1.46 ± 1.12	1.21 ± 1.01	1.16 ± 1.03	−30.3%	24.97 (<0.001)	0.203

Note: Values are presented as mean ± standard deviation. Lower Skindex-16 scores indicate lower dermatology-related burden. Change (T0 → T3) is expressed as the relative percentage change from baseline to day 90. Friedman-test analyses were based on 41 participants with complete repeated Skindex-16 data in the anti-age cohort. Kendall's W is reported as the effect size.

Table 4 presents the objective Visioscan® parameters measured across the scheduled study visits. Significant time effects were observed for all evaluated instrumental skin surface variables (all $p < 0.001$). From baseline to day 90, progressive reductions were noted in skin roughness (SEr), scaliness (SEsc), the wrinkle parameter (SEw), contrast, entropy, variance, and the anisotropy index, accompanied by increases in skin smoothness (SEsm), homogeneity, and energy. The greatest numerical change over time was observed for SEsm, while marked reductions were also observed for SEw, SEr, SEsc, and the anisotropy index. Taken together, the objective findings indicate consistent longitudinal changes in skin surface appearance and microrelief-related parameters over the 90-day observation period.

Table 4. Objective Visioscan® Parameters Across the 90-Day Study Period.

Parameter	T0	T1	T2	T3	Observed Mean Change (T3 − T0)	Overall *p* Value *
SEr (Skin roughness)	4.99 ± 2.29	3.24 ± 0.77	2.56 ± 0.59	1.66 ± 0.67	−3.33	<0.001
SEsm (Skin smoothness)	237.82 ± 76.86	323.43 ± 91.85	423.46 ± 113.15	605.68 ± 192.65	+367.86	<0.001
SEsc (Scaliness)	4.67 ± 3.98	1.63 ± 1.35	0.88 ± 0.63	0.40 ± 0.30	−4.27	<0.001
SEw (Wrinkles)	191.08 ± 87.26	116.73 ± 30.04	92.35 ± 21.79	74.27 ± 15.25	−116.81	<0.001
Contrast	2.23 ± 0.85	1.68 ± 0.62	1.38 ± 0.43	1.09 ± 0.35	−1.14	<0.001
Energy	0.01 ± 0.00	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	+0.02 †	<0.001
Entropy	1.50 ± 0.05	1.46 ± 0.05	1.43 ± 0.05	1.40 ± 0.04	−0.10	<0.001
Homogeneity	1.30 ± 0.08	1.35 ± 0.08	1.39 ± 0.07	1.45 ± 0.07	+0.15	<0.001
Variance	6.02 ± 1.26	5.26 ± 1.09	4.80 ± 0.91	4.20 ± 0.84	−1.82	<0.001
Anisotropy Index	34.92 ± 9.26	29.75 ± 10.23	25.43 ± 7.18	17.79 ± 3.81	−17.13	<0.001

Note: Values are presented as mean ± SD. The observed mean change was calculated directly from the displayed unadjusted mean values as T3 − T0. Model-based pairwise contrasts with 95% confidence intervals and Holm-adjusted *p* values are presented separately in Supplementary Table S2. * Overall time effects were evaluated using linear mixed-effects models. † The displayed value is based on means rounded to two decimal places.

To complement the mean ± SD presentation in Table 4, median (IQR) values for objective Visioscan® parameters across scheduled study visits are provided in Supplementary Table S1.

Post hoc pairwise comparisons for the objective Visioscan® parameters are provided in Supplementary Table S2. Following Holm correction for multiple comparisons, the observed longitudinal changes were primarily driven by significant differences between baseline and each follow-up visit.

Representative clinical and Visioscan® images of the lateral canthal region obtained at baseline and day 90 are presented in Figure 1 and visually complement the observed longitudinal changes in skin surface microrelief and texture.

4. Discussion

The present prospective observational study provides instrumental and patient-reported evidence of temporal skin surface changes during a standardized 90-day dermocosmetic regimen containing Prolom thermal water. In the present study, non-invasive imaging demonstrated significant time-dependent modulation of key skin microrelief parameters, including reductions in skin roughness (SEr), scaliness (SEsc), wrinkle-related parameters (SEw), and improvements in smoothness (SEsm) and texture uniformity. These objective changes were accompanied by improvements in participant-reported outcomes and good tolerability. Given the single-arm design, the findings should be interpreted as descriptive observations of skin changes under controlled dermocosmetic conditions rather than proof of causal efficacy.

The observed longitudinal trends may also have been influenced by factors unrelated to the intrinsic effect of the dermocosmetic regimen. These include improved adherence to a structured skincare routine, participant expectation or placebo-related effects, increased attention to facial care during repeated study visits, concurrent daytime sunscreen use, and seasonal variation in ultraviolet exposure, ambient temperature, and humidity. Because the study lacked a placebo, sunscreen-only, or no-treatment comparator group, the independent contribution of these factors cannot be separated from the observed changes.

The magnitude of the relative changes observed in several Visioscan® parameters should be interpreted cautiously. SELS® outputs are instrument-specific indices of skin surface morphology and texture and cannot be interpreted as direct proportional reductions in clinical wrinkle burden, visible dryness, or biological skin aging. Participants were enrolled because they had visible signs of facial aging, including dryness, uneven texture, and surface irregularity, which may have provided greater scope for within-participant temporal

change. In addition, the structured twice-daily routine, repeated study visits, increased attention to facial care, concurrent daytime photoprotection, and seasonal environmental variation may all have contributed to the observed longitudinal trends.

Although previous instrumental studies have reported changes in skin-surface parameters during the use of anti-aging formulations, a direct numerical comparison across studies remains limited because of differences in devices, algorithms, anatomical sites, formulations, study duration, and population characteristics [13]. In particular, no validated threshold for clinically meaningful change has been established for the specific Visioscan® parameters evaluated in the present study. Therefore, the numerical magnitude and statistical significance of the observed changes should not be interpreted as direct evidence of biological or clinically meaningful efficacy.

The observed temporal changes in instrumental parameters may be interpreted in the context of prior studies of dermocosmetic formulations containing commonly used active ingredients; however, the present design does not permit attribution of these changes to any individual component. Hyaluronic acid (HA), a central component of many anti-aging formulations, is well established for its ability to enhance skin hydration and viscoelastic properties, thereby influencing surface smoothness and wrinkle appearance [13–15]. In the present study, instrument-derived surface scaliness (SEsc) and roughness (SEr) demonstrated pronounced temporal changes. These parameters reflect optical and morphological characteristics of the skin surface but do not directly measure epidermal hydration, stratum corneum water content, transepidermal water loss, or barrier integrity [13–20]. Although topical hyaluronic acid has been associated with hydration-related effects in previous studies, the present findings should be interpreted as changes in surface texture and microrelief rather than as direct evidence of improved hydration or barrier function.

Statistical significance should not be equated with clinical significance. Although statistically significant longitudinal changes were observed for several instrumental parameters and Skindex-16 domains, no validated minimal clinically important difference has been established for the specific Visioscan® indices used in this study. Similarly, the study-specific product questionnaire was not formally validated as a clinical outcome instrument. The findings should therefore be interpreted as exploratory evidence of temporal changes under standardized observational conditions rather than proof of clinically meaningful efficacy.

Similarly, previous studies have described associations between topical niacinamide use and improvements in skin texture, tone uniformity, and fine lines [21–23]. Proposed mechanisms include barrier-related, antioxidative, and anti-inflammatory effects; however, these mechanisms were not directly evaluated in the present study. In our study, texture-related indices, including contrast, homogeneity, entropy, and variance, demonstrated significant modulation over time, reflecting a more uniform and organized skin surface. These findings are in agreement with previously described clinical effects of niacinamide on skin texture and tone. However, as no molecular or barrier-function analyses have been performed, the contribution of mechanisms such as cellular redox metabolism, stratum corneum lipid homeostasis, and pigmentation-related pathways remain speculative and are inferred solely from existing evidence [24–32].

Peptides represent another frequently studied class of dermocosmetic ingredients, with controlled trials demonstrating reductions in wrinkle depth and improvements in skin firmness associated with both signal peptides and neurotransmitter-inhibiting peptides [33–35]. In the present study, reductions in wrinkle-related instrumental parameters (SEw) and improvements in surface regularity were observed over the 90-day period. While these findings are consistent with peptide-related outcomes reported in the literature, the current

design does not allow attribution of these changes to peptide-specific effects, nor does it provide direct evidence of dermal remodeling or neuromuscular modulation.

Bakuchiol has been proposed as a retinol-like compound with improved tolerability, and comparative clinical studies have demonstrated reductions in wrinkles and hyperpigmentation comparable to retinol, with fewer adverse effects [10,36–38]. In the present study, the favorable tolerability profile and absence of clinically relevant irritation are consistent with these reports. Improvements in wrinkle-related and texture parameters observed instrumentally further align with previously described clinical outcomes of bakuchiol-containing formulations. Nevertheless, although literature suggests effects on gene expression related to collagen synthesis and extracellular matrix regulation [38–40], such mechanisms were not directly assessed and should therefore be interpreted cautiously. Accordingly, the ingredient-specific literature discussed above is included only to contextualize the multimodal formulation and should not be interpreted as evidence that any individual ingredient was responsible for the observed changes.

Thermal mineral waters are commonly incorporated into dermocosmetic formulations, yet objective instrumental data supporting their long-term effects on skin surface parameters remain limited. Prolom thermal water is characterized by its sodium-bicarbonate composition, alkalinity, and metasilicic acid content. In the present study, its use as a formulation component coincided with consistent temporal improvements across multiple surface parameters; however, the study design does not allow isolation of the specific contribution of the thermal water component relative to other formulation ingredients. The observed changes likely reflect the combined effect of the multimodal regimen rather than the action of a single constituent.

The improvement observed in Skindex-16 scores across all domains suggests that the objective skin surface changes detected instrumentally were accompanied by perceived benefits in dermatology-related quality of life [41,42]. In the present study, reductions in Symptoms, Emotions, and Functioning scores over time indicate decreased subjective burden of skin condition, consistent with previous reports linking cosmetic improvement to psychosocial well-being.

Overall, the present study highlights the utility of integrating non-invasive imaging technologies with patient-reported outcome measures in the longitudinal evaluation of dermocosmetic regimens. By combining objective assessment of skin microrelief and texture with validated quality-of-life instruments, the study provides a comprehensive characterization of skin surface dynamics during dermocosmetic use. Further controlled studies incorporating comparator groups, broader populations, and complementary biological assessments are required to clarify causal relationships and underlying mechanisms.

5. Limitations

Several limitations should be acknowledged. First, this was a prospective single-arm observational study without a placebo or comparator group, randomization, or blinding. Therefore, the observed temporal changes cannot be interpreted as definitive evidence of efficacy or causally attributed to the tested regimen. Changes over time may have been influenced by spontaneous variation, regression to the mean, improved skincare adherence, participant expectation effects, or increased attention to facial care during study participation. In addition, instrumental assessments were not performed under blinded conditions. Although imaging was conducted by the same trained examiner using standardized acquisition procedures, observer expectation bias cannot be excluded.

Second, daytime photoprotection with SPF 50 sunscreen was recommended because the study was conducted between May and October, a period associated with increased ultraviolet exposure. Although this recommendation was ethically appropriate, sunscreen

use represents an important confounding factor. Regular photoprotection alone may improve or stabilize visible features of photoaging, including skin texture, microrelief-related features, erythema, and wrinkle appearance. Because no sunscreen-only comparator group was included, the independent contribution of the tested dermocosmetic regimen cannot be separated from the potential effects of photoprotection, seasonal variation, or ultraviolet exposure. Moreover, changes in ambient temperature, humidity, and cumulative ultraviolet exposure during the study period may have independently influenced skin surface characteristics despite standardized conditions at scheduled visits.

Third, adherence was assessed through verbal inquiry, participant product-use diaries, and monitoring of returned products and product consumption. However, no electronic monitoring, biomarker-based verification, or other objective adherence measure was available. Fourth, the study included only female participants, predominantly with Fitzpatrick skin phototypes II and III, and ethnicity was not systematically assessed. Menopausal status, hormonal therapy, and remote history of cosmetic procedures were also not systematically recorded. These factors limit generalizability and leave the possibility of residual confounding related to hormonal status, previous aesthetic interventions, and other participant-specific variables.

Fifth, although the study was financially supported by Planinka d.o.o., Prolom Banja, Serbia, the sponsor had no role in study design, participant recruitment, data collection, analysis, interpretation, manuscript preparation, or the decision to submit the manuscript. Nevertheless, sponsor involvement may be perceived as a potential conflict of interest and should be considered when interpreting the findings. Finally, no biochemical, histological, molecular, hydration, transepidermal water-loss, or barrier-function assessments were performed. Therefore, proposed mechanisms remain inferential and based on the previous literature rather than on direct evidence from this study. In addition, although imaging was performed by the same trained examiner under standardized acquisition conditions, formal intra-observer reproducibility testing, test–retest repeatability assessment, and continuous environmental logging were not conducted. Therefore, residual measurement variability cannot be fully excluded. Because the regimen contained multiple active ingredients, the design also does not allow attribution of observed changes to any individual component, including Prolom thermal water. Further randomized, blinded, controlled studies involving broader populations, standardized photoprotection protocols, and comparator arms such as sunscreen alone or formulations lacking selected active ingredients are needed.

6. Conclusions

In this prospective single-arm observational study, a standardized 90-day dermocosmetic regimen was associated with measurable temporal changes in Visioscan®-derived skin surface parameters and participant-reported outcomes. Objective imaging demonstrated longitudinal modulation of skin microrelief and texture-related indices, while subjective assessments suggested reduced dermatology-related burden and good tolerability. However, the absence of a control group, concurrent photoprotection, and other potential confounding factors preclude causal interpretation and do not permit attribution of observed changes to individual regimen components. These findings should therefore be regarded as exploratory and hypothesis-generating, providing a rationale for randomized, blinded, comparator-controlled studies using validated clinical and instrumental endpoints.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/cosmetics13040176/s1, Table S1: Median (IQR) values of subject-level Visioscan® parameters across scheduled study visits; Table S2: Post hoc pairwise comparisons for objective Visioscan® parameters across scheduled study visits.

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Institutional Review Board Statement: The study adhered to the ethical principles of the Declaration of Helsinki and the regulatory standards of Good Clinical Practice (GCP). Ethical approval was obtained from: Ethics Committee of the University Clinical Centre of Vojvodina, Clinic of Dermatovenereology (Approval No. 00-156/2025 date: 21 March 2025), Ethics Committee of the Faculty of Medicine, University of Niš (Approval No. 12-3102-1/2-6 date: 3 April 2025). All participants were thoroughly informed about the study aims, procedures, potential risks, and benefits, after which they provided written informed consent. Participation was voluntary and participants had the right to withdraw from the study at any time. All collected data were anonymized and stored securely.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent for publication of the potentially identifiable clinical images presented in Figure 1 was obtained from the participant depicted.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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