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Fractional CO_2 Laser In Thermal Microcoring Mode For Phototypes III, V, IV, And VI In Mixed-Race Populations.

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Abstract:
Fractional CO_2 laser (10,600 nm) is an effective technology for resurfacing and dermal remodeling; however, its use in higher phototypes (III–VI) is limited by the increased risk of post-inflammatory hyperpigmentation. Considering the reality of tropical countries and mixed-ethnicity populations, the article discusses a low thermal-load technical approach with controlled distribution of microthermal treatment zones (MTZ), described as fractional thermal microcoring, aiming to reduce inflammation and downtime. Key procedural and skin-preparation steps are detailed, including cleansing, topical anesthesia, and the use of laser-assisted drug delivery with antioxidant agents and melanogenesis modulators. This systematized approach seeks to improve the safety and predictability of fractional CO_2 laser in pigmented skin, especially in tropical settings.
Objective: *To describe and discuss a protocol for fractional CO_2 laser treatment using conservative parameters (low thermal load and MTZ control) in phototypes III, IV, V, and VI, combined with pigment-shielding strategies.*
Conclusion: *Low thermal-load settings, wider MTZ spacing, and limited overlap, together with a three-phase pigment-shielding protocol and post-laser care, may reduce inflammation and the risk of post-inflammatory hyperpigmentation in higher phototypes. This approach broadens the clinical applicability of fractional CO_2 laser in mixed-ethnicity populations, although controlled studies are desirable to strengthen standardization and validate outcomes.*

Keywords: *CO2 laser, black skin, higher phototypes, post-inflammatory hyperpigmentation, microcoring*

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I. Introduction

The use of energy-based technologies in dermatology and aesthetic medicine has become established as one of the most effective strategies for treating cutaneous photoaging, scars, dyschromia, and overall improvement in skin quality. Among these technologies, the fractional carbon dioxide laser (CO_2 – 10,600 nm) stands out for its ability to promote controlled ablation of the epidermis and dermal remodeling through the induction of microscopic columns of thermal damage, known as microthermal treatment zones (MTZs), preserving areas of adjacent intact tissue that favor rapid re-epithelialization and skin regeneration (MANSTEIN et al., 2004).

Historically, however, the use of ablative lasers in patients with high skin phototypes was considered a relative contraindication in clinical practice. This restriction stems mainly from the higher risk of pigmentary complications, especially post-inflammatory hyperpigmentation, a condition frequently observed in individuals with higher basal melanocytic activity and higher melanosome density in the epidermis. In this context, patients classified in phototypes III, IV, V, and VI of the Fitzpatrick scale are more susceptible to pigmentary changes after procedures that induce significant skin inflammation.

In Brazil, the term 'Microcoring' is frequently used commercially to designate the superficial mode of fractional CO_2 laser, characterized by larger and shallower lesions with predominantly epidermal and papillary dermal action, favoring rapid re-epithelialization and less downtime. However, the term 'microcoring' originally refers to a distinct, non-laser-based technique for extracting microfragments of skin, which reinforces the need for terminological standardization and reproducible protocols. (BORGES et al., 2026).

This concern becomes particularly relevant in tropical countries with great ethnic diversity, such as Brazil. The Brazilian population is characterized by a high degree of miscegenation resulting from the historical

interaction between European, African, and Indigenous populations, originating a wide phenotypic skin variability. Data from the demographic census indicate that approximately 56.7% of the Brazilian population self-identifies as brown and black, a category frequently associated with individuals of mixed ancestry (IBGE, 2022).

Furthermore, epidemiological studies conducted in Brazilian populations demonstrate a significant predominance of intermediate and high phototypes. In dermatological evaluations using the Fitzpatrick classification, it is observed that phototypes III and IV can represent about 70% of the individuals evaluated, while phototypes V and VI, although less frequent, constitute a relevant clinical group in dermatological practice (HEXSEL et al., 2014).

In some tropical regions of the country, especially in areas with strong influence Among people of African and Indigenous descent, the proportion of individuals with high phototypes may be even more significant. Population studies conducted in the Amazon region have shown that approximately half of the population has phototypes classified as V and VI, considered melanoprotective phototypes.

According to the 2024 IBGE census, in the Northeast region the proportion is even more significant, with 88% of the total being Black and mixed-race (IBGE, 2022).

Despite this epidemiological reality, many technological protocols used in aesthetic dermatology were initially developed and validated predominantly in Caucasian populations, which historically led to the exclusion or underrepresentation of patients with more pigmented skin in clinical studies and therapeutic protocols. Consequently, professionals working in tropical countries often face limitations in applying certain technologies to patients with high phototypes, not necessarily due to a lack of efficacy, but due to a scarcity of well-established safety protocols for this population group.

In recent years, however, advances Technological advancements in fractional laser platforms and improved knowledge about physical parameters and tissue-laser interactions have enabled the development of safer approaches for these patients. The use of lower firing densities, greater spacing between microthermal treatment zones, reduced pulse lengths, and lower total energy load makes it possible to significantly reduce the thermal residence time in the tissue and, consequently, minimize the cutaneous inflammatory response.

Within this context, therapeutic strategies based on thinner and more spaced ablative microcolumns, often described as fractional thermal microcoring modalities, emerge as a promising alternative for the safe performance of cutaneous resurfacing in patients with high phototypes. The association of these strategies with skin preparation protocols and complementary approaches, including laser-assisted drug delivery techniques, can further contribute to modulating the inflammatory response, reducing the risk of post-inflammatory hyperpigmentation, and expanding the clinical applicability of fractional CO_2 laser in mixed-race populations.

Given the high phenotypic diversity of skin observed in tropical countries and the growing demand for safe technological treatments for black and mixed skin, it is essential to investigate and describe therapeutic protocols that consider the biological particularities of these patients. Thus, this study proposes to discuss the application of fractional CO_2 laser using low thermal load parameters and controlled distribution of microthermal treatment zones, aiming to increase the safety and efficacy of this technology in patients with phototypes III, IV, V, and VI. 2. FRACTIONAL LASER IN PHOTOTYPES III, IV, V, and VI

The use of energy-based technologies for skin rejuvenation and treatment of aesthetic dysfunctions has advanced significantly in recent decades, expanding therapeutic possibilities in dermatology and aesthetic medicine. Among these technologies, the fractional CO_2 laser remains one of the most effective modalities for inducing dermal remodeling, stimulating neocollagenesis, and improving overall skin texture (MANSTEIN et al., 2004).

However, despite the broad effectiveness of this technology, its application in patients with high phototypes remains limited in clinical practice. Individuals classified in phototypes III, IV, V, and VI of the Fitzpatrick Scale have higher basal melanocytic activity and a greater capacity for cutaneous inflammatory response, factors that significantly increase the risk of developing Post-Inflammatory Hyperpigmentation after ablative or inflammatory procedures ((ALEXIS; SERGAY; TAYLOR, 2019).

This limitation becomes particularly relevant in tropical countries, such as Brazil, characterized by great ethnic diversity and a high degree of population miscegenation. Demographic data indicate that a significant portion of the Brazilian population has intermediate to high phototypes, which makes the development of safe therapeutic protocols adapted to the biological characteristics of pigmented skin essential (HEXSEL et al., 2014; IBGE, 2022).

Historically, many skin resurfacing protocols have been developed and validated predominantly in Caucasian populations, resulting in scientific gaps related to the safety and efficacy of these technologies in patients with higher epidermal melanin density. This gap has contributed to an excessively conservative approach or even to the exclusion of these patients from potentially beneficial technological treatments (ALEXIS; SERGAY; TAYLOR, 2019).

Superficial modes of fractionated CO_2, by restricting penetration and increasing the rate of re-epithelialization, are proposed as a strategy to reduce aggressiveness and downtime. (BORGES et al., 2026).

In recent years, advances in understanding the interaction between laser and skin tissue have allowed the development of technical strategies that significantly reduce the thermal load delivered to the tissue. Among these strategies, the following stand out: reducing the density of shots, increasing the spacing between microthermal treatment zones, using shorter pulse lengths, and applying lower energies, parameters that decrease the thermal residence time in the tissue and reduce the intensity of the cutaneous inflammatory response (MANSTEIN et al., 2004; HANTASH et al., 2007).

In addition to the proper adjustment of the laser's physical parameters, pre-procedure skin preparation and post-laser therapeutic management have been recognized as fundamental elements in the prevention of pigmentary complications. Protocols that use melanogenesis-modulating actives, antioxidants, and anti-inflammatory agents can act in the so-called "pigmentary shielding," reducing melanocytic activation induced by the inflammatory process triggered by the procedure. (GRIMES, 2013).

Among these active ingredients, classic and contemporary depigmenting substances stand out, as well as antioxidant compounds and modulators of skin inflammation, which can be used both in skin preparation protocols and in laser-assisted drug delivery strategies, enhancing the transdermal penetration of therapeutic actives through the thermal microcolumns formed during the procedure.

Therefore, it becomes relevant to investigate and describe protocols that integrate three fundamental pillars for the safety of treatment in high phototypes:

(1) the appropriate technical adjustment of laser parameters to reduce the thermal load;
(2) skin preparation with melanogenesis-modulating actives;
(3) the appropriate management of the inflammatory response.

Image 1: Interface of the fractional CO_2 laser equipment in deep mode demonstrating the operational parameters used in patient 1's protocol, including energy set at 21 mJ, continuous emission mode across the entire face, intercolumnar spacing between points of 2.5 mm, and randomized microthermal zone distribution configuration.

Image 2: Control panel of the fractional CO_2 laser in deep mode showing a point application configuration, demonstrating the operational parameters used in patient 1 with energy of 21 mJ per point, intercolumnar spacing between points of 2.0 mm, and randomized firing pattern. It has 40 points per cycle, allowing precise control of the density and total thermal load applied to the tissue.

The approach can be described as a fractional thermal microcoring modality, in which the ablative columns have a smaller diameter and greater spacing between them. This configuration promotes a more controlled and superficial epidermal ablation, preserving a greater proportion of intact tissue between the treated zones, which favors faster skin recovery and reduces the likelihood of post-inflammatory hyperpigmentation.

During the procedure, the pulses are distributed homogeneously over the treated area, respecting the skin anatomy and avoiding excessive energy overlap. The treatment density is adjusted conservatively, prioritizing the uniformity of the microthermal zones and avoiding thermal accumulation in specific regions.

Energy control (joules) is performed progressively and individually, considering factors such as skin thickness, degree of photoaging, presence of dyschromias, and previous history of inflammatory response of the patient's skin. In patients with high phototypes, it is recommended to use lower energies associated with greater spacing between the thermal columns, a strategy that significantly reduces the risk of exacerbated melanocytic activation.

Another important element of the protocol is limiting the number of passes over the same area, avoiding thermal overlap that could increase the risk of intense inflammation and subsequent hyperpigmentation. In this way, the treatment is performed with a uniform and controlled approach, prioritizing biological safety over thermal aggressiveness.

The application of the laser promotes thermal microchannels that can also act as transdermal permeation pathways for pharmacological actives, allowing association with Laser-Assisted Drug Delivery strategies. This approach enables the penetration of substances that modulate inflammation and melanogenesis directly into the treated skin layers, contributing to the control of the inflammatory response and the prevention of pigmentary changes.

Thus, the proposed technique integrates three main elements: control of the thermal load through modulation of the laser's physical parameters, tissue preservation provided by the fractional modality, and association with pharmacological strategies aimed at modulating the inflammatory response and melanocytic activity.

This approach seeks to increase the safety of fractional CO_2 laser application in patients with high phototypes, especially in mixed-race populations in tropical countries, where the incidence of post-inflammatory hyperpigmentation represents one of the main clinical concerns in the use of ablative technologies.

Preparation Technique For Protocol Application

Initially, complete facial cleansing was performed with a cleansing mousse containing glycolic acid, vitamin C, gallic acid, and ellagic acid, with the aim of promoting effective cleansing, removal of impurities, mild keratolytic action, and adequate skin preparation for the procedure.

Next, standardized high-resolution photographs were taken, following rigorous protocols for positioning, lighting, and angulation, ensuring image reproducibility throughout the different stages of treatment.

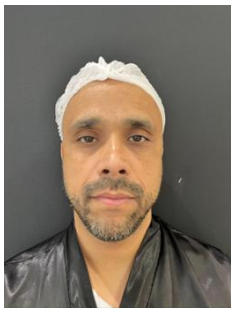

Image 3: Photographic record in frontal position, patient with gaze directed towards the horizontal plane, neutral facial expression, and lips at rest. The image was obtained with standardized lighting, distance, and framing, allowing for a global assessment of facial symmetry.

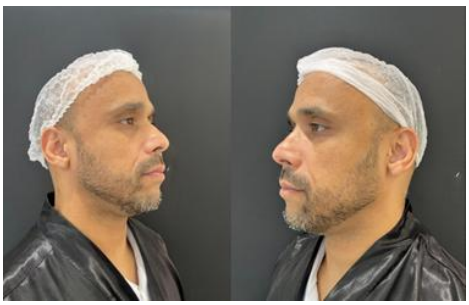

Image 4: Photographic record in oblique incidence (45°), right and left sides, with the patient in neutral facial expression and standardized positioning. This projection highlights the transition between facial planes, allowing for a more accurate analysis of skin relief, anatomical contours, and superficial irregularities, as well as the identification of texture alterations and possible pigmentary dysfunctions.

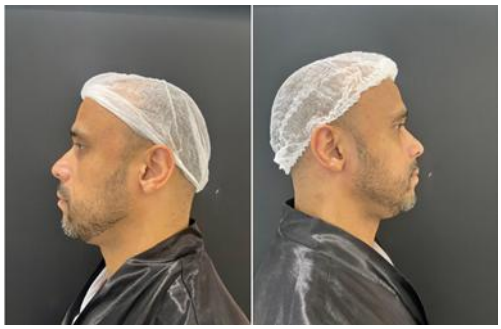

Image 5: Profile photograph (90°), right and left sides with proper alignment, patient in standardized positioning and neutral expression. This incidence allows for detailed evaluation of the facial contour, projection of anatomical structures, and analysis of the depth of furrows and skin irregularities, being fundamental for observing structural changes and tissue response to treatment.

Additionally, the patient underwent skin analysis using an analyzer system that integrates artificial intelligence resources with 8 different light spectra for quantitative and qualitative skin assessment at 17 points. The equipment allows for the objective measurement of parameters such as skin texture, uniformity of relief, pigmentation distribution, pore size, and changes related to photoaging.

Image 6: Facial analysis device using Optcare artificial intelligence

Image 7: Patient undergoing facial analysis with the Optcare device

The skin assessment in this study was performed using a digital facial analysis system based on artificial intelligence, which uses high-resolution image capture associated with multispectral analysis technology. The equipment performs standardized acquisition at different facial angles (frontal, right lateral, and left lateral), using multiple light sources, such as white light, polarized light, ultraviolet light, and combined spectra, allowing for a comprehensive analysis of epidermal and dermal structures.

The system is capable of objectively and quantitatively evaluating multiple skin parameters, including texture, superficial and deep blemishes, pores, wrinkles, fine lines, sagging, oiliness, hydration, elasticity, sensitivity, erythema, vascularization, presence of porphyrins, acne, skin barrier integrity, and skin tone uniformity, totaling seventeen clinical indicators relevant to the characterization of skin condition.

The integration of machine learning and artificial intelligence algorithms allows for the automated interpretation of images, promoting greater diagnostic accuracy, data reproducibility, and a reduction in the subjectivity inherent in traditional clinical evaluation. In addition, the system enables the monitoring of patient progress through longitudinal comparison of images and analyzed parameters, contributing to the individualization of therapeutic protocols.

These findings are consistent with the literature, which describes digital systems based on artificial intelligence and multispectral analysis as an effective tool in clinical practice, promoting greater diagnostic accuracy, standardization of assessments, and personalization of aesthetic treatment (MOLEIRO et al., 2025).

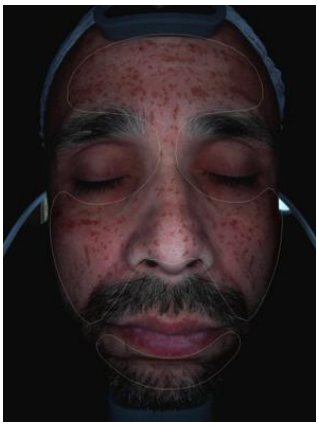

Image 8: Superficial pigmentation mapping obtained by the Skin Facial Analyzer using artificial intelligence. The image shows an irregular distribution of epidermal pigmentation, predominantly in photoexposed regions. Automated facial segmentation allows for regional quantitative analysis, contributing to therapeutic planning and monitoring of treatment response.

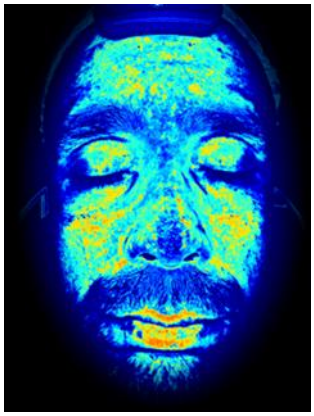

Image 9: Cutaneous thermal sensitivity analysis performed by the Skin Facial Analyzer using artificial intelligence. Spectral mapping reveals areas of greater cutaneous reactivity, represented by colors of higher intensity, suggesting greater susceptibility to inflammatory processes. This assessment helps identify regions with a potentially increased risk of exacerbated inflammatory response and post-inflammatory hyperpigmentation after ablative procedures.

The use of artificial intelligence algorithms enables standardized comparison between images obtained at different times during the protocol, minimizing observational biases inherent in subjective clinical evaluation. In this way, the system performs a comparative analysis of skin evolution, identifying subtle variations in pigmentation, texture, and skin quality, which are often not easily perceptible to isolated visual inspection.

This approach contributes to greater precision in the evaluation of clinical outcomes, allowing for more reliable monitoring of the therapeutic response to fractional CO_2 laser, especially in patients with high phototypes, in whom small pigmentary changes have significant clinical relevance.

In addition, AI-assisted analysis helps standardize evaluation criteria, favoring greater reproducibility of results and strengthening the methodological consistency of the study.

Next, topical anesthesia was performed using a formulation composed of 7% lidocaine base, 7% tetracaine hydrochloride, and 0.1% epinephrine, delivered in a high-permeability skin cream. The anesthetic was applied in a uniform layer over the entire area to be treated, remaining for approximately 30 minutes. After the action time, the product was completely removed, followed by skin antisepsis.

The use of topical anesthesia aimed to provide greater comfort to the patient during the procedure, in addition to contributing to the reduction of local bleeding due to the vasoconstrictor action of epinephrine, without interfering with the physical-thermal interaction between the laser and the cutaneous tissue.

Subsequently, the application of the fractional CO_2 laser was initiated, according to the techniques and parameters described in this study, with homogeneous distribution of the microthermal treatment zones and rigorous control of the tissue thermal load.

Immediately after the procedure, a laser-assisted drug delivery strategy was performed, using a formulation containing pure vitamin C, ferulic acid, tranexamic acid, hyaluronic acid, and growth factors, with the aim of modulating the inflammatory response, promoting antioxidant action, and assisting in the control of melanogenesis.

Finally, the procedure was completed with the application of a renewing serum containing mandelic acid, retinol A, nanoencapsulated active ingredients, and polyphenols, aiming to enhance skin regeneration, optimize clinical results, and contribute to pigmentary stability in the post-procedure period.

The clinical rationale for using superficial modes is associated with rapid re-epithelialization and less downtime when properly parameterized. (BORGES et al., 2026).

Clinical Evaluation And Evolutionary Record

After the proposed sessions, the patients presented overall clinical improvement of the treated skin, evidenced by a favorable response in pigmentary, structural, and textural parameters. In case 1, an approximate 20% reduction in periocular hyperchromia was observed, in addition to improved skin quality in the region and a significant improvement in fine wrinkles in the periarticular area of the eyes.

In case 2, a reduction of around 50% in post-inflammatory hyperpigmentation of post-traumatic origin was identified, indicating a satisfactory response of the protocol in modulating dyschromias.

In both cases, an improvement in skin texture was observed, with apparent refinement of skin relief, decreased pore visibility, increased tissue density, and improved overall skin hydration. These findings suggest that fractional CO_2 laser, when used with controlled parameters and associated with adequate management of the inflammatory response, can contribute to... This treatment is not only for functional and aesthetic improvement of pigmented skin, but also for tissue remodeling.

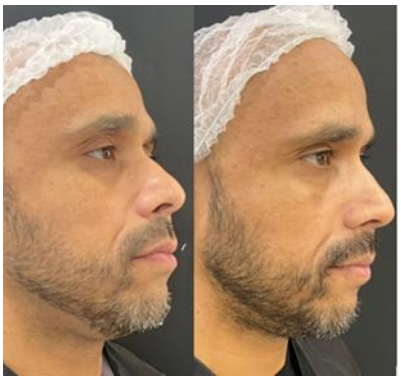

Image 10: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the right side of the face at a 45º angle, the result after one follow-up session with a 30-day interval.

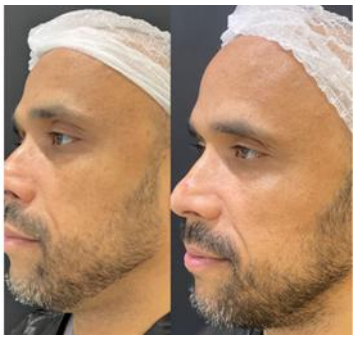

Image 11: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the left side of the face at a 45º angle, the result after one follow-up session with a 30-day interval.

Image 12: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the face at a frontal angle, the result after one follow-up session with a 30-day interval.

Image 13: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the face at a frontal angle, the result after one follow-up session with a 30-day interval.

Image Image 14: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the right side of the face at a 45º angle, the result after one follow-up session with a 30-day interval.

Image 15: Comparison before and after fractional CO2 laser treatment. The comparative photo shows the left side of the face.

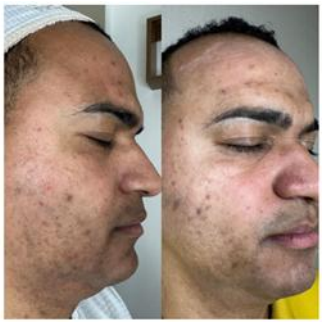

Figure 16: Comparison of the face at a 45º angle, the result after 1 follow-up session with a 30-day interval.

Figure 17: Comparison before and after fractional CO2 laser treatment. On the left, we have the initial photo before application and on the right, the result after 3 follow-up sessions with a 30-day interval between sessions.

Figure 18: Comparison before and after fractional CO2 laser treatment. On the left, we have the initial photo before application and on the right, the result after 6 follow-up sessions with a 30-day interval between sessions.

II. Hybrid Microcoring Modality And Comparison With Conventional Fractional Co_2 Laser

The development of fractional ablative technologies has brought significant advances in aesthetic dermatology by allowing the controlled induction of skin remodeling with a shorter recovery time compared to traditional ablative lasers. The fractional CO_2 laser acts by creating multiple microscopic columns of thermal ablation known as Microthermal Treatment Zones (MTZ), interspersed with areas of intact tissue that function as cellular reservoirs for rapid epidermal regeneration (MANSTEIN et al., 2004).

In the conventional fractional mode, each shot generates an epidermal ablation column associated with a peripheral thermal coagulation halo in the dermis. This thermal halo plays an important role in tissue contraction and stimulation of neocollagenesis, but it is also directly related to the intensity of the inflammatory response induced by the procedure (HANTASH et al., 2007).

In patients with high phototypes, classified as phototypes III, IV, V, and VI on the Fitzpatrick Scale, the exacerbated inflammatory response can stimulate melanocytic activity and trigger Post-Inflammatory Hyperpigmentation, one of the most frequently associated complications of ablative procedures in pigmented skin (ALEXIS; SERGAY; TAYLOR, 2019).

With the aim of reducing this tissue thermal load and increasing the safety of the procedure, new technological strategies have begun to incorporate hybrid approaches, in which different laser-tissue interaction patterns are combined in the same therapeutic protocol. Among these strategies, the modality known as fractional thermal microcoring stands out.

The concept of microcoring is based on the creation of thinner and deeper ablative microcolumns, with smaller diameter and greater spacing between the treated zones. This approach allows for the microscopic removal of small fractions of skin tissue with less lateral heat diffusion, reducing the thermal coagulation halo and, consequently, the intensity of the local inflammatory response.

In clinical practice, the hybrid mode can combine conventional fractional ablative shots with smaller diameter microcolumns and lower thermal load, distributed in a more spaced manner. This configuration promotes dermal remodeling and collagen stimulation while preserving a greater proportion of intact tissue between the treated areas.

Compared to the conventional fractional mode, the hybrid modality presents some relevant technical characteristics:

Conventional Fractional Co_2 Laser
• thermal columns with larger diameter
• larger thermal coagulation halo
• higher tissue inflammatory load
• higher risk of pigmentary changes in high phototypes

Hybrid Microcoring Modality
• thinner ablative microcolumns
• less lateral thermal diffusion
• greater spacing between treated zones
• lower inflammatory intensity
• greater preservation of adjacent tissue

From a physiological point of view, the reduction of the total thermal load and cutaneous inflammation plays a fundamental role in preventing post-procedure melanocytic activation. This aspect becomes especially relevant in patients with higher epidermal melanin density, in whom small variations in the intensity of the inflammatory response can result in clinically significant pigmentary changes.

Furthermore, the creation of thermal microchannels through these ablative columns can favor the transdermal permeation of pharmacological actives when associated with Laser-Assisted Drug Delivery strategies, allowing the targeted delivery of substances that modulate inflammation and melanogenesis directly into the treated skin layers.

In this way, the combination of the microcoring modality with conservative energy and density parameters represents a promising strategy to increase the safety of CO_2 laser application in patients with high phototypes, especially in mixed-race populations in tropical countries, where the demand for safe technological treatments for pigmented skin is growing.

III. Pigmentary Shielding And Management Of Post-Laser Hyperpigmentation In High Phototypes

The occurrence of Post-Inflammatory Hyperpigmentation represents one of the main complications associated with the use of ablative technologies in patients with high phototypes. This phenomenon is directly related to melanocytic activation secondary to the inflammatory process induced by the procedure, resulting in increased synthesis and transfer of melanin to epidermal keratinocytes (GRIMES, 2013).

In individuals classified in phototypes III, IV, V, and VI of the Fitzpatrick Scale, the melanocyte exhibits greater basal activity and a greater capacity to respond to inflammatory, hormonal, and thermal stimuli. As a consequence, procedures that induce intense skin inflammation can trigger an exacerbated melanogenic response, leading to the development of persistent hyperpigmentation (ALEXIS; SERGAY; TAYLOR, 2019).

In this context, the management of pigmentation in procedures with ablative technologies should be understood as a multifactorial process that involves not only the treatment of already established hyperpigmentation, but mainly preventive strategies.

Pigment shielding consists of adopting therapeutic measures aimed at reducing melanocyte activation before, during, and after the induction of the cutaneous inflammatory process. Among these strategies, the appropriate choice of technology and physical parameters used in the procedure represents one of the most determining factors for the safety of the treatment.

In the case of fractional CO_2 laser, controlling the thermal load delivered to the tissue is essential to limit the intensity of the inflammatory response and, consequently, reduce the stimulation of melanogenesis. Technologies that allow precise adjustments of parameters such as firing density, pulse duration, energy per point, and spacing between microthermal treatment zones enable a more controlled distribution of thermal energy in the cutaneous tissue.

The use of modalities that promote thinner ablative microcolumns with less lateral heat diffusion, as observed in hybrid approaches of fractional thermal microcoring, contributes to reducing accumulated tissue temperature and limiting local inflammatory activation. This reduction in thermal load plays a fundamental role in preserving the functional stability of the melanocyte.

In addition to the thermal modulation provided by the technology, skin preparation protocols and post-procedure management play an essential role in preventing pigmentary changes. Pre-treatment of the skin may include the use of melanogenesis-modulating actives, antioxidants, and anti-inflammatory agents that act in regulating melanocytic activity and reducing oxidative stress induced by the procedure.

Among the active ingredients frequently used in skin preparation protocols, substances with inhibitory action on tyrosinase, a key enzyme in the melanogenesis process, stand out, as well as compounds capable of modulating inflammatory mediators involved in melanocytic activation. These agents can be used both in topical formulations and in Laser-Assisted Drug Delivery strategies, taking advantage of the microchannels formed by microthermal zones to promote transdermal permeation of therapeutic actives.

In the post-procedure period, controlling the cutaneous inflammatory response and maintaining melanocytic stability become fundamental objectives of clinical management. Strategies that combine rigorous photoprotection, antioxidant agents, and melanogenesis modulators can contribute to reducing the risk of post-inflammatory hyperpigmentation and promoting more predictable skin recovery.

Thus, the safety of applying ablative technologies in patients with high phototypes depends on the integration of three main pillars: appropriate choice of technology and physical parameters, skin preparation with melanogenesis-modulating actives, and therapeutic management aimed at preventing post-procedure hyperpigmentation.

This integrated approach becomes particularly relevant in tropical countries and in mixed-race populations, where the higher density of epidermal melanin requires carefully structured therapeutic protocols to ensure clinical efficacy without compromising pigmentary safety.

IV. Three-Phase Pigment Shielding Protocol For Fractional Co_2 Laser Procedures In High Phototypes

The prevention of Post-Inflammatory Hyperpigmentation in patients undergoing ablative procedures requires a structured therapeutic approach involving adequate skin preparation, immediate management of the inflammatory response, and control of melanocytic activity during the tissue regeneration process. In individuals classified as phototypes III, IV, V, and VI on the Fitzpatrick Scale, these strategies become particularly relevant due to higher basal melanocytic activity and greater susceptibility to inflammation-induced hyperpigmentation (GRIMES, 2013).

In this context, a pigment shielding protocol is proposed, divided into three therapeutic phases: pre-procedure skin preparation, immediate post-laser intervention, and control of late melanogenesis.

Phase 1 – Pre-Procedure Skin Preparation

The preparation of the skin before performing fractional CO_2 laser procedures aims to reduce basal melanocytic activity, modulate inflammatory mediators, and prepare the epidermis to respond more stably to the thermal stimulus induced by the procedure.

This phase is usually initiated between two and four weeks before treatment and may include the use of topical agents capable of modulating melanogenesis and reducing cutaneous oxidative stress. Among the most active ingredients...

V. Conclusion

It is concluded that fractional CO_2 laser can be used more safely in phototypes III to VI when parameters such as low thermal load, greater spacing between MTZs, lower firing density, energy control, and limitation of overlap are prioritized, reducing inflammatory intensity and, consequently, the risk of post-inflammatory hyperpigmentation. In this context, the approach described as fractional thermal microcoring, with thinner and more spaced microcolumns, proves to be particularly suitable for mixed-race populations in tropical countries, as it favors faster re-epithelialization and less downtime.

In addition to technical adjustment, the predictability of the treatment depends on an integrated three-phase pigment shielding strategy, associated with rigorous photoprotection and, when indicated, assisted drug delivery to modulate inflammation and pigmentation. Thus, the standardization of specific protocols for pigmented skin expands the clinical applicability of fractional CO_2, maintaining a balance between efficacy and safety.

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