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Original Research

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Clinical Evaluation and Experience in Treatments Performed with Fractional CO_2 Laser on Latin American Skin: An Observational Retrospective Study

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Abstract

Background: The carbon dioxide (CO_2) laser is an ablative system that evaporates, remodels, and coagulates tissues, becoming therefore a gold standard piece of equipment for the treatment of dermatological pathologies and esthetic imperfections.
Objective: To evaluate the efficacy and safety of CO_2 laser treatments in different patients' skin pathologies.
Methods: A total of 705 patients with an age range between 18 and 70 years, with phototypes on the Fitzpatrick scale III, IV, V, and VI, were enrolled from October 2021 to May 2022, and were treated using the CO_2 laser system.
Results: Ninety-six patients were treated with fractional CO_2 laser, used for skin rejuvenation and stretch marks. One patient presented reactivation of herpes simplex, 10 postinflammatory hyperpigmentation that resolved after 3 months with depigmenting agents, 6 with persistent erythema. A total of 13 patients with rhinophyma were treated, and no complications were observed; a total of 64 patients with wrinkles were treated. They improved in 6 months. A total of 340 patients were treated for seborrheic keratosis, papulosa nigra dermatosis, fibropapillomas, sebaceous hyperplasias, verruca vulgaris, and condylomata acuminata. One patient presented with a complication hypopigmented macule. A total of 136 patients underwent treatment for laser ablation of intradermal nevi and verrucous epidermal nevi, without complications. A total of 56 patients were treated with keloids and hypertrophic scars. One patient presented with ulceration of a keloid that resolved with the application of clostridiopeptidase A and chloramphenicol after 2 weeks.
Conclusions: The use of the CO_2 laser in any phototype and race, which are factors with a high incidence in Latin America, provides a safe and effective result for different dermatological pathologies.

Keywords: laser, CO_2, skin types, Latin Americans, hyperpigmentation, resurfacing

Introduction

Due to strong skin remodeling, fully ablative laser treatments, particularly those performed with the carbon dioxide (CO_2) lasers, have been considered the gold standard for resurfacing treatments for a long time. The CO_2 laser has been successfully used to treat a wide variety of scars, and to improve their texture, color, and contracture.[1–5]

The CO_2 laser is an ablative laser, with a wavelength of 10,600 nm, which works based on the theory of selective photothermolysis. This means that the emitted light is absorbed by a specific chromophore, in this case, water, which represents >80% of the composition of the skin.[6,7] The CO_2 laser is the most versatile laser used in the treatment of cutaneous lesions. Its uniqueness can be used for resurfacing, excisional as well as incisional procedures.[6,8–12]

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Nevertheless, when it comes to treating Latin-type skin using laser devices, where phototypes III, IV, V, and VI are prevalent, the risk of complications is higher. This can be further influenced by the use of high fluences, inadequate tissue cooling, and poor patient selection, resulting in negative post-treatment outcomes such as pigmentary changes, swelling, erythema, blistering, crusting, and, in some cases, scarring.[13,14]

Hypopigmentation was observed earlier with resurfacing treatments, but it is less with fractional devices.[15] Fractional ablative lasers have a higher safety profile than traditional ablative lasers[16] with shorter erythema onset and recovery times.[17] Fractional lasers reduced the downtime and complications compared with nonfractionated ones. As recently demonstrated in the literature for the treatment of syringomas[18] and verrucous epidermal nevus,[19] the use of fractional CO_2 laser yielded excellent cosmetic results with minimal adverse effects.

These advantages, combined with the associated reduction in scarring and pigmentation issues, have contributed to the popularity of fractional laser treatments. The fractional ablative laser causes immediate ablation at the epidermal/dermal level, and the ablation area is completely replaced by invaginating epidermal cells within 48 h of treatment. The epidermal tissue is surrounded by a microscopic ablative zone, and Microscopic Epidermal Necrotic Debris (MEND) can be seen in the stratum corneum.

MEND exfoliation is visible on the seventh day, and MEND is replaced by the normal stratum corneum 1 month later.[20] Recently published studies[21,22] show the mechanism of action of the fractional CO_2 laser in the management of skin scarring by the stimulation of collagen and fibroblasts in the dermis, resulting in skin remodeling and shrinking. These results demonstrate the effectiveness and safety of CO_2 laser devices for skin scarring treatment, speeding up scars' healing time. Based on these observations, this study aimed to evaluate the efficacy and safety of fractional CO_2 laser treatment in dark phototypes for different patients' skin pathologies.

Materials and Methods

Device description

In this study, all treatments were performed with the Glide CO_2 laser (DEKA M.E.L.A, Florence, Italy) with freehand handpieces or with a scanner, which creates microzones of controlled thermal damage (DOT) separated by healthy tissue (DOT spacing). The device at hand can offer different kinds of laser emission modes. Three ultrapulsed shapes are available: high-peak pulse (HP), smart pulse (SP), and deep pulse (DP). A continuous pulse, which allows working on different pathologies and esthetic imperfections such as static wrinkles, coarse texture, enlarged pores, and superficial pigment, is also attainable (Fig. 1).

The abovementioned technology, with a range of available pulsed modes, induces different tissue biological effects such as stimulating new collagen production in the dermis, naturally regenerating the tissue structure, and improving skin tightening or softness. In detail, the SP is able to induce homogeneous coagulation of the surrounding tissues thanks to a more circular form of ablation. Differently, the DP mode generates a greater contraction of the ablation

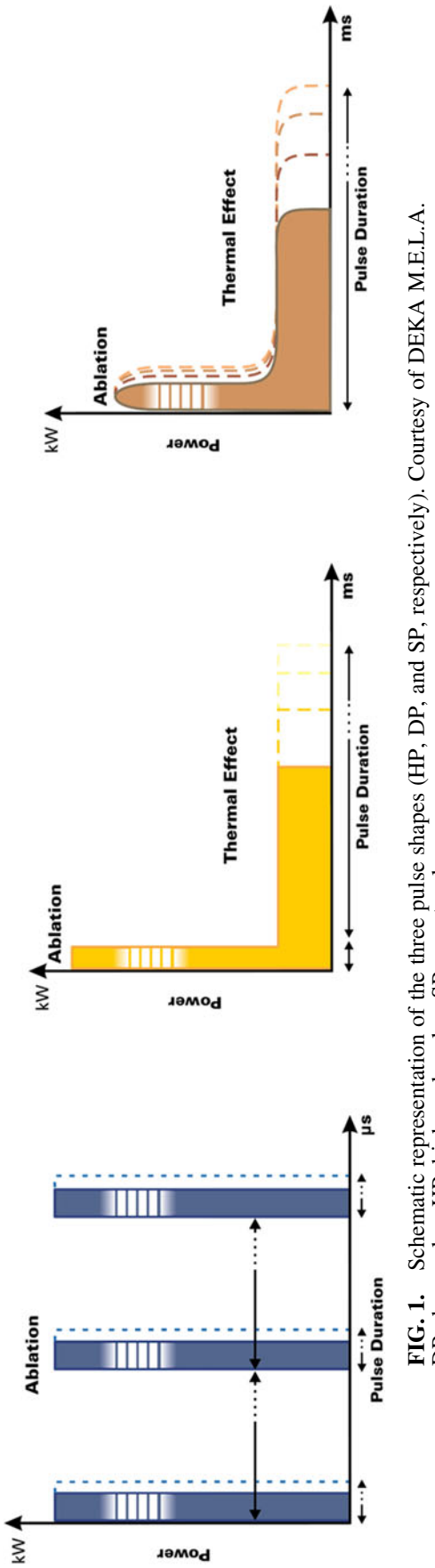


FIG. 1. Schematic representation of the three pulse shapes (HP, DP, and SP, respectively). Courtesy of DEKA M.E.L.A. DP, deep pulse; HP, high-peak pulse; SP, smart pulse.

columns and more circumscribed coagulation acting more incisively on the reticular dermis. Thanks to the higher peak power compared with SP and DP modes, the HP pulse makes it possible to obtain a colder effect on the tissues and, if necessary, a greater ablation.

Study protocol and patient's population

The observational retrospective study was carried out between October 2021 and May 2022 at Derma Internacional Centre, Buenos Aires, Argentina. A total of 705 patients (38% males and 62% females) with an age range of 18–70 years, with phototypes between III and VI, and different kinds of skin pathologies and conditions were enrolled for a total of 837 procedures (Tables 1, 2).

Common skin disorders such as acne scars, striae, keloids, rhinophymas, syringomas, xanthelasmas, seborrheic keratoses, dermatosis papulosa nigra, verrucous epidermal nevi, intradermal nevi, fibropapillomas, sebaceous hyperplasias, common warts, and condylomata acuminata were observed, as well as imperfections in texture, luminosity, and flaccidity. Treatments on patients were performed using Glide CO_2 laser (DEKA M.E.L.A) and, depending on pathology type, different emission modes were selected, in the conditions of seborrheic keratosis, papulosa nigra dermatosis, intradermal cellular nevi, fibropapillomas, sebaceous hyperplasias, common warts, and condylomas.

For a total of 64 patients affected by syringomas and xanthelasmas, ultrapulsed emission mode HP was used, and power was regulated according to the thickness of the lesion (varying from 0.5 to 2 W). Similarly, under the previous condition, intralesional anesthesia with adrenaline is administered before to prevent bleeding. In many cases, patients required more than one treatment session.

Table 1. Procedures and Patient Phototype

Procedures	n	%
Free hand	—	—
Seborrheic keratoses	129	15.4
Dermatosis papulosa nigra	26	3.1
Sebaceous hyperplasia	12	1.4
Syringomas	37	4.4
Warts	94	11.2
Accuminate condylomas	69	8.2
Verrucous epidermal nevi	74	8.8
Intradermal nevus	62	7.4
Fibropapillomas	10	1.2
Xanthelasmas	27	3.2
Rhynophymas	13	1.6
Fractional scanner	—	—
Acne, striae	121	14.5
Keloids, hypertrophic scar	56	6.7
Wrinkles, texture, pores, sup. pigment	107	12.8
Total	**837**	**100**
Patient phototype		
III	169	24.0
IV	226	32.1
V	218	30.9
VI	92	13.0
Total	**705**	**100**

A total of 13 patients were treated for rhinophymas condition. Before the laser treatment, intralesional anesthesia was administered, and the ultrapulsed HP mode was selected. Treatments were performed with a power of 10 or 5 W if a continuous emission mode was chosen to model the skin asymmetries. Differently, for acne scar and stretch marks treatment, the SP emission mode (fluence 1.86–3.30 J/cm^2; power 6–10 W; pulse duration 500–800 μs; DOT spacing 400–500 μm) was selected to treat 96 patients.

In some cases, the skin was prepared with retinoids or depigmenting agents, such as 4% hydroquinone, adapting the parameters according to the phototype, type of lesion to be treated, and application site. In general, depigmenting treatments or antiaging creams were indicated after the scab fell off, in addition to strict photoprotection.

Another option is to lower the power and increase the stack, which involves the emission of successive pulses on the same point, and guarantees maximum precision in the control of skin vaporization depth and thermal action. In all cases, the treatment was performed at intervals of 1 month, in about three sessions to improve the quality of the patient's skin after the initial treatment. Three hundred forty patients with seborrheic keratoses, papulosa nigra dermatosis, fibropapillomas, sebaceous hyperplasias, verruca vulgaris, and condylomata acuminata were treated with the ultrapulsed HP emission mode (power 0.5–2 W) depending on the thickness of the lesions. This ensured the treated lesions to achieve the desired level of thickness to avoid complications.

Checkups were carried out 1 month after the treatment, to evaluate possible retouching. For rejuvenation conditions, specifically for the treatment of static wrinkles, coarse texture, dilated pores, and superficial pigment, low parameters (fluence 1.86–3.30 J/cm^2; power 6–10 W; DP duration 500–800 μs; DOT spacing 400–500 μm) were set. In some cases, to shorten the patient's downtime by reducing ablative damage, the HP pulse, with a power between 3 and 4 W, with a DOT spacing of 500 μm, was adopted, and treatment sessions were performed every 4 weeks at least.

For 136 patients who underwent ablation treatment for intradermal nevi and verrucous epidermal nevi, the ultrapulsed emission mode with a power ranging from 0.5 to 2 W was selected. For 56 patients presenting with keloids and hypertrophic scars, SP emission mode SP, with a fluence varying between 2.98 and 5.76 J/cm^2, power ranging between 10 and 15 W, stack between 1 and 2, dwell time between 1000 and 2000 μs, and DOT spacing of 400 and 500 μm, was selected. In some cases, drug delivery or intralesional injections of triamcinolone were applied.

Results

Skin rejuvenation/disorders treatments with Glide CO_2 laser (DEKA M.E.L.A) were performed. For patients affected by rhinophymas, no complications were noted after treatment sessions. During the excision of syringomas and xanthelasmas, hypopigmented macules in one patient were observed. They improved in 6 months. After the treatment of acuminate patients, one subject presented with a complication hypopigmented macule.

Concerning patients affected by intradermal nevi and verrucous epidermal nevi, a favorable response was obtained without complications or side effects. The results obtained from

Table 2. Percentage of Total Incidence and Incidence on Type of Procedure of Side Effects Examined

Side effect	n	*Phototype distribution*	*Procedures*	*Incidence on type of procedure (%)*	*Total incidence (%)*
Herpes simplex	1	III:1	Acne	1	0.1
3 months PIH	10	III:5, IV:3, V:2	Acne, striae	8.3	1.2
Persistent erythema	6	III:4, IV:2	Acne, striae	5.0	0.7
6 months hypopigmentation	2	V:1, VI:1	Syringomas, accuminate condylomas	2.1	0.1
2 weeks ulceration	1	IV:1	Keloids, hypertrophic scar	1.8	0.1

PIH, postinflammatory hyperpigmentation.

keloids and hypertrophic scars after laser treatments were excellent and achieved in a short time. Better results were obtained with sessions at 1-month intervals between treatments. As complications, only one patient presented with ulceration of a keloid that resolved after 2 weeks with subministration of clostridiopeptidase A and chloramphenicol. Also, the patients treated for seborrheic keratoses, acne scars, stretch marks, surface pigment, and static wrinkles conditions obtained good results without having any complications (Figs. 2–4).

After laser treatment on participants with acne scars and stretch marks, only 1 patient presented with reactivation of herpes simplex (Fig. 5), 10 patients with postinflammatory hyperpigmentation (PIH) (which resolved after 3 months with depigmenting agents), and 6 patients with a persistent erythema. The use of the cold pulse with high peak in high phototypes, at power between 3 and 4 W with a DOT spacing of 500 μm, was recommended to shorten patient's downtime and reduce ablative damage, and the onset of risk of hyperpigmentation. Noticeable results were achieved without risks in three to four sessions.

Discussion

The use of fractional ablative CO_2 laser can sometimes induce hyperpigmentation (PIH) and prolonged bleeding, in correlation with the quantity of used energy. These adverse post-treatment responses are associated with acute inflammatory responses to skin heat damage. Indeed, during the inflammatory process there is an increase in arachidonic acid metabolites, which stimulates melanocytes to synthesize melanin.[23,24]

Other complications include prolonged erythema, acne, milia, bacterial infection, and herpes simplex reactivation. For the latter, an antiviral treatment is recommended before and after treatment for 10 days in patients with a history of herpes simplex episodes.[25] However, the most frequent complication is represented by PIH. Having dyschromias as the most frequent complication, whether these are hypopigmentation or hyperpigmentation.

PIH is the most feared side effect because even if it can occur in any race and phototype, it is more common in high ones, tanned subjects, and photodamaged skin. This can be further influenced by the use of high fluences, inadequate tissue cooling, and poor patient selection. It improves over time through the use of sunscreens and depigmenting agents such as hydroquinone. Topical corticosteroids are also recommended in case of intense purpura, as they would reduce PIH.[26] For this purpose, some authors, such as Goldman, recommend measures to prevent PIH, such as

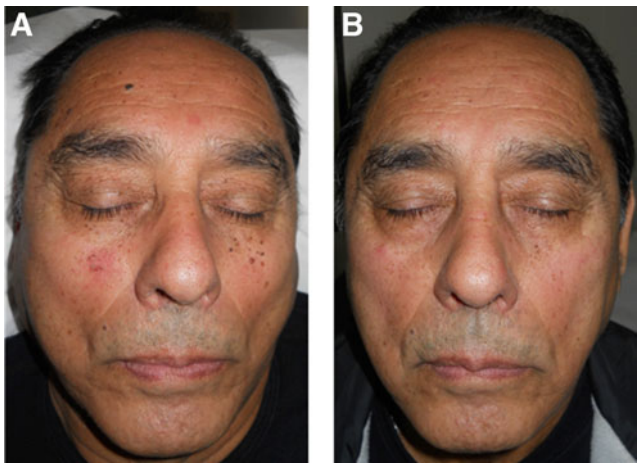


FIG. 2. Frontal view of a male patient before **(A)** and after **(B)** Glide CO_2 laser treatment. A visible improvement of seborrheic keratosis was observed. For seborrheic keratosis emission mode HP (power 0.5–2 W) was selected.

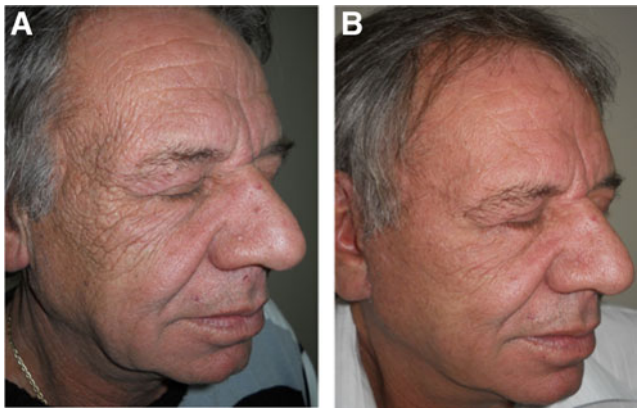


FIG. 3. Lateral view of a male patient before **(A)** and after **(B)** Glide CO_2 laser treatment. A visible improvement of patient's ocular intradermal nevus in upper lid area, skin texture, and wrinkles was achieved. For wrinkles treatment, emission mode HP with fluence 1.86–3.30 J/cm^2, power 6–10 W, DP duration 500–800 μs, and DOT spacing 400–500 μm was set. For ocular intradermal nevus management, the ultrapulsed emission mode with power ranging from 0.5 to 2 W was selected.



FIG. 4. Lateral view of a female patient before **(A)** and after **(B)** Glide CO_2 laser treatment. A clear esthetic improvement of skin texture, wrinkles, and surface pigment was observed. For wrinkles treatment, emission mode HP with fluence 1.86–3.30 J/cm^2, power 6–10 W, DP duration 500–800 μs, and DOT spacing 400–500 μm was set.

photoprotection during the day with a night application of 2% hydroquinone or 4% if tolerated by subjects, at the first sign of hyperpigmentation.

Moreover, the combination of hydroquinone with tretinoin or azelaic acid or kojic acid can be considered, since it was shown to be superior in this condition than when used in monotherapy. Finally, the use of topical corticosteroids is recommended if PIH shows signs of inflammation. When the topical treatment percentages are reduced and inflammation persists, depending on the potential for irritation, the following therapeutic sequence is recommended: Azelaic acid < kojic acid <2% hydroquinone < tretinoin <4% hydroquinone.[27]

Based on our experience for high phototypes, to overcome the problem of the onset of the most frequent PIH, low parameters have to be set (fluence 1.86–3.30 J/cm^2; power 6–10 W; pulse duration 500–800 μs; and DOT spacing 400–500 μm). In some cases, to reduce patient downtime and ablative damage, the cold pulse with HP with power between 3 and 4 W with a DOT spacing of 500 μm was applied; in this case sessions were repeated every 4 weeks and noteworthy results were seen after three to four sessions.

Keloids and hypertrophic scars can affect all races, but there is a greater predilection for black, Hispanic, and Asian races. The CO_2 laser works by stimulating basic fibroblast growth factor (bFGF) and by inhibiting the secretion of transforming growth factor beta 1 (TGF-β1). bFGF is mitogenic and limits collagen production, and TGF-β1 is responsible for stimulating the growth and production of collagen that is involved in the production of keloids, which, when inhibited, would improve healing.[28]

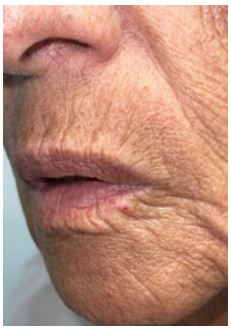


FIG. 5. Reactivation of herpes simplex in one patient after laser treatment.

In our experience, good results were obtained with the CO_2 laser, by selecting the SP emission mode, with the following parameters: fluence between 2.98 and 5.76 J/cm^2, power between 10 and 15 W, stack between 1 and 2, time of permanence between 1000 and 2000 μs, and DOT spacing between 400 and 500 μm. In some cases, drug delivery or intralesional injections with 1 mL of triamcinolone were used, obtaining greater results in less time. Xanthelasma is the most common type of xanthomas, and it is associated with disorders in lipid metabolism, genetic and environmental factors. It is located in the periorbital area, with a prevalence from 0.3% to 4% in Western countries, especially in women and older adults.

The ultrapulsed CO_2 emission mode showed excellent results in Caucasian races, but there are limited reports in high phototypes. The most frequent complication in these cases is hypopigmentation.[29] For both xanthelasma and syringomas, before the procedure, intralesional anesthesia infiltrations with adrenaline (2% of lidocaine with 0.1 mL of epinephrine) were applied, and subsequently the CO_2 laser in ultrapulsed emission mode HP was used (the power was regulated according to the thickness of the lesion, from 0.5 to 2 W).

In many cases, more than one session was required. In some patients, we observed hypopigmented macule and atrophic scar that improved at 6 months. Seborrheic keratoses are the most common benign tumors, and there are multiple ways to treat them. The CO_2 laser is a safe way to vaporize the tissue, even without the use of anesthesia. The ultrapulsed emission mode HP was used for seborrheic keratoses, warts, and condylomata acuminata with power varying between 0.5 and 2 W, and the energy was selected according to the thickness of the tissue to be treated.

Epidermal and sebaceous nevi are often difficult to treat due to recurrence or owing to an unsatisfactory cosmetic result. Before treatment, dermatoscopic examination was performed and ultrapulsed emission mode was used, obtaining a favorable response without complications. The fluence, pulse duration, and distance were modified according to the type of lesion, location, and phototype.

The correct use of surgical lasers considers the fact that higher power and laser pulses with shorter amplitudes than the thermal relaxation time (TRT) of the selected target result in less thermal damage. This is the theory behind the selective photothermolysis, which is the selective heating of tissue through preferential light absorption and heat production in the targeted tissue using appropriate wavelengths and pulse durations.

The fractional CO_2 laser generates perfectly controlled pulses (DOTs) by managing the ''energy per pulse'' parameter, the ''DOT spacing'' between two microscopic wounds, and the pulse duration (known as ''dwell time''). Many articles have already reported its effectiveness in improving skin texture and hyperpigmentation also in dark phototypes.[30–32] This study clearly shows that the CO_2 laser can be used in high phototype patients with only minimal side effects, and that its effectiveness is due to the link between the pulse emission modes used and TRT.

In our experience, immediate side effects include pain, erythema, and edema, which are most common with older methods that use higher powers, resulting in long recovery times of weeks or even months. With these scanned CO_2 systems, which are associated with the use of lower parameters, edema and erythema are limited to some hours or few days after the treatment.

Furthermore, the treatment was carried out by an independent operator, ensuring greater control over the treatment session. When using lower parameters, the percentage of post-treatment keloids and hypertrophic scars was very low (1%).[33] The benefits of CO_2 laser include faster healing, less anesthesia, less thermal damage, less bleeding, less inflammation, less pain, and minimal unfavorable side effects (esthetic scarring and dyschromic changes). These advantages must be weighed against the disadvantages of other available surgical techniques, which require frequent anesthesia, a longer recovery period, slower cicatrization, and high incidence of hypertrophic scars and keloids.

Furthermore, relevant restriction of other different surgical interventions involves their limited use in many anatomically difficult areas such as the earlobes, or the genitals areas, which are characterized by a high incidence of dermal damage. When performing fractional CO_2 laser in high phototypes, low energies application is recommended, informing the patient that for a greater impact on the change in skin quality more sessions will be required. At the first sign of hyperpigmentation, the use of depigmenting agents such as hydroquinone, tretinoin, kojic acid, or azelaic acid, associated with strict photoprotection is suggested.

Conclusions

Based on our experience, we can affirm that the use of the CO_2 laser in any phototype and race, which represent high incidence factors in Latin America subjects, provides a safe and effective result for different dermatological pathologies. Moreover, considering the patient's care before and after the treatments, the choice of energy and emission mode, which varies according to the lesion to be treated, is crucial. Although PIH is the most feared complication, it improves over time and well responds to topical depigmenting treatments.

Authors' Contributions

D.R.G., G.B.A., and P.M.S. designed conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, and funding acquisition; D.R.G., G.B.A., P.M.S., and I.F. contributed to writing—original draft preparation and visualization; I.F. assisted with writing—review and editing; D.R.G. performed supervision and project administration; all authors have read and agreed to the published version of the article.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki. Ethical review and approval were waived for this study because the device at hand is a CE-marked device from April 14, 2021.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Author Disclosure Statement

I.F. is employed at El.En. Group. The remaining authors have no conflicts of interest to declare.

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