cosmetics

MDPI

Article

Evaluation of the Effect of PRP Injections on Changes in Facial Skin Structures Assessed by Ultrasound Imaging

Alina Koshkinbayeva [1], Alina Ogizbayeva [2,*], Olga Ponamareva [3] and Bauyrzhan Omarkulov [4]

[1] Department of Phthisiology and Dermatovenereology, NJSC Karaganda Medical University, Karaganda 100029, Kazakhstan; shar_surgeon89@mai.ru
[2] Department of Emergency Medical Care, Anesthesiology and Resuscitation, NJSC Karaganda Medical University, Karaganda 100029, Kazakhstan
[3] Department of Biomedicine, NJSC Karaganda Medical University, Karaganda 100029, Kazakhstan; ponamareva@qmu.kz
[4] Department of Family Medicine, NJSC Karaganda Medical University, Karaganda 100029, Kazakhstan; omarkulov@qmu.kz
* Correspondence: eleusizova.a@qmu.kz

Abstract

The aim of this study was to evaluate the efficacy of platelet-rich plasma (PRP) injections into the facial skin in women based on facial skin ultrasound findings. The study included 50 women who underwent intradermal PRP injections into the facial skin for the first time. All patients underwent an ultrasound scan of the facial soft tissues and a skin assessment using a 3D skin analyzer both before the procedure and one month afterwards. Positive changes in the ultrasound parameters of the facial soft tissues were observed. The median thickness of the dermis increased by 30.8% in the forehead region, by 29.6% in the mid-cheek region and by 17.4% in the parotid region ($p < 0.05$). The thickness of the subcutaneous fat layer increased by 37.1%, 14.0% and 25.0% respectively ($p < 0.05$). The thickness of the subepidermal low-echogenic band decreased by 16.7% in the forehead region, by 8.3% in the mid-cheek region and by 16.7% in the parotid region; statistically significant changes were observed in the mid-cheek ($p = 0.0299$) and parotid regions ($p = 0.036$). High-frequency ultrasound enabled the quantitative assessment of short-term changes in facial soft tissue parameters following PRP administration. However, these findings represent ultrasound-derived morphometric changes and do not independently establish the presence of tissue regeneration or a treatment-specific biological effect.

Keywords: platelet-rich plasma; PRP; high-frequency ultrasound; effectiveness; facial skin; dermatology; cosmetology

Check for updates

Academic Editor: Enzo Berardesca

Received: 27 September 2026
Revised: 4 November 2026
Accepted: 9 November 2026
Published: 13 November 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Assessing the efficacy of platelet-rich plasma (PRP) in aesthetic medicine requires the use of objective methods to monitor the morphofunctional state of the skin [1–5]. Despite the widespread use of clinical scales for assessing rejuvenation outcomes (GAIS, Glogau, WSRS, VISIA, etc.), instrumental imaging methods are considered the most informative, as they allow for a quantitative assessment of changes in skin structure following PRP injections [6,7]. One of the most promising methods is high-frequency ultrasound (HFUS), which allows for a non-invasive assessment of the condition of the epidermis, dermis and superficial hypodermis [6,8–11].

The resolution of an ultrasound examination depends on the frequency of the transducer used: higher frequencies provide greater detail of superficial structures but result

in a shallower depth of penetration for the ultrasound waves. Specialized high-frequency ultrasound systems, with transducer frequencies ranging from 20–70 MHz, are used for detailed skin imaging, whereas linear transducers from standard ultrasound units—operating at 7–15 MHz—are employed to examine superficial soft tissues, including the skin and subcutaneous adipose tissue [8–12]. As terminology regarding ultrasound frequency ranges can vary by source, it is essential to consider the technical specifications of the specific equipment when interpreting results. Key ultrasound parameters of interest when evaluating age-related skin changes and the evolution of skin condition following aesthetic procedures include dermal thickness, the thickness of the subepidermal low-echogenic band (SLEB), and the thickness of the subcutaneous adipose tissue. While changes in these metrics may reflect shifts in the ultrasonic characteristics of the tissues, they do not, in themselves, provide direct confirmation of specific histological or molecular processes.

When administering PRP injections, ultrasound examination allows for an objective assessment of the dermal remodeling processes induced by platelet-derived growth factors. The most significant ultrasound parameters are: dermal thickness; dermal echogenicity; the thickness of the subepidermal low-echogenic band (SLEB); the condition of the superficial hypodermis; and the uniformity of the echo signal distribution. Modern ultrasound scanners enable automated image analysis with the calculation of quantitative tissue density indices. This significantly reduces the subjectivity of interpreting the examination results and improves the reproducibility of the data obtained [10–13].

It is well established that age-related skin changes involve the remodeling of the extracellular matrix, alterations in the organization of collagen and elastic fibers, and shifts in the composition of the intercellular matrix. These processes can manifest as changes in dermal echogenicity and the formation of a subepidermal low-echogenic band (SLEB), which can be detected via ultrasound [1,13]. Following PRP injections, variations in the thickness of the dermis and the SLEB may be observed. One potential explanation for these changes is the influence of growth factors—contained within platelets—on cellular activity and the renewal of the extracellular matrix. Nevertheless, ultrasound measurements alone cannot definitively confirm neocollagenesis or other specific mechanisms of tissue remodeling without supplementary histological, biochemical, or molecular analyses [1,10–13].

Despite the growing interest in the use of PRP in aesthetic medicine, the objective, quantitative assessment of changes in the various layers of facial soft tissue following such procedures remains an important area for research. Combining ultrasound imaging with instrumental assessment of the skin allows for a comprehensive study of the dynamics of both the structural characteristics of the tissues and the external condition of the skin. The specific contribution of the present study lies in the simultaneous assessment of ultrasound-detected changes in the epidermal-dermal complex and subcutaneous adipose tissue following PRP administration. Particular attention was paid to the dynamics of dermal thickness, SLEB thickness, and subcutaneous fat thickness in three standardized facial anatomical regions. An additional methodological feature was the use of a PRP injection protocol involving different administration depths (4–5 mm and 6 mm), allowing the assessment of changes in both dermal and subcutaneous tissue compartments. Although this study does not establish the biological mechanisms underlying these changes, it provides additional quantitative data on the short-term ultrasound characteristics of facial soft tissues following PRP treatment. The aim of this study was to evaluate the efficacy of PRP injections into the facial skin in women based on facial skin ultrasound findings.

2. Materials and Methods

2.1. Patients

The study included 50 women with a median age of 35.0 (Q1–Q3: 28.0–41.0), who underwent their first course of intradermal PRP injections into the facial skin. The study followed a prospective design, with assessments conducted both before the intervention and one month afterward in the same participants. There was no control group in the study. No preliminary sample size calculation was performed; the number of participants was determined based on practical feasibility and patient availability. These factors were taken into account when interpreting the results and are considered study limitations.

Prior to the procedure, all participants underwent a general examination with a thorough medical history to rule out systemic diseases and acute viral/bacterial infectious diseases at the time of the study.

Patients meeting the following criteria were excluded from the study: age under 20 years; pregnancy or breastfeeding; the presence of comorbidities such as coagulopathy, thyroid dysfunction, autoimmune and infectious diseases, diabetes mellitus or any other severe comorbidities affecting well-being and quality of life; taking any medication (particularly anticoagulant therapy); a history of previous plasmolifting procedures (PRP injections).

PRP preparation and facial skin injections were performed according to the authors' previously described protocol [14]. The present work is an independent study involving a separate cohort of 50 participants. The participants and individual data in this study do not overlap with the cohort or data from the previous publication. Thus, the reference to the earlier work pertains solely to the intervention methodology, while the results of the ultrasound and instrumental skin assessments presented in this article were obtained as part of a distinct study.

To prepare the PRP, 27 mL of venous blood was collected into three 9 mL vacuum tubes with heparin and separating gel. The samples were subjected to a single centrifugation step for 5 min at 3200 rpm, yielding approximately 13–14 mL of PRP. The total platelet count in the final PRP preparation was $1.2 \pm 0.2 \times 10^9$ platelets per 4.5 mL of plasma. Based on the final PRP volume, the estimated platelet concentration was $267 \pm 44 \times 10^9$/L. PRP was not activated (PRP products can be used without the addition of an activation agent because platelet activation is spontaneously induced due to exposure to dermal collagen and thrombin once PRP is injected).

Injections were administered starting from a depth of 4–5 mm throughout the hypodermis and dermis layer, in a uniform dose of 0.2–0.3 mL with an interval of 1–1.5 cm between injections along the facial surface marked in green in Figure 1. Injections in a dose of 0.4 mL with an interval of 2–2.5 cm between injections along the facial surface marked in blue in Figure 1 were administered starting from a depth of 6 mm throughout the hypodermis and dermis layers. All patients underwent a single session of PRP therapy; no additional sessions or other stimulating procedures were performed as part of this protocol.

The method used ensured uniform distribution of PRP within the dermal layer, minimal tissue trauma due to the use of fine needles, maintenance of sterility at all stages of the procedure, and prevention of local complications. Furthermore, intradermal injection created optimal conditions for the spontaneous activation of platelets and the subsequent release of growth factors directly into the facial skin tissues. All patients underwent an ultrasound scan of the facial soft tissues and a skin assessment using a 3D skin analyzer both before the procedure and one month afterwards.

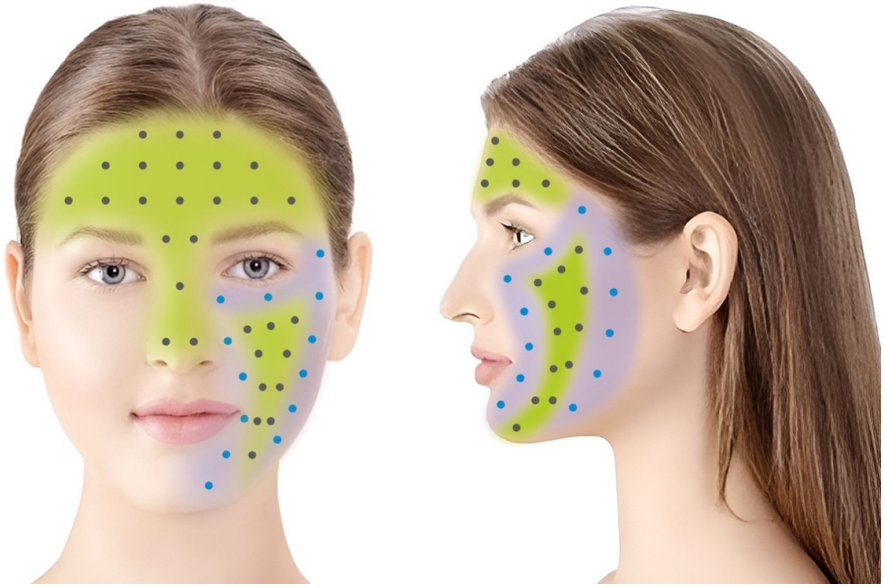


Figure 1. The green-colored areas indicate injection sites where the needle was inserted to a depth of 4–5 mm, with a dose of 0.2–0.3 mL and an interval of 1–1.5 cm between injections. The blue-colored areas indicate injection sites where the needle was inserted to a depth of 6 mm, with a dose of 0.4 mL and an interval of 2–2.5 cm between injections [14].

To assess the morphometric characteristics of the facial soft tissues, an ultrasound examination was performed using the SonoAce-X6 diagnostic ultrasound scanner (Samsung Medison, Seoul, Republic of Korea) equipped with an HL5-12ED broadband linear transducer (operating frequency range: 7.5–12 MHz). This range corresponds to the high-frequency linear transducers typically used in standard ultrasound systems for imaging superficial soft tissues. The equipment employed does not fall into the category of specialized, ultra-high-frequency dermatological ultrasound systems (which operate, for instance, in the 20–50 MHz range). As the specific operating frequency of the transducer was not recorded during the examination, it is not possible to provide an exact value. Despite the absence of a recorded exact operating frequency, the selected transducer provided sufficient image quality to identify the superficial skin layers and visualize the SLEB in the examined anatomical regions. However, the spatial resolution of the equipment should be considered a technical limitation, particularly when interpreting measurements of thin superficial structures. Therefore, the measurements obtained should be regarded as ultrasound-based morphometric estimates rather than high-resolution histological equivalents. The capabilities and limitations of the ultrasound equipment used were taken into account when interpreting the findings. Key ultrasound parameters of interest when evaluating age-related skin changes and the evolution of skin condition following aesthetic procedures include dermal thickness, the thickness of the subepidermal low-echogenic band (SLEB), and the thickness of the subcutaneous adipose tissue. While changes in these metrics may reflect shifts in the ultrasonic characteristics of the tissues, they do not, in themselves, provide direct confirmation of specific histological or molecular processes.

The examinations were conducted in B-mode (two-dimensional grayscale) using Tissue Harmonic Imaging (THI). The scanning depth was set to 30 mm. Gain and brightness settings remained constant between the initial and follow-up examinations. All scans were performed by the same experienced ultrasound specialist. Patients were positioned sitting upright with their heads in a neutral position. To minimize compression of the soft tissues, an ample amount of acoustic gel was applied, and the transducer was pressed against the skin with minimal force.

Morphometric assessment was conducted in three anatomical regions of the face (Figure 2):

- Frontal region (segment S1): a point on the midline of the forehead, in the upper third of the face, located at the intersection of reference lines within the boundaries of segment S1.
- Mid-cheek region (segment S2): a fixed point in the middle third of the cheek.
- Parotid region (segment S3): a point located 1 cm medial to the tragus of the ear.

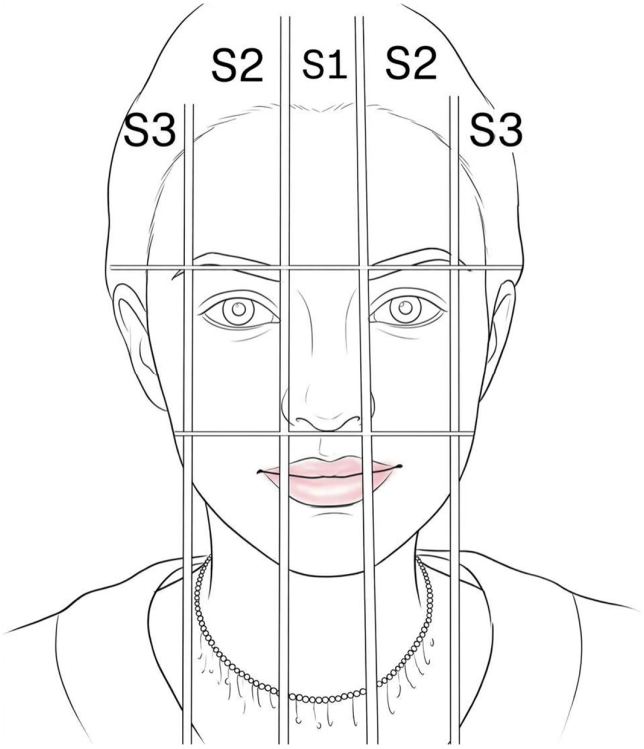


Figure 2. Ultrasound-based morphometric assessment of facial soft tissues was performed before PRP injections and 1 month after the procedure in three anatomical regions: the frontal region (S1)—along the midline of the forehead in the upper third of the face; the mid-cheek region (S2)—at a fixed point in the middle third of the cheek; and the parotid region (S3)—1 cm medial to the tragus of the ear.

The same anatomical landmarks were used for follow-up examinations. No photographic documentation or skin marking was employed to replicate the measurement points. In each anatomical region, one measurement was taken before the procedure and another 1 month afterward. The values presented correspond to the results of individual measurements, rather than the mean or median values of a series of repeated measurements.

The thickness of the structures under study was determined perpendicular to the skin surface using the built-in electronic calipers of the ultrasound system. The thickness of the dermis, the subepidermal low-echogenicity band (SLEB), and the subcutaneous adipose tissue were measured sequentially. The thickness of the muscle layer was assessed only in the frontal region.

The dermis is visualized as a relatively homogeneous hyperechoic structure of moderate intensity, the echogenicity of which is determined by the content of collagen and elastic fibers. The subcutaneous adipose tissue is represented by hypoechoic fat lobules separated by hyperechoic connective tissue septa [15,16]. Measurements were taken perpendicular to the skin surface using the ultrasound system's built-in electronic calipers. The following were assessed in sequence: the thickness of the dermis; the thickness of the subepidermal

low-echogenic band (SLEB); the thickness of the subcutaneous fat layer; and the thickness of the muscle layer (in the forehead region only) (Figure 3).

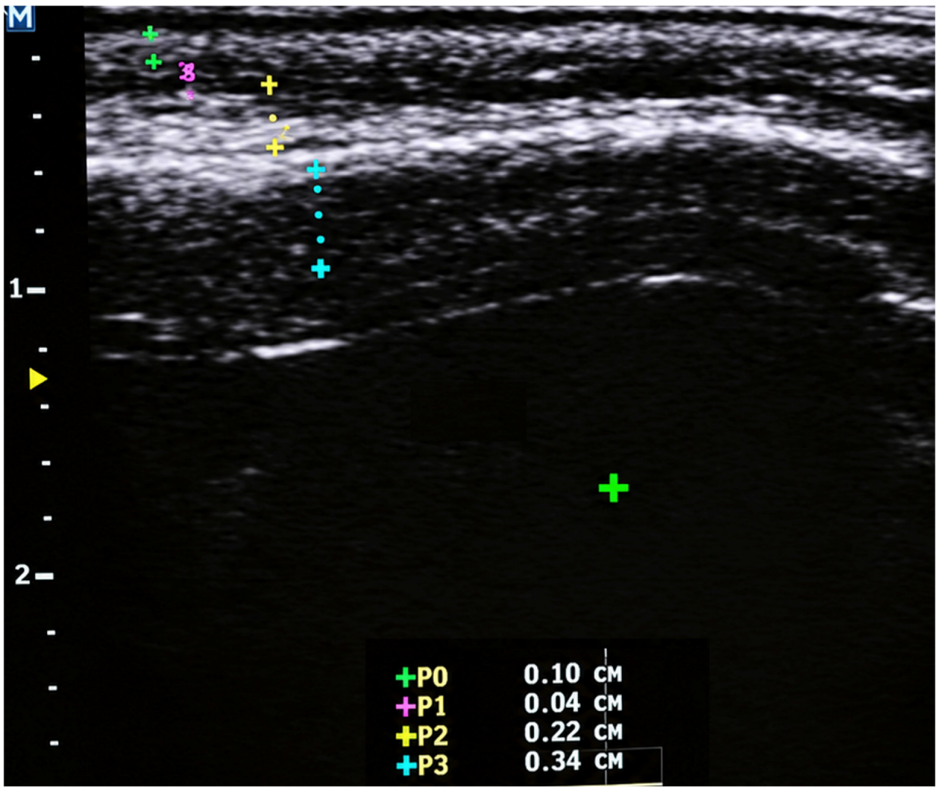


Figure 3. Ultrasound examination of facial soft tissues: P0—dermal thickness (green); P1—Subepidermal Low-Echogenic Band (SLEB, pink); P2—subcutaneous fat layer thickness (yellow); P3—muscle layer thickness (blue).

All measurements were performed by a single specialist; however, no blinding regarding the study stage was applied. Measurement reproducibility, as well as intra-operator and inter-operator variability, were not specifically assessed. Therefore, it is impossible to entirely rule out the influence of the operator, the specific positioning of the transducer, or the selection of boundaries for the structures being measured on the obtained results.

Furthermore, to assess the condition of the skin before and one month after the procedure, the Bitmoji 3D facial skin analyzer from Guangzhou Ideal Beauty Equipment Co., Ltd. (Guangzhou, China) was selected. Automated image analysis was performed by the device's software, utilizing computer image processing algorithms and artificial intelligence. The technology employed is based on generally accepted principles of multispectral digital imaging, computerized image analysis and automated quantitative assessment of the skin's morphometric and spectral characteristics. The analyzer's optical unit captures images under several lighting conditions. When examining the skin under visible (RGB) light, a video diagnosis is performed to assess the skin's overall condition, tone, surface imperfections, wrinkles and pores. The use of cross-polarized light (PL) enables video diagnosis of the vascular network, skin texture characteristics, micro-relief and pore size by suppressing surface light reflections. The use of the ultraviolet (UV) spectrum enables the visualization of epidermal pigmentation, hidden pigmented lesions and areas of hyperkeratosis, allowing for an objective assessment of the degree of photodamage to the skin. Digital images were analyzed using the RGB, PL and UV spectra to assess skin age, sensitivity, pigmented spots, wrinkles, blackheads and pores (Figure 4).

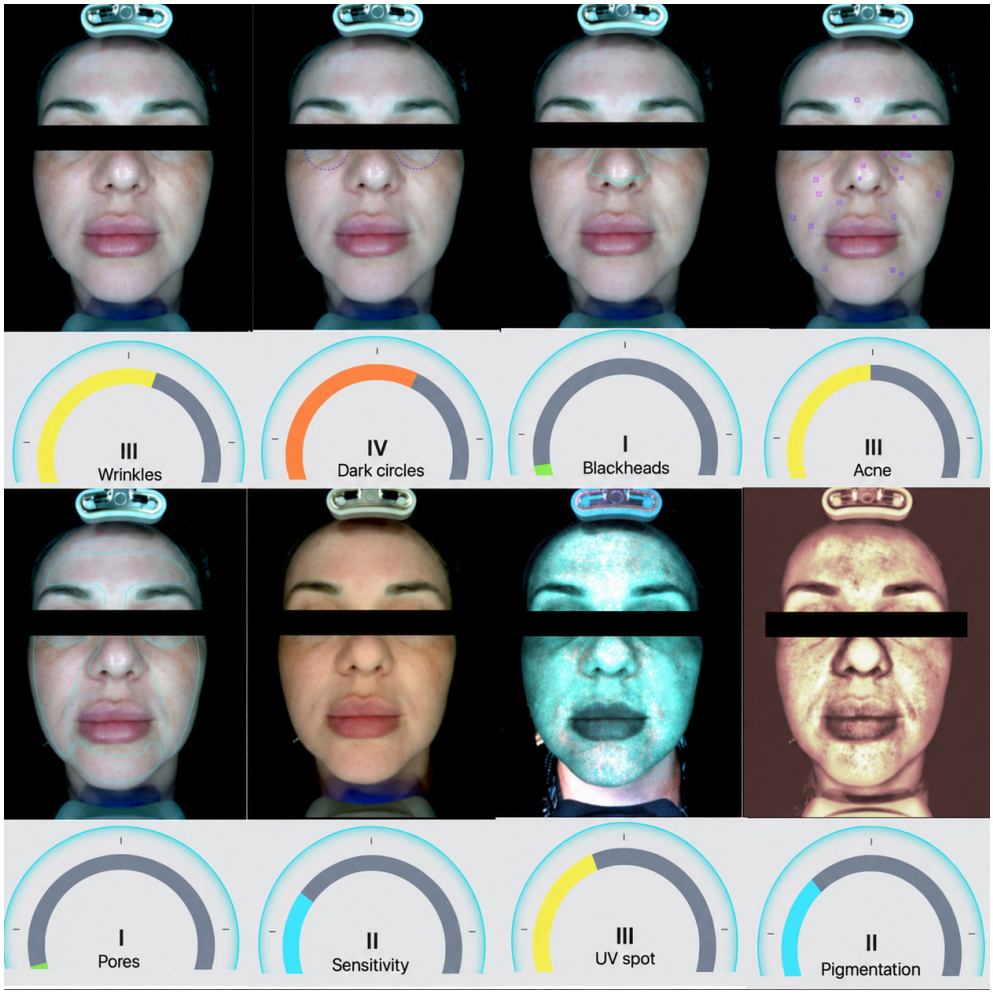


Figure 4. Assessment of skin condition using the 3D Bitmoji facial skin analyzer from Guangzhou Ideal Beauty Equipment Co., Ltd. (Guangzhou, China).

To enhance the comparability of results, the conditions for the assessment were standardized. The examination was conducted with the subject in a seated position, with the head stabilized using the chin and forehead rests integrated into the device's design. During follow-up assessments, the same patient positioning and alignment procedure were applied to minimize potential variations resulting from head orientation during image capture. The software presented the results of the automated analysis as quantitative metrics (expressed as percentages) and color-coded scales, accompanied by textual descriptions of the corresponding skin characteristics. When interpreting changes over time, the numerical values, color-coding, and textual descriptions provided by the software were all taken into account. Results obtained before treatment were compared with those recorded one month post-treatment to evaluate changes in the measured skin characteristics. It should be noted that the color-coded indicators and textual descriptions are elements of the software's visualization and interpretation interface; they do not constitute independently validated clinical criteria for improvement in skin condition. This study did not include an independent clinical validation of the analyzer's algorithms, nor did it assess the accuracy of individual metrics, the reproducibility of repeated measurements, or the alignment of results with reference methods. While standardizing patient positioning ensured consistency in the image acquisition process, this does not, in itself, confirm the analytical accuracy or reproducibility of the device's algorithms. Consequently, the values obtained were treated as supplementary instrumental data and interpreted with these limitations in mind. Vali-

dated reference ranges and minimal clinically important differences were not available for these analyzer scores; therefore, changes in the scores cannot be interpreted as validated clinical improvement.

2.2. Ethics Statement

The study was carried out in accordance with the principles of the Declaration of Helsinki and was approved by the Local Bioethics Commission (protocol No. 15, approval No. 98, dated 17 November 2023). Written informed consent was obtained from all study participants.

2.3. Statistical Analysis

Statistical analysis was performed using STATISTICA 8.0 software (StatSoft, Tulsa, OK, USA). The data were summarized by calculating the median (Me) and the lower and upper quartiles (Q1 and Q3). Paired changes from baseline to one month were assessed with two-sided Wilcoxon signed-rank tests, and associations between paired changes were assessed with Spearman rank correlation coefficients. No single primary endpoint was prospectively prespecified; for interpretation, dermal-thickness change was treated as the principal morphometric outcome, while SLEB, subcutaneous fat, muscle, skin-analyzer, and correlation results were considered secondary or exploratory. No adjustment for multiple comparisons was applied. All p-values are therefore nominal, and the risk of type I error should be considered. For Table 1, two-sided asymptotic p-values were aligned with the reported standardized Wilcoxon Z statistics. Statistical significance was defined as $p < 0.05$.

Table 1. Results of the study of facial skin thickness before and 1 month after PRP injection.

Facial Area	Measurement	Median	Q1 (Lower Quartile)	Q3 (Upper Quartile)	Z (Wilcoxon Test)	p-Level
Frontal region	Dermal thickness before PRP injections	1.30	1.05	1.40	3.309	0.0009
	Dermal thickness 1 month after PRP injections	1.70	1.55	1.80		
	SLEB before PRP injections	0.60	0.50	0.80	1.475	0.140
	SLEB 1 month after PRP injections	0.50	0.45	0.65		
	Thickness of the subcutaneous fat layer before PRP injections	1.75	1.25	2.25	2.925	0.003
	Thickness of the subcutaneous fat layer 1 month after PRP injections	2.40	2.20	2.70		
	Thickness of the muscle layer before PRP injections	3.70	3.15	3.80	1.444	0.149
	Thickness of the muscle layer 1 month after PRP injections	3.85	3.40	4.35		
Mid-cheek region	Dermal thickness before PRP injections	1.35	1.20	1.50	3.294	0.001
	Dermal thickness 1 month after PRP injections	1.75	1.70	1.80		
	SLEB before PRP injections	0.60	0.60	0.85	2.172	0.0299
	SLEB 1 month after PRP injections	0.55	0.40	0.65		
	Thickness of the subcutaneous fat layer before PRP injections	2.85	2.75	3.40	2.306	0.021
	Thickness of the subcutaneous fat layer 1 month after PRP injections	3.25	2.95	4.25		

Table 1. *Cont.*

Facial Area	Measurement	Median	Q1 (Lower Quartile)	Q3 (Upper Quartile)	Z (Wilcoxon Test)	*p*-Level
Parotid region	Dermal thickness before PRP injections	1.15	1.00	1.35	2.448	0.014
	Dermal thickness 1 month after PRP injections	1.35	1.20	1.50		
	SLEB before PRP injections	0.60	0.55	0.80	2.097	0.036
	SLEB 1 month after PRP injections	0.50	0.50	0.60		
	Thickness of the subcutaneous fat layer before PRP injections	2.00	1.95	2.60	2.350	0.019
	Thickness of the subcutaneous fat layer 1 month after PRP injections	2.50	2.10	3.30		

Measurements are reported in millimeters. The *p*-values are two-sided asymptotic values corresponding to the standardized Wilcoxon Z statistics.

3. Results

3.1. Ultrasound Examination of Facial Soft Tissues

The results of a comparative study of facial skin thickness before and one month after PRP injection are presented in Table 1 and Figure 5.

The results obtained indicate that the most pronounced changes were observed in dermal thickness across all anatomical areas studied. In the forehead region, the median dermal thickness increased from 1.30 mm to 1.70 mm ($p = 0.0009$). A similar trend was observed in the mid-cheek region, where the dermal thickness increased from 1.35 mm to 1.75 mm ($p = 0.001$), as well as in the parotid region—from 1.15 mm to 1.35 mm ($p = 0.014$).

Changes in the thickness of the SLEB, located in the superficial dermis beneath the epidermis, were moderate in nature. In the forehead region, the decrease in the median value from 0.60 to 0.50 mm did not reach statistical significance ($p = 0.140$). However, in the mid-cheek region, the measurement decreased from 0.60 mm to 0.55 mm, which was accompanied by statistically significant differences ($p = 0.0299$). Similarly, in the parotid region, a reduction in the thickness of the line from 0.60 mm to 0.50 mm was observed ($p = 0.036$). The changes observed may indicate structural reorganization of the superficial layers of the skin following PRP injections.

Analysis of subcutaneous fat thickness showed a trend towards an increase in all areas studied: in the forehead region from 1.75 mm to 2.40 mm ($p = 0.003$), in the mid-cheek region—from 2.85 to 3.25 mm ($p = 0.012$) and in the parotid region—from 2.00 to 2.50 mm ($p = 0.011$). The thickness of the muscle layer was assessed only in the forehead region. Following PRP injections, the median increased from 3.70 mm to 3.85 mm. No statistically significant change in muscle thickness was detected between baseline and the 1-month follow-up assessment ($p = 0.149$).

3.2. Analysis of Changes in Ultrasound Parameters and Skin Assessment Results Following PRP Injections

To assess the efficacy of PRP injections into the facial skin, the changes over time in the ultrasound parameters of facial soft tissues and skin condition indicators, as determined by instrumental diagnostics, were analyzed. The results are presented in Table 2.

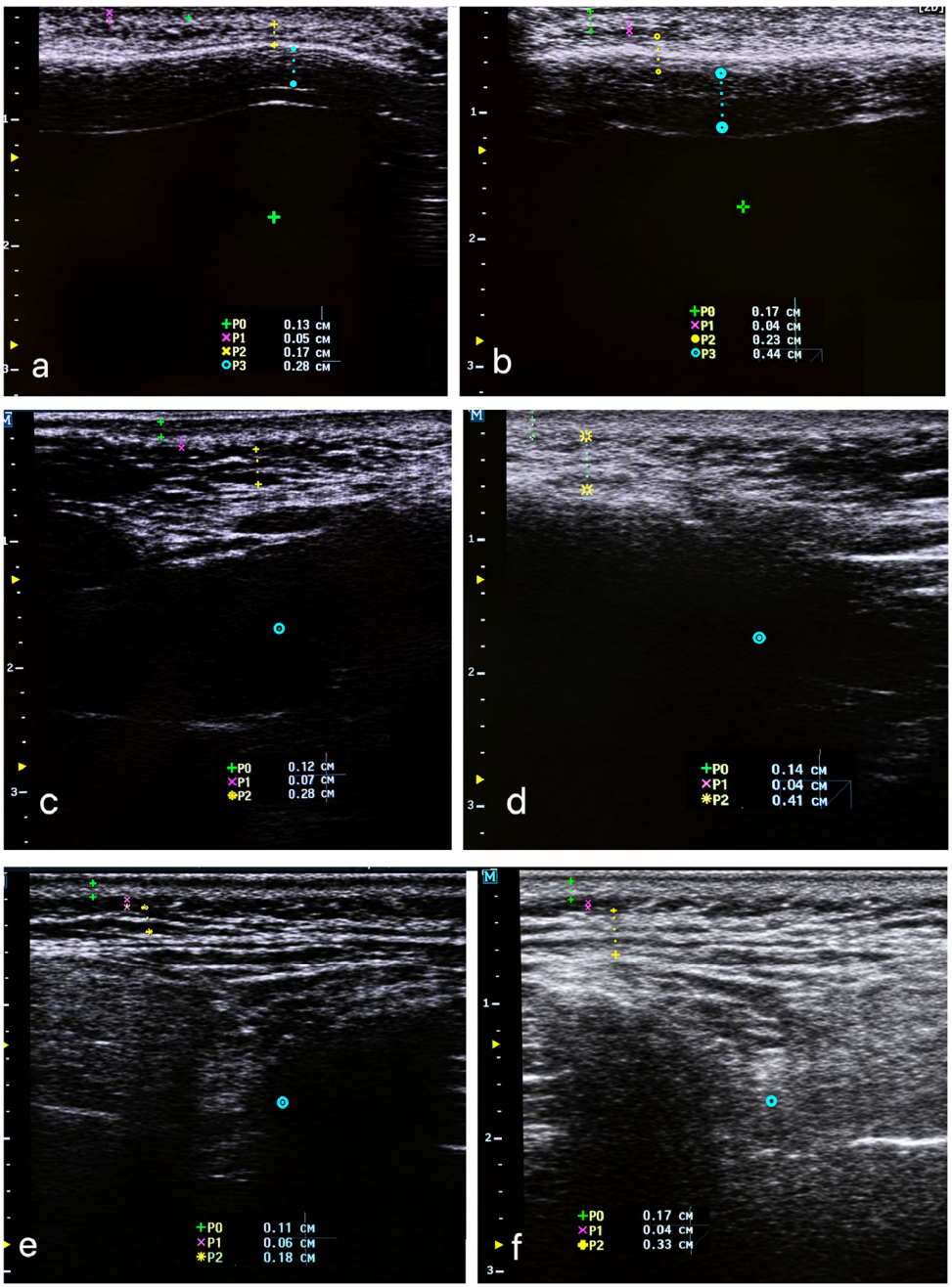


Figure 5. Ultrasound examination of the facial soft tissues: (**a**)—the forehead region before PRP injections, (**b**)—the forehead region 1 month after PRP injections, (**c**)—the mid-cheek region before PRP injections, (**d**)—the mid-cheek region 1 month after PRP injections, (**e**)—the parotid region before PRP injections, (**f**)—the parotid region 1 month after PRP injections. P0—dermal thickness (green); P1—Subepidermal Low-Echogenic Band (SLEB, pink); P2—thickness of the subcutaneous fat layer (yellow); P3—thickness of the muscle layer (blue). Paired baseline and follow-up images were obtained from equivalent anatomical sites and under comparable acquisition conditions.

Analysis of the ultrasound measurements showed that the most pronounced increase in tissue thickness was observed in the dermal and subcutaneous fat layers. Thus, the median increase in dermal thickness was 0.40 mm in the forehead region (0.20–0.60 mm) and the mid-cheek region (0.20–0.50 mm), and 0.25 mm (0.00–0.40 mm) in the parotid region. The data demonstrated an increase in ultrasound-measured dermal thickness across all three anatomical regions during the study period. However, these findings should be interpreted as morphometric changes rather than direct evidence of dermal remodeling or regeneration.

The absence of a control group and the possibility of post-injection edema or changes in tissue hydration limit the ability to attribute these changes specifically to PRP administration. The most significant increase in subcutaneous fat thickness was recorded in the forehead and parotid regions, where the median increase was 0.70 mm. In the mid-cheek region, the changes were less pronounced (median 0.15 mm), whilst the wide interquartile range indicates individual variability in the response to PRP injections. In contrast to the dermis and subcutaneous adipose tissue, the SLEB thickness decreased in all anatomical regions. The median change was −0.20 mm in the forehead and mid-cheek regions, and −0.10 mm in the parotid region. These findings demonstrate a reduction in ultrasound-measured SLEB thickness during the study period. However, this change cannot be considered direct evidence of structural reorganization or regeneration of the epidermal-dermal complex. Changes in the thickness of the muscle layer were less pronounced. In the forehead region, the median increase was 0.30 mm; however, the wide interquartile range (from −0.30 to 1.10 mm) indicates significant individual variability in this parameter and the absence of a uniform response across all patients.

Table 2. Changes in ultrasound parameters of facial soft tissues and skin condition indicators, based on diagnostic equipment results 1 month after PRP injections.

Parameter	Median	Q1 (Lower Quartile)	Q3 (Upper Quartile)
Ultrasound			
Dermal thickness (frontal region)	0.40	0.2	0.60
SLEB (frontal region)	−0.20	−0.3	0.10
Thickness of the subcutaneous fat layer (frontal region)	0.70	0.1	1.10
Thickness of the muscle layer (frontal region)	0.30	−0.3	1.10
Dermal thickness (mid-cheek region)	0.40	0.2	0.50
SLEB (mid-cheek region)	−0.20	−0.3	0.05
Thickness of the subcutaneous fat layer (mid-cheek region)	0.15	−0.2	1.15
Dermal thickness (parotid region)	0.25	0.0	0.40
SLEB (parotid region)	−0.10	−0.3	0.00
Thickness of the subcutaneous fat layer (parotid region)	0.70	0.0	0.85
Skin analyzer			
Age	−1.00	−1.5	1.00
Wrinkles	−1.50	−14.0	0.50
Skin tone	−2.00	−11.5	−2.00
Pores	0.00	−15.0	26.50
Acne	−5.00	−20.0	0.00
Blackheads	0.00	−5.0	10.00
Dark circles	−0.50	−10.0	0.00
Sensitivity	−6.50	−22.5	0.00
Pigmentation	0.00	−2.5	0.00

Values represent the median of individual changes calculated for each participant between baseline and the 1-month follow-up assessment.

The digital skin analyzer recorded changes in several skin assessment parameters between baseline and the 1-month follow-up examination (Figure 6). However, because the device's measurement algorithms and scoring scales have not been independently validated, these changes should be interpreted as supplementary instrumental observations

rather than confirmed clinical improvements. The clinical relevance and direction of some recorded changes remain uncertain.

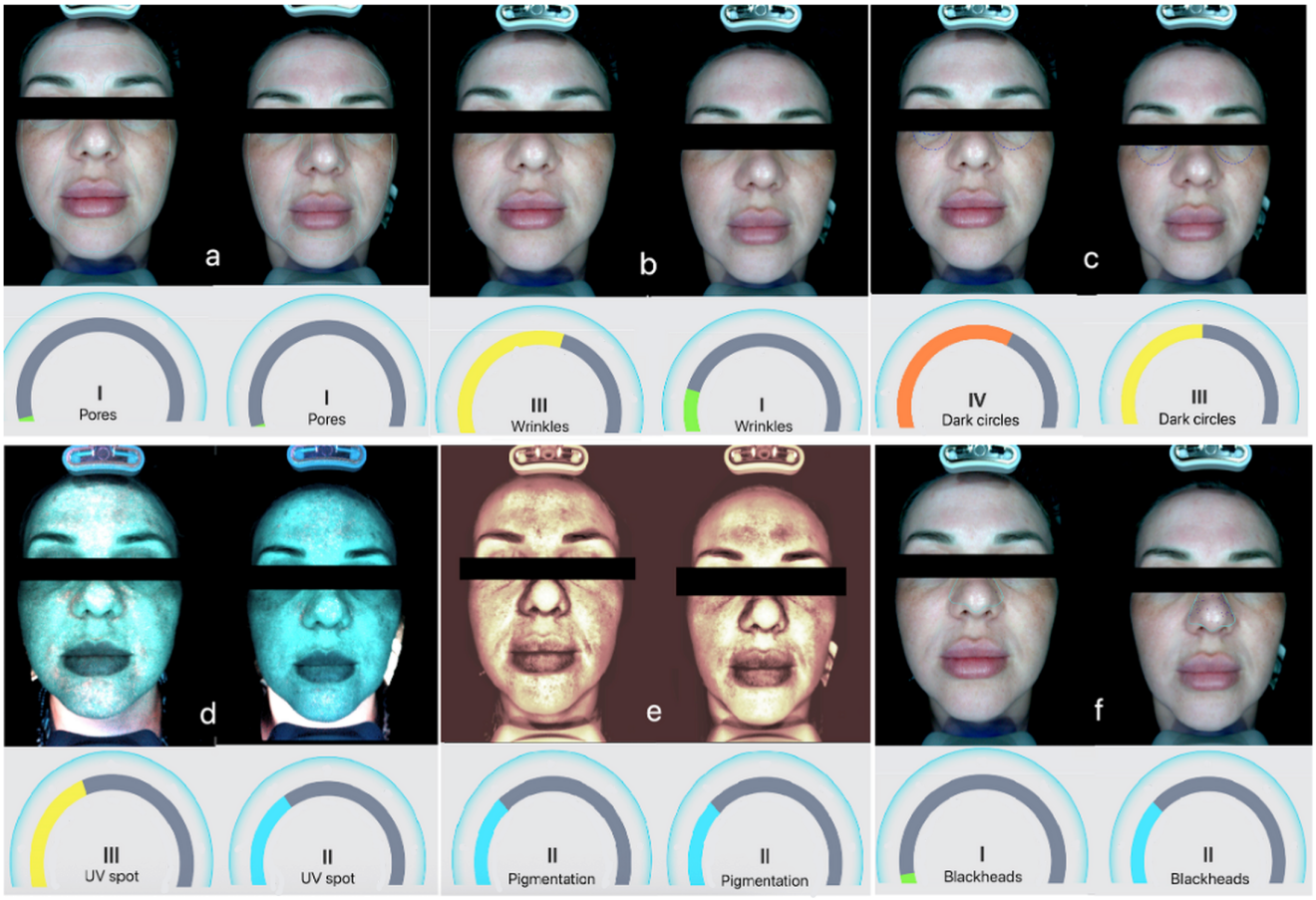


Figure 6. Assessment of skin condition using the 3D Bitmoji facial skin analyzer from Guangzhou Ideal Beauty Equipment Co., Ltd. before (left) and 1 month after (right) PRP injections into the facial skin: (**a**)—pores; (**b**)—wrinkles; (**c**)—dark circles under the eyes; (**d**)—UV spots; (**e**)—pigmentation; (**f**)—blackheads. Green indicates optimal skin condition with no significant abnormalities; blue indicates good condition with minimal changes; yellow indicates the presence of initial or moderately pronounced changes; orange indicates pronounced changes; red indicates significant changes.

The most pronounced changes were recorded for skin tone (median change –2.0 points), sensitivity (–6.5 points), acne (–5.0 points) and wrinkle severity (–1.5 points). Negative values for these changes reflect a reduction in the severity of the corresponding skin changes following PRP injections. A moderate improvement was also noted in the subjective assessment of age-related appearance (median –1.0 points) and the severity of dark circles (−0.5 points). Conversely, metrics related to pores, hyperpigmentation, and dark spots showed a median value close to zero, indicating an absence of significant changes in most patients—though, again, there was considerable individual variability, as evidenced by the wide interquartile ranges.

3.3. Correlation Analysis of the Dynamics of Ultrasound Parameters and the Results of Instrumental Assessment of Skin Condition

A correlation analysis was carried out to assess the relationship between changes in the ultrasound parameters of the facial soft tissues and the dynamics of skin condition indicators, based on the results of instrumental diagnostics (Table 3). Statistical significance was set at $p < 0.05$, and correlation analysis was considered exploratory; no multiple-

comparison correction was applied. Given the number of associations examined, these selected correlations are exploratory and at increased risk of type I error; they do not establish causation or clinical benefit.

Table 3. Correlation analysis of the dynamics of the ultrasound parameters of facial soft tissues and the dynamics of skin condition indicators, based on the results of instrumental diagnostics following PRP injections.

Region	Correlating Indicators (Ultrasound-Skin Analyzer)	r *
Frontal region	Dermal thickness—skin tone	−0.79
	Dermal thickness—pigmentation	−0.51
	SLEB—skin tone	−0.67
	Thickness of the subcutaneous fat layer—pores	−0.60
	Thickness of the muscle layer—wrinkles	−0.58
Mid-cheek region	Dermal thickness—skin tone	−0.61
	Dermal thickness—pigmentation	−0.52
	SLEB—skin tone	−0.53
	Thickness of the subcutaneous fat layer—pores	−0.71
	Thickness of the subcutaneous fat layer—blackheads	−0.55
	Thickness of the subcutaneous fat layer—pigmentation	0.63
Parotid region	Dermal thickness—skin tone	−0.58
	SLEB—skin tone	−0.57
	SLEB—pigmentation	−0.55

* For all correlation coefficients, the *p*-value was less than 0.05.

An increase in the thickness of the forehead dermis was accompanied by a marked improvement in the skin tone index ($r = -0.79$) and a reduction in the severity of pigmentation ($r = -0.51$). Similar correlations were identified for the mid-cheek ($r = -0.61$) and parotid ($r = -0.58$) dermal regions in relation to changes in skin tone. These findings indicate a relationship between changes in the ultrasonic characteristics of the dermis and the dynamics of the skin's visual parameters. An increase in dermal thickness may be associated with processes of structural reorganization within the dermal tissue, including potential alterations to the collagen component and the extracellular matrix. However, as these processes were not directly evaluated in the present study, their specific role requires further investigation.

Changes in the thickness of the SLEB were also associated with changes in skin tone. The most pronounced negative correlations were recorded for the forehead ($r = -0.67$), the mid-cheek region ($r = -0.53$) and the parotid region ($r = -0.57$). These results suggest a link between changes in the ultrasonic characteristics of the superficial skin layers and shifts in its visual parameters. A reduction in SLEB thickness may reflect alterations in the structural properties of the superficial skin layers; however, ultrasound imaging alone cannot definitively establish the underlying histological or molecular mechanisms. In particular, any potential connection between these changes and extracellular matrix remodeling would require confirmation through specialized research methods.

Thus, an increase in the thickness of subcutaneous tissue on the forehead was accompanied by a reduction in the severity of enlarged pores ($r = -0.60$), whilst an increase in subcutaneous tissue in the mid-cheek region correlated with a reduction in pore severity ($r = -0.71$), blackheads ($r = -0.55$) and was simultaneously associated with an increase in the pigmentation index ($r = 0.63$). These findings indicate that the relationships between changes in subcutaneous adipose tissue thickness and various aesthetic skin characteristics are heterogeneous. Furthermore, the observed correlations do not establish a causal relationship between these parameters. Changes in the thickness of the forehead muscle layer were accompanied by a moderate negative correlation with wrinkle dynamics ($r = -0.58$). This

association may suggest that changes in the muscular component play a role in the evolution of this clinical indicator; however, further research is required to confirm this hypothesis.

Thus, in 50 patients following PRP injections, positive changes in the ultrasound parameters of the facial soft tissues were observed. The median thickness of the dermis increased by 30.8% in the forehead region, by 29.6% in the mid-cheek region and by 17.4% in the parotid region ($p < 0.05$). The thickness of the subcutaneous fat layer increased by 37.1%, 14.0% and 25.0% respectively ($p < 0.05$). The thickness of the SLEB decreased by 16.7% in the forehead region, by 8.3% in the mid-cheek region and by 16.7% in the parotid region; statistically significant changes were observed in the mid-cheek ($p = 0.0299$) and parotid regions ($p = 0.036$).

An increase in the thickness of the dermis and subcutaneous adipose tissue, combined with a decrease in SLEB thickness, are ultrasound-documented changes following PRP therapy. Potential biological explanations for these shifts in dermal parameters include alterations in tissue hydration, the structure of the dermal matrix, and the activity of processes involved in collagen synthesis and organization. However, the present study did not include a histological, biochemical, or molecular assessment of collagen or other extracellular matrix components. Consequently, these findings do not provide direct confirmation of neocollagenesis or extracellular matrix remodeling. Further research, employing appropriate morphological and molecular methods, is required to establish these mechanisms.

4. Discussion

The use of objective instrumental assessment methods is one of the key trends in modern aesthetic medicine. Most early studies of PRP were based predominantly on subjective patient assessment or photographic analysis, whereas modern studies increasingly utilize high-frequency ultrasound, optical coherence tomography, confocal laser microscopy and three-dimensional digital photography [5,10–13].

One of the most promising methods for assessing the effectiveness of PRP in aesthetic medicine is high-frequency ultrasound imaging, which allows for a non-invasive assessment of the condition of the epidermis, dermis and superficial hypodermis [1,5,15]. At present, high-frequency ultrasound with the characteristics of being noninvasive, rapid, and economic has been gradually applied in dermatology [16,17]. A systematic review from 2025 shows that ultrasound imaging is gradually becoming one of the most objective methods for monitoring the effectiveness of PRP injections. Unlike photographic assessment and subjective patient satisfaction scales, HFUS enables the non-invasive detection and quantitative assessment of changes in the ultrasound characteristics of skin structures over time [2,18,19]. Modern ultrasound systems enable not only qualitative but also quantitative image assessment. The use of specialized software facilitates the automatic calculation of average tissue echogenicity, dermal thickness, SLEB area, image heterogeneity coefficient and other morphometric parameters. Automated analysis significantly reduces the subjectivity of the examination and improves the reproducibility of results, which is particularly important when conducting clinical studies [13,20].

The capabilities of this method are determined by the technical specifications of the equipment, such as transducer frequency, scanning depth, image quality, and the standardization of measurement procedures. In the present study, an HL5-12ED linear broadband transducer was used, with an operating frequency range of 7.5–12 MHz and a scanning depth of 30 mm. While these specifications allow for the visualization of superficial facial soft tissues, they do not provide the same level of spatial resolution as specialized dermatological transducers operating at frequencies of 20–30 MHz or higher. Therefore, the results of this study should be interpreted with consideration for the equipment used and the specific characteristics of how superficial structures are visualized. According to Jeong K.M. et al.,

ultrasonography represents a promising non-invasive method for assessing age-related skin changes, enabling the evaluation of skin thickness, echogenicity, and dermal structural characteristics [21]. However, the dependence of measurements on operator technique and the potential for measurement variability emphasize the importance of methodological standardization and further research to improve di-agnostic accuracy [22].

It is known that age-related changes in the skin are accompanied by the degradation of collagen fibers and a reduction in the content of elastin and hyaluronic acid, leading to a decrease in dermal echogenicity and the formation of a SLEB, which is clearly visualized during high-frequency ultrasound examination [1,13,23]. According to systematic studies, an increase in the thickness of this zone correlates with the patients' age, the duration of ultraviolet exposure, the severity of wrinkles and clinical signs of photoaging [24]. In recent years, it is precisely the thickness of the SLEB that has been regarded as one of the most sensitive objective biomarkers of the efficacy of rejuvenation procedures. The formation of this zone is associated with solar elastosis, disruption of the dermal architecture and degradation of collagen fibers [1,13]. When PRP injections are administered, one of the main expected effects is the restoration of normal dermal architecture through the activation of new collagen synthesis and remodeling of the extracellular matrix [25].

High-frequency ultrasound allows the thickness of the dermis to be measured quantitatively with a high degree of reproducibility. Measurements are taken at standard anatomical sites (forehead, periorbital region, cheeks, chin) before and after PRP injections [5]. Most studies indicate that the age-related reduction in dermal thickness is due to a decrease in the number of fibroblasts, reduced synthesis of types I and III collagen, and degradation of the extracellular matrix [26]. Following a course of PRP treatment, a statistically significant increase in dermal thickness is observed, which is attributed to the activation of neocollagenogenesis and enhanced biosynthetic activity of fibroblasts [1,5]. Majewska et al. utilized ultrasound assessment of the skin following PRP and PRF injections in patients from various age groups. It was shown that an increase in dermal thickness and an increase in tissue density are recorded as early as a few weeks after PRP injections and persist for several months. However, the extent of the changes depended on the patients' age and the initial condition of the skin [27–29].

The results of our study demonstrate that the most pronounced effect of PRP injections is associated with an increase in dermal thickness, which was observed in all the anatomical regions studied. The median dermal thickness increased by 30.8% in the forehead region, by 29.6% in the mid-cheek region and by 17.4% in the parotid region ($p < 0.05$). Furthermore, a statistically significant reduction in the thickness of the SLEB was observed in the mid-cheek and parotid regions, as well as an increase in the thickness of subcutaneous adipose tissue in all areas studied. The thickness of the SLEB decreased by 16.7% in the forehead region, by 8.3% in the mid-cheek region and by 16.7% in the parotid region; statistically significant changes were identified in the mid-cheek ($p = 0.0299$) and parotid ($p = 0.036$) regions. The thickness of the subcutaneous fat layer increased by 37.1%, 14.0% and 25.0% respectively ($p < 0.05$). No significant changes in muscle layer thickness were observed. Taken together, the data indicate that PRP injections primarily affect the dermal component of the facial soft tissues, which may be regarded as an objective ultrasound marker of the procedure's efficacy.

These results indicate an increase in dermal thickness, as measured by ultrasound, one month after the procedure. Regarding the potential biological mechanisms underlying these observations, PRP administration may induce morphometric changes in dermal matrix organization through modulation of fibroblast activity and the synthesis of extracellular matrix components. However, these processes were not directly assessed in the present study. Furthermore, the absence of a control group means that the potential influence of

other factors, such as natural tissue variability and measurement fluctuations, cannot be ruled out. Therefore, the observed changes cannot be definitively interpreted as evidence of PRP-stimulated neocollagenesis.

Despite their statistical significance, the magnitude of the observed changes should be interpreted with caution. A reduction in the thickness of the subepidermal low-echogenicity band (SLEB) may be associated with changes in the ultrasonic characteristics of the superficial skin layers. However, this study cannot determine whether such dynamics reflect a stable restructuring of the dermis, an alteration in the state of the superficial tissues, or variability in the visualization and delineation of the measured area. Consequently, the observed decrease in SLEB thickness should be viewed as a morphometric change, while its potential link to extracellular matrix remodeling remains a hypothesis that requires further validation. Given the relatively small magnitude of the observed differences and the technical limitations associated with ultrasound assessment of superficial skin structures, the findings related to SLEB thickness should be considered preliminary morphometric observations rather than definitive evidence of structural skin regeneration. Further studies incorporating standardized acquisition protocols, repeated measurements, and formal assessment of intra- and interobserver reliability are warranted. An increase in the measured thickness of the subcutaneous adipose tissue does not automatically imply an increase in total adipose tissue volume, adipocyte hyperplasia, or the stimulation of adipocyte regeneration. The results may have been influenced by various factors, including individual variations in tissue hydration, residual post-procedural changes, patient positioning, the accuracy of relocating anatomical landmarks, and differences in the degree of tissue compression applied by the transducer. Despite the use of acoustic gel and efforts to minimize transducer pressure, it is impossible to entirely eliminate the influence of these factors. An additional limitation is that only one measurement was taken at each anatomical site before the procedure, with a single follow-up measurement performed one month later. No series of repeated measurements was conducted to assess intra-operator variability. Thus, an increase in the thickness of the subcutaneous adipose tissue should be interpreted as a change in an ultrasound-based morphometric parameter, rather than as evidence of an increase in the quantity or volume of adipose tissue. Verifying the robustness of this finding would require repeated standardized measurements, an assessment of the method's reproducibility, and a longer follow-up period.

In recent years, studies have emerged that combine HFUS with digital skin image analysis, optical 3D photography and artificial intelligence to provide a comprehensive assessment of the efficacy of PRP. This multimodal approach allows for the simultaneous assessment of both structural changes in the dermis and the clinical manifestations of photoaging, which significantly enhances the objectivity of the evaluation of results following PRP injections [2]. In a study by Ye et al., high-frequency ultrasound and instrumental assessment of skin condition were used to investigate the efficacy of three PRP treatments in patients with signs of facial photoaging. The authors demonstrated a 29–47 per cent reduction in SLEB thickness and a 24–51 per cent increase in dermal thickness following a course of PRP injections. At the same time, a statistically significant improvement was observed in parameters such as wrinkles, pores, pigmentation and erythema, confirming the high diagnostic value of ultrasound monitoring [1]. The authors concluded that HFUS allows morphological changes in the skin to be detected considerably earlier than pronounced clinical results become apparent.

In this study, the correlation analysis carried out showed that the ultrasound parameters of facial soft tissues are closely linked to the results of instrumental assessment of skin changes. The most informative parameters were dermal thickness and SLEB thickness. An increase in dermal thickness and a reduction in SLEB thickness were associated with

improvements in skin tone and pigmentation parameters. At the same time, changes in individual aesthetic parameters, such as enlarged pores, hyperpigmentation and dark circles, were less pronounced and characterized by significant inter-individual variability. The exploratory correlation analysis identified associations between changes in ultrasound-derived morphometric parameters and changes in digital skin assessment indicators. However, these associations do not establish a causal relationship or confirm underlying tissue remodeling. The most consistent correlations were found between the increase in dermal thickness and improvements in skin tone, as well as between synchronous changes in ultrasound parameters across different anatomical regions. The observed increase in dermal thickness may be considered an ultrasound-derived morphometric finding following PRP administration, although its clinical and biological significance requires further investigation.

The interpretation of the 3D analyzer's results is further limited by the lack of data regarding independent validation of the device, measurement reproducibility, and the specific algorithms used to generate the scores. In particular, for a valid comparison of results, it is necessary to know which parameters are expressed in physical units, which represent arbitrary scores, how final values are calculated, and which direction on a given scale signifies an improvement. In the absence of such information, the analyzer's metrics should be considered auxiliary research parameters. These correlations do not establish that a change in dermal thickness directly caused a change in skin color or other aesthetic characteristics.

Despite the method's high diagnostic value, certain limitations exist. A significant issue remains the lack of uniform international guidelines for conducting ultrasound monitoring of patients following aesthetic procedures. Currently, various research groups use transducers of different frequencies, employ differing scanning protocols and apply inconsistent criteria for the quantitative assessment of images, which makes it difficult to compare the results of different studies [1,5]. Study results may be influenced by the frequency of the transducer used, the standardization of the patient's position, the degree of tissue compression by the transducer, the amount of contact gel, the scanning angle, skin hydration, ambient temperature and the investigator's experience. Therefore, current research recommends the use of standardized scanning protocols and the performance of repeat measurements at strictly identical anatomical sites and with identical device settings [1,5,30].

Although the instrumental approach is promising, this study has several methodological limitations. In particular, additional assessments at 2 months and at subsequent follow-up intervals would help determine whether the observed ultrasound changes persist after the early post-injection period or represent transient tissue responses. First, the lack of a control group makes it impossible to distinguish the changes observed following PRP therapy from natural fluctuations, the influence of other factors, or measurement variability. Therefore, these findings should not be interpreted as definitive proof of a causal effect of PRP. Second, the observation period was limited to one month following a single procedure. While this timeframe allows for the assessment of short-term changes, it is insufficient to determine the durability of these effects or their long-term progression. Third, only one measurement was taken for each anatomical site both before and after the procedure. Although all assessments were performed by a single specialist, there was no blinding regarding the observation stage, and neither intra-rater nor inter-rater reliability was formally evaluated. This limits the ability to quantify the reproducibility of the results. Fourth, despite the use of anatomical landmarks and the standardization of core scanning conditions, it is impossible to entirely eliminate the influence of transducer pressure, patient positioning, scanning angle, and the precision of repositioning. Fifth, no direct histological, biochemical, or molecular analyses were performed; therefore, the hypothesized processes of neocollagenogenesis and extracellular matrix remodeling cannot be considered confirmed. The

interpretation of the 3D analyzer results is limited by a lack of information regarding independent validation of the device, the characteristics of its measurement scales, and the reproducibility of its readings. Also, *p*-values obtained from correlation analyses were not adjusted for multiple comparisons. Given the number of associations examined between ultrasound parameters and skin analyzer measurements, the possibility of false-positive findings cannot be excluded. Therefore, the observed correlations should be interpreted with caution and considered exploratory. Furthermore, no validated clinical outcome scales, standardized physician assessments, or patient-reported outcome measures were included in the study. Therefore, the observed ultrasound and digital imaging changes could not be directly correlated with validated clinical improvements or patient satisfaction. Future studies should incorporate standardized clinical assessment tools and patient-reported outcome measures to provide a more comprehensive evaluation of treatment outcomes. An additional limitation is that the study included only women, which precludes the automatic generalization of these findings to men.

5. Conclusions

The present study demonstrated short-term changes in ultrasound-derived morphometric parameters of facial soft tissues one month after PRP administration. An increase in dermal and subcutaneous adipose tissue thickness was observed across the three anatomical regions, while a reduction in SLEB thickness reached statistical significance in the mid-cheek and parotid regions.

High-frequency linear ultrasound imaging enabled the non-invasive visualization and quantitative assessment of these changes. However, the findings should be interpreted as short-term ultrasound-detected morphometric changes rather than direct evidence of tissue regeneration, neocollagenesis, or extracellular matrix remodeling.

The absence of a control group, the short follow-up period, the use of single measurements at each anatomical site, and the lack of formal assessment of measurement reproducibility limit the interpretation of the results. Furthermore, the absence of histological, biochemical, and molecular analyses prevents confirmation of the underlying biological mechanisms.

Further controlled studies involving standardized ultrasound protocols, repeated measurements, validated clinical outcome measures, patient-reported assessments, and longer follow-up periods are required to determine the clinical significance and persistence of the observed changes following PRP administration.

Author Contributions: Conceptualization, A.K., A.O., O.P. and B.O.; methodology, A.K.; validation, O.P. and A.K.; formal analysis, A.K. and A.O.; investigation, A.K. and A.O.; resources, A.K.; data curation, A.K. and A.O.; writing—original draft preparation, A.K. and A.O.; writing—review and editing, O.P., A.K., A.O. and B.O.; supervision, O.P. and B.O.; project administration, A.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was carried out in accordance with the principles of the Declaration of Helsinki and was approved by the Local Bioethics Commission (protocol No. 15, approval No. 98, dated 17 November 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent was obtained from all participants included in the research.

Data Availability Statement: The data supporting this study's findings are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

PRP	platelet-rich plasma
HFUS	high-frequency ultrasound
SLEB	Subepidermal Low-Echogenic Band
THI	Tissue Harmonic Imaging
PL	cross-polarized light
UV	ultraviolet
RGB	visible light (red, green, blue)

References

1. Ye, W.; Liu, T.; Zhang, W.; Peng, S.; Liao, Y. Assessment of Subepidermal Low-Echogenic Band via High-Frequency Ultrasound for Evaluating the Efficacy of Platelet-Rich Plasma Injection in Treating Facial Skin Photoaging: A Case Series. *J. Cosmet. Dermatol.* **2026**, *25*, e70684. [CrossRef]
2. Rodríguez-Castro, M.J.; Cortés-Rodríguez, A.E. Efficacy of platelet-rich plasma in facial rejuvenation: A systematic review. *Enferm. Clin. (Engl. Ed.)* **2025**, *35*, 502161. [CrossRef]
3. Phoebe, L.K.W.; Lee, K.W.A.; Chan, L.K.W.; Hung, L.C.; Wu, R.; Wong, S.; Wan, J.; Yi, K.-H. Use of Platelet Rich Plasma for Skin Rejuvenation. *Skin Res. Technol.* **2024**, *30*, e13714. [CrossRef]
4. Gentile, P.; Garcovich, S. Systematic Review: Platelet- Rich Plasma Use in Facial Rejuvenation. *Plast. Reconstr. Surg.* **2023**, *152*, 72e–82e. [CrossRef]
5. Bajaj, S.; Orbuch, D.; Wang, J.V.; Geronemus, R.G. Preparation and Utility of Platelet-Rich Plasma (PRP) for Facial Aging: A Comprehensive Review. *Adv. Ther.* **2022**, *39*, 4021–4036. [CrossRef]
6. Zhao, S.; Wang, M.; Lai, X.; Yan, Y. Noninvasive Assessment Methods for the Therapeutic Effect Following Facial Rejuvenation. *J. Cosmet. Dermatol.* **2025**, *24*, e70482. [CrossRef]
7. Chen, H.; Zhou, X. Meta-Analysis of the Efficacy of Platelet-Rich Plasma in Treating Skin Aging. *Aesthetic Surg. J. Open Forum* **2026**, *8*, ojaf150. [CrossRef]
8. Jacobson, J.A.; Middleton, W.D.; Allison, S.J.; Dahiya, N.; Lee, K.S.; Levine, B.D.; Lucas, D.R.; Murphey, M.D.; Nazarian, L.N.; Siegel, G.W.; et al. Ultrasonography of superficial soft tissue masses: Society of radiologists in ultrasound consensus conference statement. *Radiology* **2022**, *304*, 18–30. [CrossRef]
9. Liu, C.H.; Hsu, S.Y.; Wang, C.P. Ultrasound examinations of the head and neck—From the beginning to now. *J. Med. Ultrasound* **2020**, *28*, 5–6. [CrossRef]
10. Alimova, S.; Sharobaro, V.; Yukhno, A.; Bondarenko, E. Possibilities of ultrasound examination in the assessment of age related changes in the soft tissues of the face and neck: A review. *Appl. Sci.* **2023**, *13*, 1128. [CrossRef]
11. Nasreddine, H.; Tlaiss, Y.; Hassan, F.; Ibrahim, R. Ultrasound Assessment of Facial and Neck Aging: A Noninvasive Approach to a Minimally Invasive Treatment. *J. Med. Ultrasound* **2024**, *32*, 244–248. [CrossRef]
12. Meng, Y.; Feng, L.; Shan, J.; Yuan, Z.; Jin, L. Application of high-frequency ultrasound to assess facial skin thickness in association with gender, age, and BMI in healthy adults. *BMC Med. Imaging* **2022**, *22*, 113. [CrossRef]
13. Nicolescu, A.C.; Ionescu, S.; Ancuta, I.; Popa, V.-T.; Lupu, M.; Soare, C.; Cozma, E.-C.; Voiculescu, V.-M. Subepidermal Low-Echogenic Band-Its Utility in Clinical Practice: A Systematic Review. *Diagnostics* **2023**, *13*, 970. [CrossRef]
14. Koshkinbayeva, A.; Ogizbayeva, A.; Ponamareva, O.; Omarkulov, B.; Yutskovskaya, Y. Evaluation of the Effectiveness of Injections of Autologous Platelet-Rich Plasma into Facial Skin. *Cosmetics* **2024**, *11*, 175. [CrossRef]
15. Levy, J.; Barrett, D.L.; Harris, N.; Jeong, J.J.; Yang, X.; Chen, S.C. High-frequency ultrasound in clinical dermatology: A review. *Ultrasound J.* **2021**, *13*, 24. [CrossRef]
16. Bhatta, A.K.; Keyal, U.; Liu, Y. Application of high frequency ultrasound in dermatology. *Discov. Med.* **2018**, *26*, 237–244.
17. Van Mulder, T.J.; de Koeijer, M.; Theeten, H.; Willems, D.; Van Damme, P.; Demolder, M.; De Meyer, G.; Beyers, K.C.; Vankerckhoven, V. High frequency ultrasound to assess skin thickness in healthy adults. *Vaccine* **2017**, *35*, 1810–1815. [CrossRef]
18. Kehrer, A.; Ruewe, M.; Platz Batista da Silva, N.; Lonic, D.; Heidekrueger, P.I.; Knoedler, S.; Jung, E.M.; Prantl, L.; Knoedler, L. Using High-Resolution Ultrasound to Assess Post-Facial Paralysis Synkinesis—Machine Settings and Technical Aspects for Facial Surgeons. *Diagnostics* **2022**, *12*, 1650. [CrossRef]
19. Mlosek, R.K.; Migda, B.; Migda, M. High-frequency ultrasound in the 21st century. *J. Ultrason.* **2021**, *20*, e233–e241. [CrossRef]
20. Vergilio, M.M.; Vasques, L.I.; Leonardi, G.R. Characterization of Skin Aging Through High- Frequency Ultrasound Imaging as a Technique for Evaluating the Effectiveness of Anti- Aging Products and Procedures: A Review. *Skin Res. Technol.* **2021**, *27*, 966–973. [CrossRef]

21. Jeong, K.M.; Seo, J.Y.; Kim, A.; Kim, Y.C.; Baek, Y.S.; Oh, C.H.; Jeon, J. Ultrasonographic analysis of facial skin thickness in relation to age, site, sex, and body mass index. *Ski. Res. Technol.* **2023**, *29*, e13426. [CrossRef]
22. Pequeno, A.L.V.; Bagatin, E. Dermatological ultrasound in assessing skin aging. *Front. Med.* **2024**, *11*, 1353605. [CrossRef]
23. Rayner, R.; Carville, K.; Leslie, G.; Dhaliwal, S.S. Measurement of morphological and physiological skin properties in aged care residents: A test-retest reliability pilot study. *Int. Wound J.* **2017**, *14*, 420–429. [CrossRef]
24. Wortsman, X.; Ferreira-Wortsman, C.; Quezada, N. Facial Ultrasound Anatomy for Non-invasive Cosmetic and Plastic Surgery Procedures. In *Atlas of Dermatologic Ultrasound*; Springer: Cham, Switzerland, 2018; pp. 147–178. [CrossRef]
25. Koshkinbayeva, A.R.; Yutskovskaya, Y.A.; Omarkulov, B.K.; Ponamareva, O.A.; Ogizbayeva, A.V. The opportunities and effectiveness of the use of autologous platelet-rich plasma in plastic surgery, anti-age medicine and dermatology. *Med. Ecol.* **2024**, *4*, 17–28. [CrossRef]
26. Alves, R.; Grimalt, R. A Review of Platelet-Rich Plasma: History, Biology, Mechanism of Action, and Classification. *Skin Appendage Disord.* **2018**, *4*, 18–24. [CrossRef]
27. Majewska, L.; Kijowski, J.; Dorosz, K. Effect of Patient Age on Platelet-Rich Plasma (PRP) and Fibrin Treatments for Skin Density and Thickness: A Single-Center Ultrasound Study. *Life* **2025**, *15*, 308. [CrossRef]
28. Niu, Z.; Wang, Y.; Zhu, Q.; Liu, J.; Liu, Y.; Jin, H. The value of high-frequency ultrasonography in the differential diagnosis of early mycosis fungoides and inflammatory skin diseases: A case-control study. *Skin Res. Technol.* **2021**, *27*, 453–460. [CrossRef]
29. Sykes, J.M.; Riedler, K.L.; Cotofana, S.; Palhazi, P. Superficial and Deep Facial Anatomy and Its Implications for Rhytidectomy. *Facial Plast. Surg. Clin. N. Am.* **2020**, *28*, 243–251. [CrossRef]
30. Almuhanna, N.; Wortsman, X.; Wohlmuth-Wieser, I.; Kinoshita-Ise, M.; Alhusayen, R. Overview of Ultrasound Imaging Applications in Dermatology. *J. Cutan. Med. Surg.* **2021**, *25*, 521–529. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.