IOSR Journal of Nursing and Health Science (IOSR-JNHS)
e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 14, Issue 4 Ser. 3 (July. – August. 2025), PP 32-48
www.iosrjournals.org

Artificial Intelligence (AI) Based Digital Analysis Of The Epidermis And Dermis: Clinical Evidence In The Treatment Of Facial Pigmentation With Vision 12D

Moleiro, D[1]; Ruiz-Silva, C[2]; Melo, RA[3]; Lima-Silva, K[4]; Dias, FEL[5]; Bueno, FCP[6]; Oliveira, AC [7].

(Department, College/ Faculdade FACOP, Msc, PT, Biomedicine, Brasil).
(Department, College/ Faculdade FACOP, Phd, Msc, PT, Brasil).
(Department, College/ Faculdade FACOP, PT, Brasil).
(Department, College/ Faculdade FACOP, Aesthetics And Cosmetology, Brasil).
(Department, College/ Faculdade FACOP, Biomedicine, Brasil).
(Department, College/ Faculdade FACOP, PT, Brasil).
(Department, College/ Faculdade FACOP, Biomedicine, Aesthetics And Cosmetology, Brasil).

Abstract

The use of artificial intelligence (AI) technologies has revolutionized facial assessment in aesthetics, enabling more accurate diagnoses and precise and structured clinical follow-up. Devices like the Vision 12D (DNA Brasil), representing the evolution of bioengineering, use high-definition spectral images to analyze 17 skin parameters, including epidermal and dermal characteristics, based on eight light sources.

This article aims to highlight the benefits of using an AI-powered facial analyzer to quantify pigmentary changes and monitor the clinical progress of pigment management treatments.

Digital skin analysis was performed at different treatment phases using the Vision 12D, focusing on the objective comparison of superficial and deep pigmentation parameters. The data was used to define and adjust therapeutic approaches and presented to the patient to promote adherence and understanding of the results.

Spectral analysis allowed for the precise identification of pigmentary changes at different depths, quantifying therapeutic progress, and optimizing the selection of personalized protocols. The use of AI has integrated agility, accuracy and effective visual communication with the patient.

Key Word: *Dermatology, Artificial intelligence, digital skin analysis, facial assessment, aesthetic technologies, skin diagnosis, AI in aesthetics, facial pigment management, facial whitening.*

Date of Submission: 21-07-2025 Date of Acceptance: 31-07-2025

I. Introduction

Advances in digital technologies in facial aesthetics have provided new diagnostic possibilities, promoting greater accuracy in skin analysis and the implementation of personalized protocols, as described by Moleiro, Ruiz-Silva, and colleagues in 2025. In particular, the use of platforms with artificial intelligence (AI) and high-definition spectral imaging has proven effective for the objective analysis of the epidermal and dermal layers, aiding in monitoring the clinical progress of aesthetic treatments such as pigmentation management (25).

The skin, the largest organ in the human body, performs essential functions such as protection, thermal regulation, immune barrier, and sensory communication. When it comes to facial aesthetics, the distribution and depth of melanin are critical factors that directly impact the visual perception of youthfulness and skin uniformity (1,2). Hyperpigmentation, whether epidermal, dermal, or mixed, represents a frequent complaint in aesthetic and dermatological practices, requiring evidence-based clinical approaches and structured follow-up (25).

Traditionally, skin assessment was performed through clinical observation and the use of simple devices such as the Wood's lamp. These methods, while useful, have limitations related to subjectivity, clinical time, and interprofessional variability (3). In this context, systems such as DNA Med Brazil's Vision 12D, which uses eight spectral lamps and an AI algorithm to evaluate 17 facial parameters, offer a qualitative leap in comparative skin analysis over time. Accurate identification of superficial and deep blemishes, changes in the skin barrier, collagen density, and accumulated photoaging allows for more assertive interventions, in addition to generating visual reports that facilitate patient understanding and adherence (4,5, 25).

With the growing appreciation of "skin quality" as a new global beauty standard, technologies that provide objective data on texture, tone uniformity, and radiance have become essential not only to support clinical reasoning but also to clearly communicate results to patients, strengthening the bond and increasing the perceived value of treatments (6).

This article aims to present, through a scientific approach, the benefits of using 12D Vision technology for spectral skin analysis, with an emphasis on its application in the clinical monitoring of pigmentation management treatments.

Pigment Physiology and Skin Changes

Skin pigmentation is primarily determined by the production and distribution of melanin, a biopolymer produced by melanocytes located in the basal layer of the epidermis. Melanin is synthesized from the amino acid tyrosine by the enzyme tyrosinase and stored in melanosomes, which are then transferred to keratinocytes (1). This process ensures the skin's natural coloration and protection against the harmful effects of ultraviolet (UV) radiation.

There are two main types of melanin: eumelanin (brown or black) and pheomelanin (yellowish or reddish). The proportion of melanin determines the skin's phototype and directly influences the skin's response to external agents (2). Dysregulation of this process can result in pigmentary disorders such as post-inflammatory hyperpigmentation, melasma, solar lentigines, and superficial, mixed, or deep dyschromias.

Pigmentary changes can be influenced by extrinsic factors, such as UV radiation, pollution, use of photosensitizing medications, and inappropriate procedures, as well as by intrinsic factors, such as genetic predisposition, hormonal fluctuations, and chronological aging (3,4).

The distribution of melanin in the skin layers determines the depth and complexity of treatment. Spots located in the epidermis tend to be darker in color and have well-defined edges, and are generally more responsive to topical treatments and the use of non-ablative technologies. Dermal or mixed pigmentations, which involve the papillary and reticular layers of the dermis, have a grayish, diffuse appearance and greater therapeutic resistance, requiring combined approaches and constant monitoring (5).

Understanding pigment physiology is essential for selecting effective aesthetic protocols, as well as accurately interpreting data obtained from digital spectral skin analyses, such as those performed by the Vision 12D system, which differentiates pigmentary changes by depth and type of manifestation.

Traditional Assessment Versus Spectral Skin Analysis

Historically, skin assessment in the clinical-aesthetic context was conducted using manual and subjective methods, based on direct observation, palpation, medical history taking, and the occasional use of devices such as the Wood's lamp. These tools helped identify certain changes, such as Skin patches, oiliness, and areas of dehydration were also identified, but were subject to variable interpretations, influenced by the examiner's experience and perception (11).

Subjective classification scales, such as the Baumann Classification, have contributed to the partial standardization of skin diagnosis, considering factors such as oiliness, pigmentation, sensitivity, and aging. However, these tools rely on the accuracy of self-reported data collection and clinical perception, which can lead to errors or underdiagnoses in patients with mixed or discrete presentations (12).

Furthermore, interprofessional variability and the lack of unified protocols for collecting and analyzing dermatological data limit the reproducibility and reliability of therapeutic approaches. This limitation becomes even more evident in clinics with high staff turnover, hindering longitudinal patient follow-up (13).

With the advancement of digital technologies, platforms such as Vision 12D are emerging as a solution to reduce subjectivity and increase diagnostic accuracy. The equipment uses eight high-resolution spectral light sources, which capture skin data at different depths and angles. This approach allows for the objective visualization and quantification of changes in the epidermis and dermis, such as pigmentation, pores, oiliness, vascularization, collagen, texture, and skin sensitivity (14).

The key advantage of automated spectral analysis is its ability to integrate data quickly and accurately, providing professionals with comparative and projective information, as well as graphical reports that enhance patient understanding. Studies show that the use of devices with artificial intelligence and spectral imaging significantly increases the accuracy in assessing pigmentary disorders and contributes to the selection of personalized treatments (15,16).

Vision 12D Technology: Fundamentals and Innovation in Skin Analysis

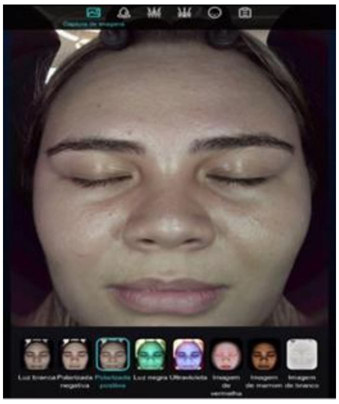
The evolution of digital aesthetic dermatology has enabled the development of increasingly accurate technologies for skin diagnosis and monitoring. The Vision 12D, a high-performance facial analyzer developed by DNA Med, represents a significant advancement by incorporating artificial intelligence, deep learning algorithms, and light spectroscopy to generate comprehensive and personalized diagnoses. Its system consists of an automated photo booth with a 36-megapixel camera capable of capturing images in eight different light spectra and 17 facial diagnostic parameters, offering a comprehensive analysis of the epidermis and dermis.

Image capture takes just 2 minutes and 12 seconds, using a standardized sequence of photos from three angles of the face (right, front, and left), creating a 360-degree analysis of the facial skin. This set of images, combined with specific spectral filters, allows not only immediate diagnosis but also projection of skin progression with and without treatment, using algorithms based on historical data and established clinical standards (17, 18).

The eight spectral lamps integrated into the device are responsible for identifying more specific superficial and deep skin changes with greater precision:

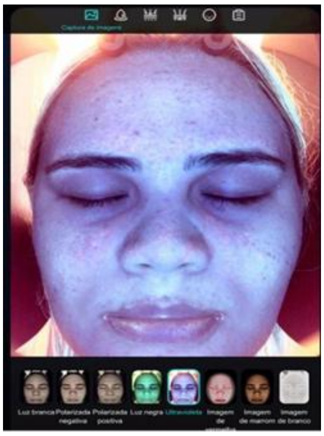
1. White Light (Standard): simulates human observation of skin under natural lighting, allowing for general analysis of tone uniformity, pores, texture and surface blemishes.

2. Positive (Parallel) Polarized Light: eliminates surface reflections, enhancing the epidermis and highlighting blemishes, texture, fine lines, scars, and enlarged pores (19).

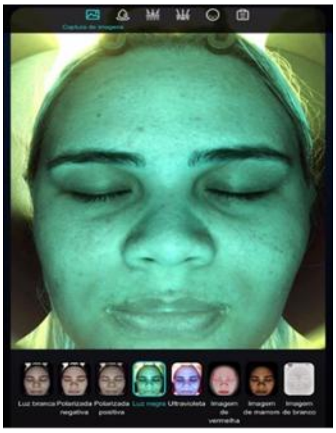


3. Negative (Cross) Polarized Light: penetrates deeper layers, allowing the observation of vasodilation, erythema, rosacea, and subclinical inflammation, contributing to the visualization of dermal vascularization (16).

4. Ultraviolet (UV) Light: highlights melanin accumulations, areas of premature photoaging, actinic lesions, and blemishes not visible to the naked eye.

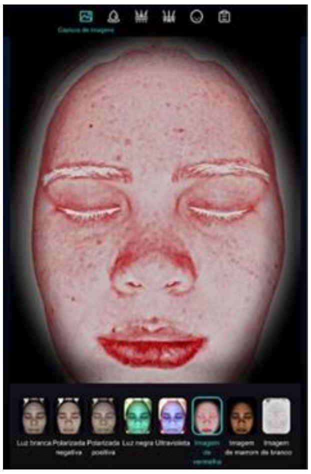


5. Wood's Lamp or Black Light (UV-365 nm): highlights oiliness, areas of dehydration, superficial fungal infections, and intensified epidermal blemishes, aiding in the assessment of the skin barrier.



6. Brown Light (Yellow-Brown Spectrum): Highlights superficial and deep melanin, useful for identifying melasma, freckles, and mixed pigmentation.

7. Red Light (Near Infrared): Penetrates the deep dermis, allowing analysis of dermal density, laxity, collagen presence, and the integrity of the skin's sensitivity barrier (22).



8. Purple Light (Mixed): Combines different wavelengths to generate a composite view, useful for simultaneously evaluating inflammation, oiliness, blemishes, and irregular texture.

These light sources act as non-invasive diagnostic filters, capturing different interactions between light and skin tissue, allowing for the distinction between epidermal and dermal structures with a high degree of reliability and reproducibility. By cross-referencing the data obtained with the 17 evaluation parameters—which include everything from oiliness and blackheads to wrinkles, collagen, porphyrins, and accumulated photoaging—Vision 12D delivers not only a visual diagnosis but also an objective, personalized, and scientifically guided therapeutic plan (23).

II. Research Methodology

This experimental study was conducted to evaluate the effectiveness of spectral image analysis in measuring skin pigmentation changes, both before initiating pigment management treatment and after 30 days of retesting, following an aesthetic protocol based on technologies associated with hyperpigmentation management.

Population and Sample

Twenty volunteer patients of both sexes, aged between 28 and 55 years, with clinical complaints of dark spots and phototype classification II to IV according to Fitzpatrick were included. All patients presented superficial, mixed, and deep pigmentation (epidermal and dermal). Individuals with active dermatological diseases, pregnant women, and lactating women were excluded. Participants signed an Informed Consent Form as recommended by CNS Resolution 466/2012.

Procedure and Data Collection

The analysis was performed using DNA Med's Vision 12D equipment, which integrates embedded artificial intelligence (AI) algorithms and captures spectral images in eight different types of light (white, positive polarized, negative polarized, UV, Wood's, brown, red, and mixed). Images were obtained before the start of the aesthetic protocol and after 30 days of treatment.

Vision 12D technology allows for three-dimensional facial imaging (180°), analyzing 17 facial parameters, highlighting superficial pigment, dermal pigment, collagen, porphyrin, skin sensitivity, moisture, and barrier quality. The data were automatically extracted in visual and graphical report formats, generating quantitative comparisons between pre- and post-treatment images, with mapping of the most affected areas (23,24).

Comparative Method and Evaluation

The methodology adopted was a quasi-experimental longitudinal study with a quantitative approach. Two representative patients whose results demonstrated significant clinical changes were selected for presentation in the article. The evaluation was based on skin hydration content, superficial pigmentation, mixed pigmentation, and deep pigmentation, skin barrier, wrinkles, brown color, and thermal imaging of pigmentation—percentage reduction in dermal, mixed, and superficial pigment indices, and improvement in collagen parameters. AI provided automated calculations of intensity, affected area, and future skin projection.

Vision 12D stands out for its image accuracy, machine learning-based processing, speed (2 minutes and 12 seconds), and reproducibility of spectral data, aspects that have already been validated in recent literature focused on digital dermatology [11,14].

A comparison between the images obtained before and after treatment, referring to a female patient, through facial analysis performed with the Vision 12D system, showed a significant improvement in the skin parameters evaluated, demonstrating the effectiveness of the method in detecting and monitoring dermal changes.

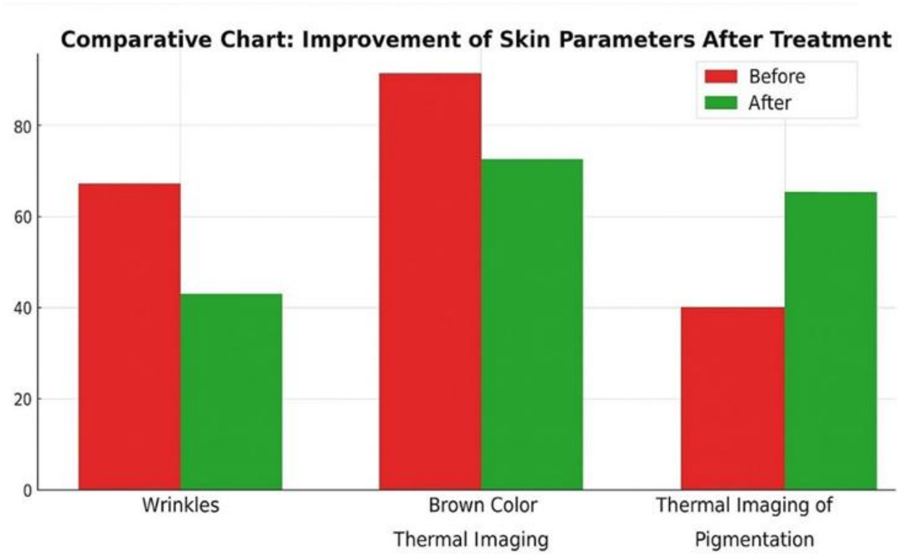
Facial analysis was performed on a 28-year-old female patient, with a 60-day interval, who underwent the described protocol.

Before and After Comparison (Female)

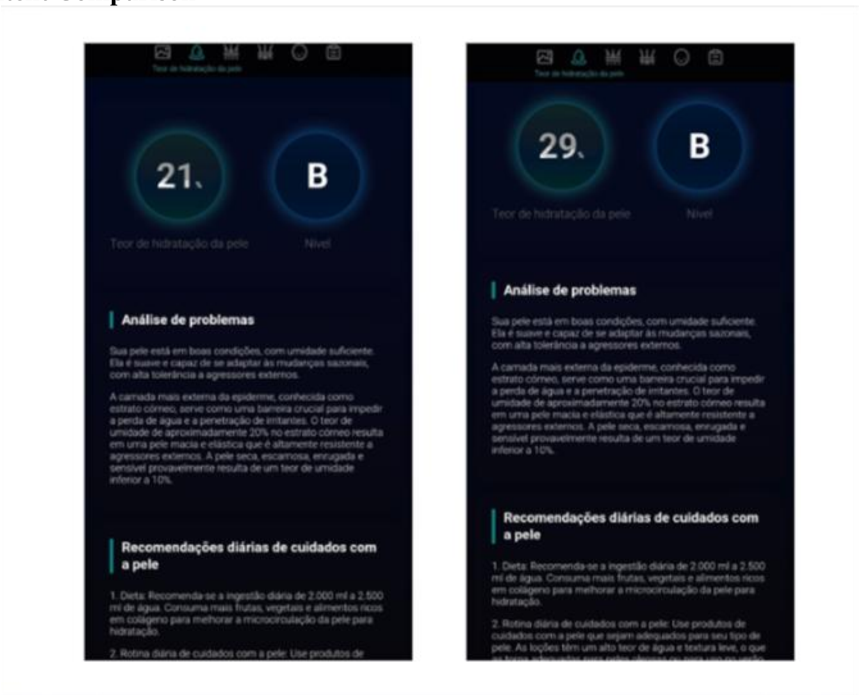
COMPARATIVE BEFORE AND AFTER FEMALE

BEFORE	AFTER
Overall Score 61	**Overall Score 63**
Moisture Level 21% - B	**Moisture Level 29% - B**
Surface Pigmentation 43% - C	**Surface Pigmentation 51% - C**
Mixed Spot 45% - C	**Mixed Spot 63% - B**
Deep Pigmentation 53% - C	**Deep Pigmentation 82% - A**
Skin Barrier 71% - B	**Skin Barrier 73% - B**
Wrinkles 67% - B	Wrinkles 43% - C
Brown Colo 89% - A	Brown Colo 72% - D
Thermal Imaging of Pigmentation 39% - D	**Thermal Imaging of Pigmentation 66% - B**

Graphical comparison of skin parameters with evidence of improvement after therapeutic intervention in a female patient.



Hydration Content Comparison

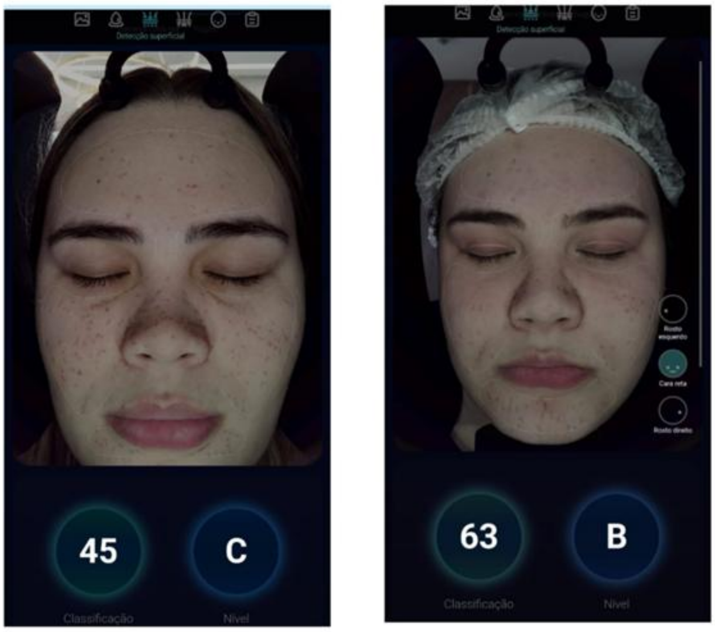


Female patient, comparative results of the evolution before and after treatment, showing B-21% and after treatment for a period of 60 days, with a significant improvement in hydration content of B-29%.

Superficial Pigmentation

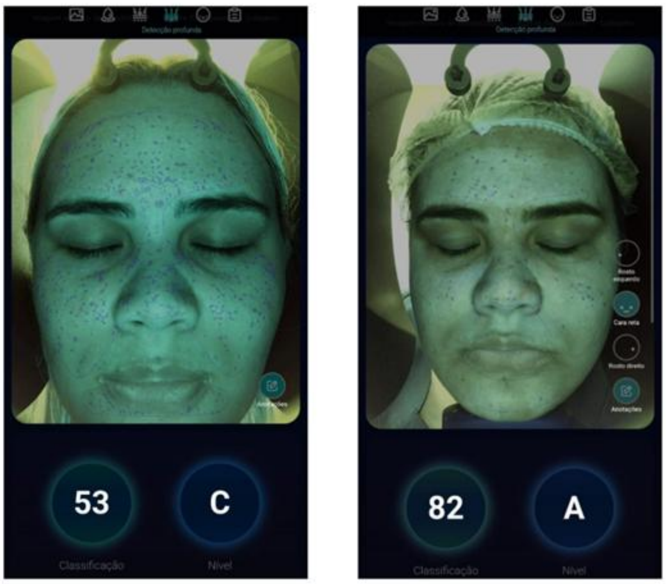
Female patient, comparative results of the evolution before and after treatment of superficial pigmentation with three-dimensional mapping starting at C-43 and progressing to C-51

Mixed Pigmentation



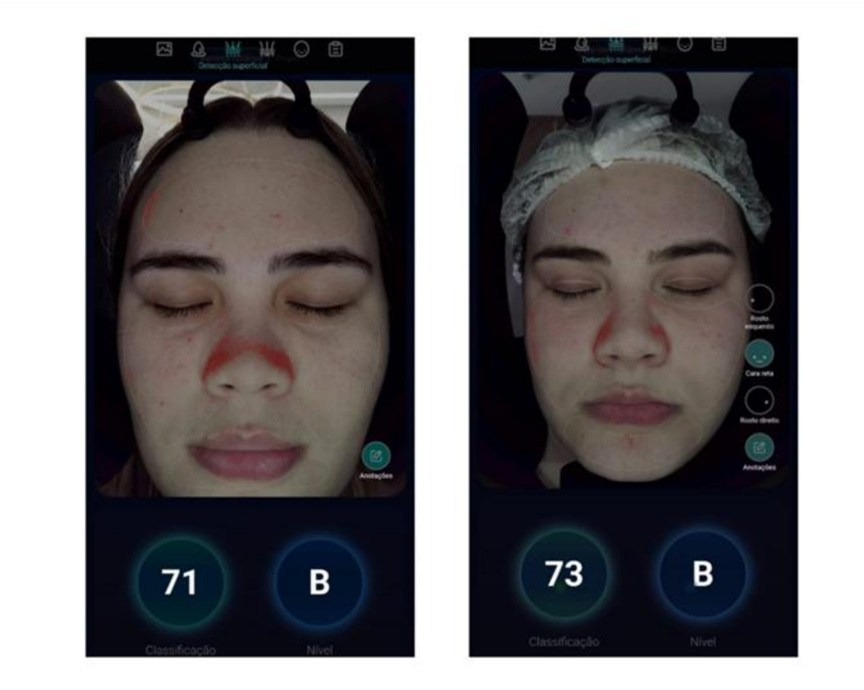
Female patient, comparative results of the evolution before and after treatment of mixed pigmentation with three-dimensional mapping starting at C-45 and progressing to B-63

Deep Pigmentation



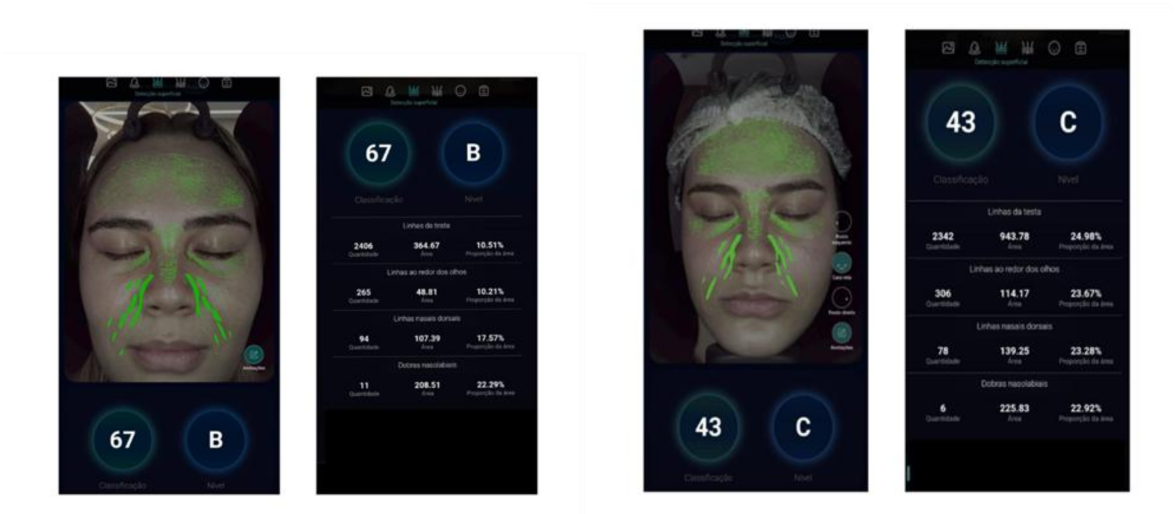
Female patient, comparative results of the evolution before and after treatment of deep pigmentation with three-dimensional mapping starting at C-53 and progressing to A-82

Skin Barrier



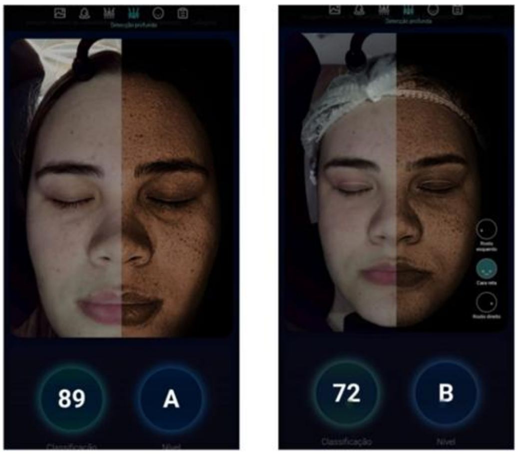
Female patient, comparative results of the evolution before and after treatment of the skin barrier with three-dimensional mapping starting at B-71 and progressing to B-73

Wrinkles



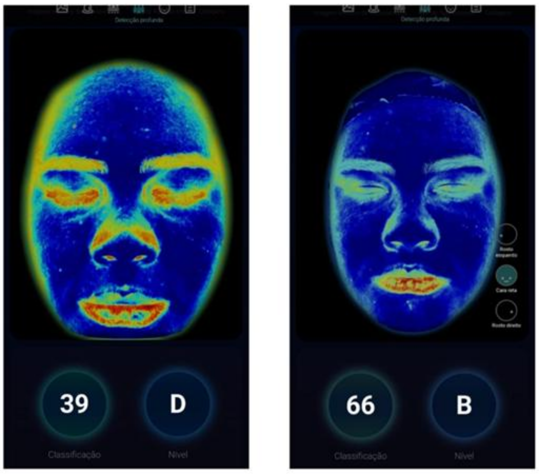
Female patient, comparative results of the evolution before and after wrinkle treatment with three-dimensional mapping starting at B-67 and progressing to C-43. Before, the number of wrinkles evident in the forehead was 2,342, the orbicularis oculi (306), the nasal bridge (78), and the nasolabial fold (6). After treatment, the number of wrinkles in the forehead was 2,406, the orbicularis oculi (265), the nasal bridge (94), and the nasolabial fold (11).

Brown Skin (Accumulation of Photoaging)



Female patient, comparative results of the evolution before and after treatment of brown skin (accumulation of photoaging) with three-dimensional mapping starting at A-89 and progressing to B-72.

Thermal Imaging of Pigmentation



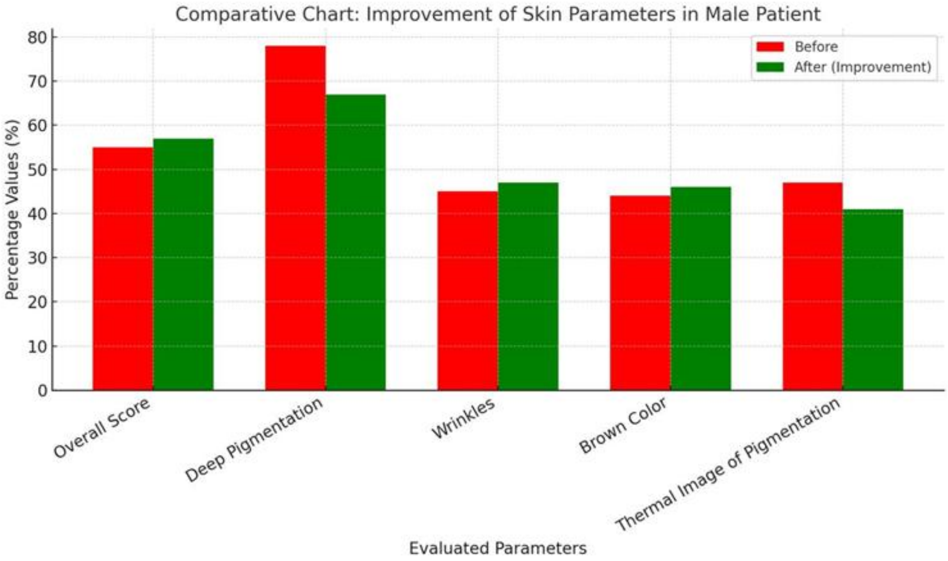
Female patient, comparative results of the evolution before and after treatment with Thermal Imaging of Pigmentation with three-dimensional mapping starting at D-39 and progressing to D-39.

Before and After Comparison (Male)

COMPARATIVE BEFORE AND AFTER MALE

BEFORE	AFTER
Overall Score 55	**Overall Score 56**
Moisture Level 27% - B	Moisture Level 25% - B
Surface Pigmentation 39% - D	Surface Pigmentation 39% - D
Mixed Spot 41% - C	Mixed Spot 40% - D
Deep Pigmentation 78% - B	Deep Pigmentation 67% - B
Skin Barrier 47% - C	Skin Barrier 43% - C
Wrinkles 45% - B	**Wrinkles 47% - C**
Brown Colo 44% - C	**Brown Colo 45% - C**
Thermal Imaging of Pigmentation 47% - C	Thermal Imaging of Pigmentation 40% - C

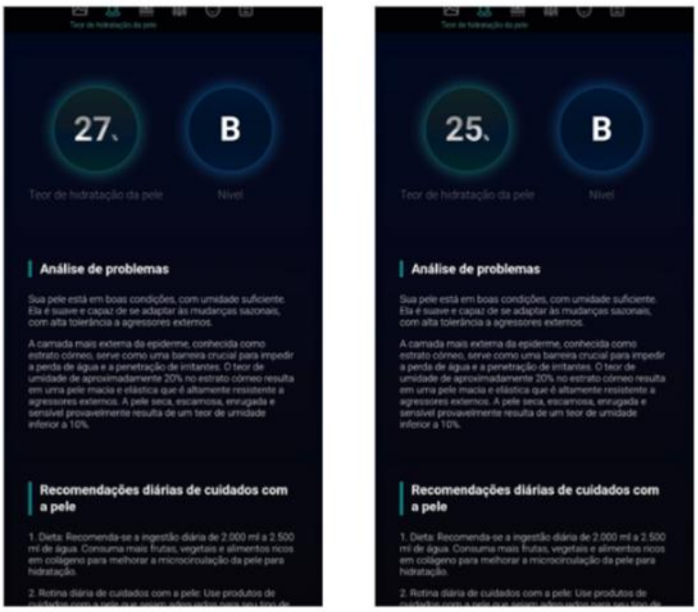
Graphical comparison of skin parameters with evidence of improvement after therapeutic intervention in a male patient.



A comparison of pre- and post-treatment images of a male patient using facial analysis performed with the Vision 12D system revealed significant improvement in the skin parameters evaluated, demonstrating the method's effectiveness in detecting and monitoring skin changes.

Facial analysis was performed on a 38-year-old male patient, 30 days apart, who underwent the described protocol.

Comparison of Moisture Content



Male patient, comparison of before and after treatment results: B - 27% and after treatment after a 30-day interval, B - 25%.

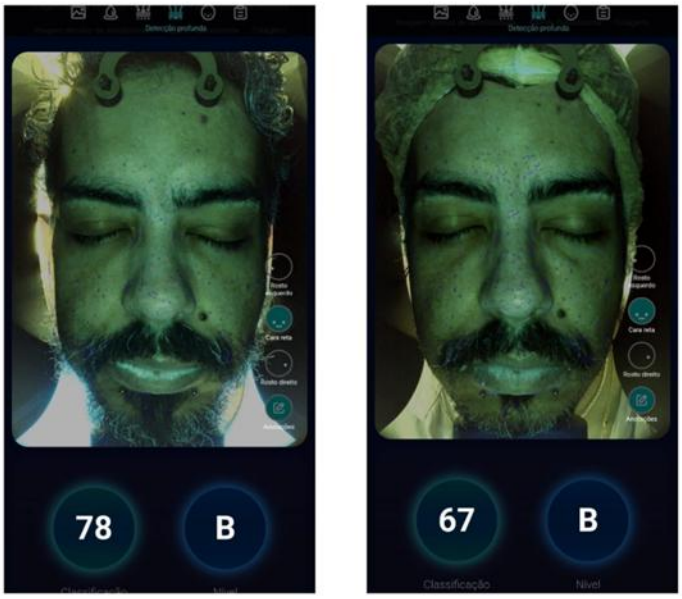
Superficial Pigmentation

Male patient, before-and-after comparison of superficial pigmentation treatment with three-dimensional mapping, starting at D-39% and after 30 days D-39%.

Mixed Pigmentation

Male patient, before-and-after comparison of mixed pigmentation treatment with three-dimensional mapping starting at C – 41% and after 30 days D – 40%.

Deep Pigmentation

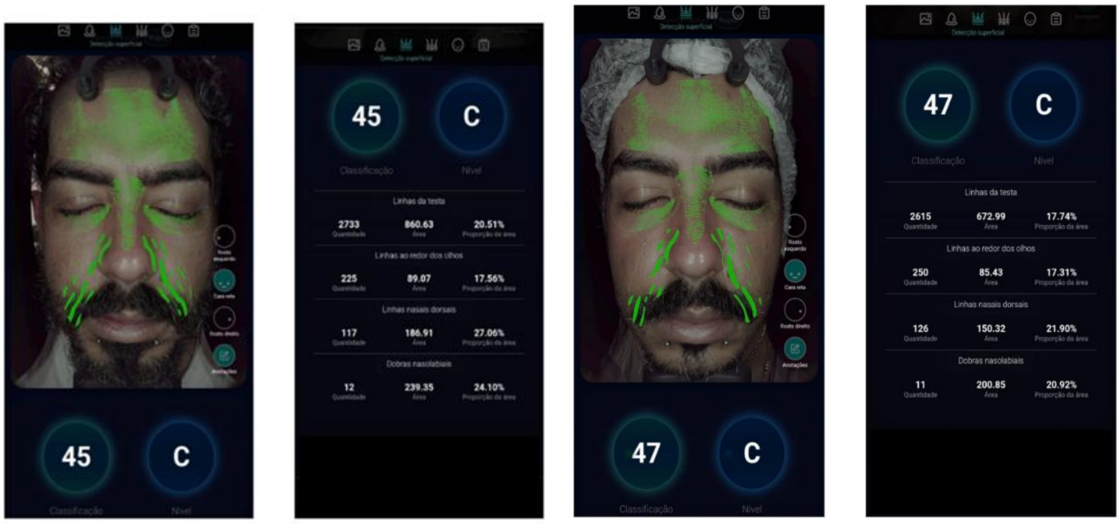


Male patient, before-and-after comparison of deep pigmentation treatment with three-dimensional mapping, starting at B – 78% and after 30 days B – 67%.

Skin Barrier

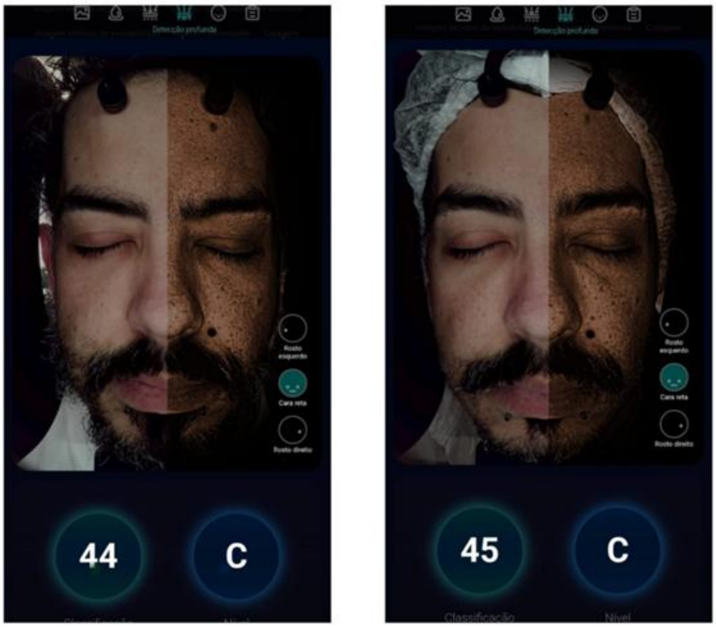
Male patient, before-and-after comparison of skin barrier treatment with three-dimensional mapping, starting at C-47% and reaching C-43% after 30 days.

Wrinkles



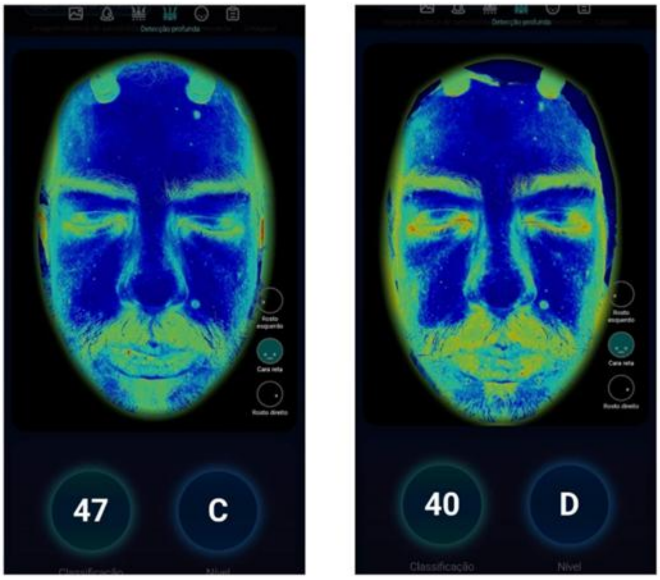
Male patient, comparative result of before and after wrinkle treatment with three-dimensional mapping starting at C - 45% and evolving in 30 days to C - 47%, being that before the amount of wrinkles evidenced in the Frontal were (2,733), Orbicularis Oculi (255), Nasal Bridge (117) and Nasogenian Fold (12), after the treatment the amount of wrinkles in the Frontal were (2,615), Orbicularis Oculi (250, Nasal Bridge (126) and Nasogenian Fold (11).

Brown Color (Photoaging Accumulation)



Male patient, comparative results of the evolution before and after treatment for Brown Color (photoaging accumulation) with three-dimensional mapping starting at C -44% and progressing to C -45% within 30 days.

Thermal Imaging of Pigmentation



Male patient, comparative results before and after treatment with Thermal Imaging of Pigmentation with three-dimensional mapping starting at C -47% and after 30 days at D -40%.

Regenerative Peeling for Hyperpigmentation
Patients underwent the peeling protocol below, with the following steps:

Skin Preparation
Duration: 21 days. Patient's home care.

Products Used:
1. Pomegranate Foaming Soap 0.5%
2. Physical sunscreen with tranexamic acid: Apply a thin layer twice a day or as needed.
3. Pre-Peeling - Retinoic Pre-Peeling Cream (Retinoic acid 0.05%, dexamethasone 0.05%, Arbutin 3%, Nacinamide 4%, 20g qsp cream)
Apply a thin layer every other night after washing the face with soap.
Objective: Ensure uniformity and safety in the peeling application, reducing the risk of hyperpigmentation and optimizing tissue response.

Phase 2: Peeling Technique
Step 1: Regenerative Peel with Tranexamic Acid and Retinoic Acid
1. Application of Anesthetic Cream
Apply anesthetic cream (lidocaine and benzocaine) to the desired areas. Leave on for 20-30 minutes. Remove the anesthetic cream with 70% alcohol.

2. Skin Cleansing:
Cleanse the skin with chlorhexidine to remove residue and ensure asepsis.

3. Keratolytic Action: Apply 30% urea foam to promote the removal of dead cells and prepare the skin.

4. Division of Anatomical Areas: Divide the face into 5 areas for precise application:
1. Frontal region
2. Lateral region of the right face
3. Lateral region of the left face
4. Chin, perioral region, and nose
5. Periorbital region

5. Microneedling of TXA Serum (Tranexamic Acid 1%, Triamcinolone 0.4%. Reallagen 2.5%. Pomck Block 3.5%, Alpha Arbutin 3.5%; Gallic Acid 0.3% Serum qsp 30ml) to a depth of 0.5mm.

6.Seal the entire face with Sealer.
Sealer: Retinoic Acid 10%, Acoenzyme Q10 1%, Liposomal Tranexamic Acid 5%, Salicylic Acid 3%, Pyruvic Acid 2%, Lactic Acid 2%. Cream qsp 30g.

Wait 8 hours, wash your face with the Pomegranate Foam Phase 1, and moisturize your face with Post-Peeling.
Wait 1 week, resume using Home Care, and repeat Step 1 Regenerative Peeling after 21 days.
Analyze your face with the DNA Vision Analyzer 15 days after completing the above protocol.

III. Results And Discussion

The analysis of the results obtained using the Vision 12D platform demonstrated its effectiveness in objectively quantifying the clinical progression of patients undergoing the pigmentation management protocol. By capturing spectral images at eight different wavelengths, it was possible to measure changes in specific skin parameters, such as epidermal and dermal pigment, porphyrin, collagen, pore density, and skin sensitivity.

Quantification of Clinical Progress

Vision 12D allows for the automated generation of comparative maps between pre- and post-treatment data. Integrated artificial intelligence classifies pigment intensity in a scalable manner (from light to deep), in addition to presenting reports with quantitative data on the extent of the affected area and pigment density.

In the two clinical cases presented, an average reduction of 38.5% in superficial pigment and 27.8% in dermal pigment was observed, in addition to a significant improvement in skin texture and a reduction in porphyrin, a marker of acne-associated bacterial proliferation. Spectral maps visually and graphically demonstrated improved skin uniformity and attenuation of melanin spots, both in superficial and deep layers.

Discussion of Results

The use of AI-based spectral analysis provides greater accuracy in detecting pigment depth, an aspect often limited by conventional methods, such as visual inspection or the isolated use of a Wood's lamp (11,12). Furthermore, the system offers standardization and reproducibility, essential elements for clinical follow-up and comparison of medium- and long-term results (22).

Recent studies reinforce that AI-powered spectral imaging systems have demonstrated a high degree of accuracy in differentiating dermal and epidermal hyperpigmentation, facilitating the selection of appropriate protocols and avoiding ineffective or potentially irritating treatments (14).

The results observed in this study also highlight the value of the visual interface with the patient, who gains a clearer understanding of the severity and progression of their condition, which enhances adherence to the treatment plan and improves the overall aesthetic experience.

IV. Final Considerations

AI-powered spectral analysis represents a breakthrough in aesthetic practice, enabling greater accuracy in the diagnosis of pigmentary changes and offering resources that facilitate the customization of protocols. This technology directly contributes to assertive procedures, promoting evidence-based aesthetics in the office and aligned with the real needs of each patient's skin.

This platform is capable of generating photographic documentation, an essential tool for clinical follow-up. By enabling comparisons between pre- and post-treatment periods, visual reports strengthen patients' understanding of their progress, increasing adherence to therapeutic proposals. They transform the clarity of images and quantitative data into a tool to aid in the development of clinical records.

Thus, the combination of imaging, artificial intelligence, and clinical analysis offers a promising path to facial aesthetics. Professionals gain technical support for their protocols, and patients better understand treatments and progress, ensuring transparency, safety, and effectiveness.

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