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RESEARCH

Laser CO_2 scar treatment for moderate to high Fitzpatrick skin types in patients with acne sequelae from Argentina: treatment characteristics, evaluation of results and satisfaction

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Abstract

Background Persistent scarring, which significantly affects quality of life, is highly prevalent among acne patients, with some estimates reaching as high as 95%. The fractional ablative laser is a well-established technology for scar management, with numerous recent studies focusing on improving outcomes and reducing adverse effects. Latin Americans' skin types represent a challenge due to the risk of postinflammatory hyperpigmentation (PIH). This retrospective data collection presents findings from acne scarstreated with melanogenesis inhibitors before and after treatment, the post-treatment satisfaction level, and the complication rate in the Argentinian skin population treated with a fractional carbon dioxide (CO_2) laser device.

Methods Data from adolescents and adults with facial acne scars treated with a fractional CO_2 laser with two different handpieces, higher parameters, and several passes between April 2010 and April 2024 were retrospectively analyzed. Tranexamic acid 5% with glycolic acid 10% cream was indicated 1 month before and 3 to 6 months after treatment for patients with Fitzpatrick III to V. The primary endpoint was the baseline change in qualitative Goodman and Baron (GB) acne scores. The secondary endpoints included the general aesthetic improvement scale (GAIS) score and patient satisfaction score, both of which are measured on a 5-point scale (1 [low] to 5 [high]). Additionally, several factors were evaluated as potential predictors. The occurrence and frequency of adverse events (AEs) were monitored for safety assessment.

Results Forty-one patients, 25 males and 19 females, with an average age of 30 y.o. (16 youngest y.o., 56 oldest y.o.) were treated and included in this study. Following treatment, 81% of patients (33 patients) presented a reduction in GB score which was significantly different from baseline value (Wilcoxon signed-ranke test,, $p < 0.001$). The mean patient satisfaction score was 4.09, and the mean GAIS score was 3.95. No statistically significant relationships were found between any potential predictive factors and outcomes. Nearly 70% of patients (28) did not experience any AEs. The remaining patients experienced temporary and anticipated postinflammatory hyperpigmentation (PIH) and erythema. No scars or permanent side effects resulting from laser treatment were observed.

Conclusions This study demonstrated the high level of satisfaction, safety, and efficacy of fractional CO_2 laser with relative high parameters and several passes associated with two different handpieces for treating acne scars over Argentinien skin types with only one or two sessions, including those with relatively high Fitzpatrick skin types, and the importance of using pre- and posttreatment melanogenesis inhibitors to prevent and treat PIH.

Level of evidence Level IV, Risk / Prognostic Study.

Keyword Acne sequelae scar – co_2 – PIH – tranexamic acid

Introduction

Acne is a multifaceted, common dermatologic condition that affects mainly adolescents and young adults [1, 2]. It usually resolves by the mid-20 s, but some individuals may struggle with it throughout adulthood [3, 4]. Two primary patterns of acne are generally observed: a noninflammatory state, typically oberved in the peripuberty period, and an

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inflammatory state that is more prone to persistent scarring, significantly impacting patient well-being [5]. The global prevalence of acne scarring among individuals with acne has not been consistently reported, with estimates ranging from approximately 40% to as high as 95% [6]. Acne scarring is attributed to an altered wound-healing response in which inflammation disrupts collagen biosynthesis, leading to either a gain or loss of tissue. Excessive collagen production results in raised scar tissue, which is categorized as hypertrophic or keloid scars,whereas collagen deficiency results in tissue damage, which is categorized as atrophic scars [7]. Acne scars are mostly atrophic and are further classified on the basis of structural features into ice-pick (V-shaped), rolling (M-shaped), and boxcar (U-shaped) types. In addition, scars may vary in color due to erythema and melanogenesis [7, 8]. Numerous treatment options are available to improve acne scars, with energy-based devices emerging as attractive noninvasive alternatives [9–11]. The energy from these devices initiates collagen damage in the skin, resulting in neocollagenesis and extracellular matrix remodeling. Ablative lasers operate in a wavelength range that vaporizes water molecules in the skin, creating a peeling effect on the epidermis and stimulating collagen production in the dermis [9, 10]. One of these lasers is10,600 nm carbon dioxide (CO_2), which primarily targets tissue water with a minimal direct effect on melanin and hemoglobin [11]. The long recovery times and side effects associated with traditional ablative lasers have motivated the development of fractional laser technology. The underlying principle of this technology is the delivery of energy in a pixelated fashion, which creates microscopic, regularly spaced channels in the skin, known as microthermal treatment zones (MTZs), while leaving the surrounding skin intact. The unaffected skin supports faster healing of the ablated tissue columns [7]. The fractional CO_2 laser is a well-established technology for treating atrophic scars, and numerous studies have confirmed its efficacy. Various laser parameters have been investigated to explore their utility further, suggesting that higher energy levels are associated with better outcomes but often result in more pronounced adverse effects [12].

The Latin-American´ skin types are majority darkness and relatively high basis on Fitzpatrick skin type scale [13]. Majority of Argentine´ Fitzpatrick skin types are between grade II and grade V. Postinflammatory hyperpigmentation (PIH) appears to be the most common and problematic CO_2 laser treatment AEs, primarily when it is performed over dark skin types [14]. One of the ways to treat and prevent PIH in this treatment is by using a tranexamic acid topical formula. Tranexamic acid (TXA) prevents blood loss by acting as a plasmin inhibitor.It is administered to prevent abnormal fibrinolysis by preventing the plasminogen activator from converting plasminogen to plasmin. Moreover, plasmin elevates α-melanocyte-stimulating hormone, which activates melanin synthesis in melanocytes. TXA is thought to block melanogenesis, and its efficacy in melasma and other light-induced pigment disorders might be due to its antiangiogenic and antimelanogenetic properties [15].

Accurate assessment of acne scarring is critical for determining appropriate treatments and monitoring the effectiveness of therapeutic interventions. A global grading system for acne scarring was proposed by Goodman and Baron in 2006 [16]. The Goodman and Baron (GB) scale is a qualitative system that categorizes postacne scarring into four grades on the basis if lesion morphology and patient perception, allowing for a comprehensive and standardized assessment. Grade 1 (macular disease) includes erythematous, hyperpigmented, or hypopigmented flat marks. Grade 2 (mild disease) features mild atrophy or hypertrophy that can be concealed by makeup or natural shadows. Grade 3 (moderate disease) involves more pronounced atrophic or hypertrophic scarring visible at social distances but can be flattened by manual skin stretching. Grade 4 (severe disease) comprises severe scarring that is highly visible at social distances, is not easily covered by makeup, and is resistant to flattening by stretching [16].

The present report seeks to show, on the basis of parameters used by the author (millijouls, depths of action, melanocytic inhibitor pre- and posttreatment), the results obtained via a fractional CO_2 laser and two different handpieces over Argentine Fitzpatrick skin types by comparing the appearance of scars before and after the procedure.

Methods

This retrospective cohort study collected data from patients treated for facial acne scars via an iPixel fractional CO_2 laser (Alma iPixel CO_2, Alma Lasers) in Cirugía y Láser Dr. Pérez Rivera, Buenos Aires, Argentina, between April 2010 and April 2024. The patients included were adolescents and adults with clinically diagnosed acne scarring. Patients were excluded they had a history of keloid or hypertrophic scar formation, recurrent active facial acne, isotretinoin use within the past six months, diabetes, collagen or vascular diseases, pregnancy or nursing, or significant tanning (exposure to sunlight or ultraviolet light). The treatment and expected postoperative skin conditions were explained in detail to each patient. All patients provided their signed informed consent to share the data.

Treatment procedure

The treatment areas were cleaned with chlorhexidine 5%, and a local anesthetic cream (10% lidocaine with 10% tetracaine) was applied to the entire face. After one hour, the anesthetic cream was gently removed. In some cases, the

addition of 2% lidocaine with epinephrine to block nerves results in the emergence of supraorbital, infraorbital, sphenopalatine, and submental nerves. Treatment was conducted via two types of handpieces: the 7 × 1 rolling tip, which performs one or two passes at medium frequencies (3HZ) ranging from 100 to 130 mJ, and high frequencies (5HZ) ranging from 60 to 100 mJ, often in various combinations. After that, one pass of each one of these: 9 × 9 resurfacing, one pass of 0.5 Hz ranging from 120 to 190 mJ at low (meaning a more profound skin effect), one pass of 5 Hz ranging from 90 to 120 mJ in at medium (meaning a middle depth skin effect), and one pass of 5 Hz ranging from 40 to 90 mJ at high (meaning a superficial skin effect).

Depending on the severity of the scars, the physician administered 1 to 7 treatments to the entire face, with an average interval of four weeks between sessions. In cases of Fitzpatrick III, IV, and V, a melanocytic inhibitor topical cream (Tranexamic 5% with 10% glycolic acid) was given every day at night one month before the treatment. In all the cases, including Fitzpatrick II, this topical cream formula was applied posttreatment for three to six months according to the physician's decision. Patients were advised to avoid direct sunlight and to use sunscreen with SPF 50 + .

All patients included in this study were photographed before and after the procedure three to 6 months after the procedure.

Data collection

Data were collected through patient surveys and clinical assessments. The physician evaluated the acne scars via the GB 4-point scale, as explained above, before and after the follow-up visit, and six to twelve months after the final treatment session. In addition, the physician compared photographs taken before the treatment and at the follow-up visit, using identical settings, and provided objective clinical assessments of the general aesthetic improvement score (GAIS) on a 5-point scale (1 [low]—5 [high]). At the follow-up visit, patients were asked to rate their satisfaction level on a 5-point scale (1 [low]—5 [high]). AEs were monitored and documented during and after each session, as well as at the follow-up visit, and patients were asked to report any complications during the treatment and follow-up peroids.

Statistical analysis

Descriptive statistics were used to summarize the data. The median, mean, and standard deviation (SD) were calculated for continuous variables, whereas frequencies and percentages were computed for categorical variables. TheShapiro-Wilk test was employed to assess the normality of the data, and appropriate statistical tests were chosen on the basis of the results. Additionally, the decrease in GB score was calculated by subtracting the GB baseline score from the GB posttreatment score for each patient, and the percentage of patients who showed improvement (reduction) in their GB score after the treatment was also calculated. The Wilcoxon signed-rank-test was used to evaluate the differences in GB scores before and after treatment, and Spearman rank collection was employed to assess the relationships between them. The Mann–Whitney U test was used to assess differences in GAIS scores, patient satisfaction scores, and GB score reduction between sexes. Spearman rank correlation was used to evaluate the associations between GAIS scores and skin type, age, and number of treatment sessions, as well as between patient satisfaction scores and the same factors and, similarly, between GB score reduction and the same factors. For safety assessment, the number and percentages of AEs were calculated. The alpha level for statistical significance was set at 0.05. All the statistical analyses were performed via R version 4.3.3.

Results

This retrospective data collection analyzed data from forty-three patients, 24 men and 19 women, who received between one and seven sessions, 86% of whom received only 1 to 2 sessions, of CO_2 laser treatment for acne scars. Most patients achieve successful results with one or two sessions (86%). Only two patients requested four or seven sessions. The age of the patients ranged between 16 and 56 years, with an average of 30 ± 7.4 years (mean ± SD). Demographic and clinical data, including sex, Fitzpatrick skin type, and number of sessions, are presented in Table 1.

Table 1 Summary of patients and treatment characteristics

Characteristics	Sublevel	Count	Percentage
Gender			
	F	19	44.2
	M	24	55.8
Fitzpatrick Skin Type			
	II	4	9.3
	III	30	69.8
	IV	7	16.3
	V	2	4.7
No. of Sessions			
	1	20	46.5
	2	17	39.5
	3	4	9.3
	4	1	2.3
	7	1	2.3

Performance assessment

Following the treatment, an overall improvement was demonstrated, with the mean GB score decreasing from 3.6 ± 0.8 (mean ± SD) at baseline to 2.8 ± 0.7 (mean ± SD) after the treatment and the median GB score declining from 4 at baseline to 3 after the treatment. Analysis of pre- and posttreatment GB scores revealed a statistically significant difference, as confirmed by the Wilcoxon signeg-rank test ($p < 0.001$), and a strong positive association between them was determined by Spearman correlation analysis (rho = 0.79, $p < 0.001$). Additionally, 81% (35 patients) showed a reduction in the GB score, with the mean number of sessions in this group being 1.7 ± 0.8 and 21% (9 patients) being Fitzpatrick IV or above. Additionally, both the physician and patients rated the improvement as high. Figures 1, 2, 3, 4, 5 and 6 present the improvements in acne scars observed during the treatment for all skin types. Table 2 presents summary statistics of the outcomes.

No statistically significant relationships were found between any patient or treatment factors and outcomes. Specifically, the Mann–Whitney test indicated no significant differences between males and females in GAIS scores ($p = 0.97$), patient satisfaction scores ($p = 0.335$), or the reduction in GB scores ($p = 1$). In addition, no meaningful associations were found via Spearman correlation analysis. Specifically, there were no significant correlations between GAIS scores and skin type (rho = −0.13, $p = 0.42$), GAIS scores and age (rho = 0.02 $p = 0.88$) or GAIS scores and the number of sessions (rho = 0.19, $p = 0.22$). Similarly, Spearman correlation analysis revealed no significant associations between patient satisfaction and skin type (rho = −0.09, $p = 0.56$), patient satisfaction and age (rho = −0.063, $p = 0.686$), or patient satisfaction and the number of sessions (rho = 0.093, $p = 0.55$). Additionally, no significant associations were found between the reduction in GB score and skin type (rho = 0.09, $p = 0.56$), the reduction in GB score and age (rho = 0.16, $p = 0.3$), or the number of sessions (rho = 0.06, $p = 0.68$).

Safety assessment

Nearly 70% of patients did not experience any AEs. The remaining patients experienced transient and expected mild postinflammatory hyperpigmentation (PIH) and erythema. The erythema cases resolved spontaneously within up to 3–4 weeks. PIH patients were treated with tranexamic acid at 5% and glycolic acid at 10% for 3 to 6 months. No instances of permanent lesions or sequelae have appeared. The number and frequency of AEs are presented in Fig. 4.

Fig. 1 **a-b** Digital photography of a patient with skin type II before (2a-left) and 6 months after (2b-right) fractional CO_2 laser treatment

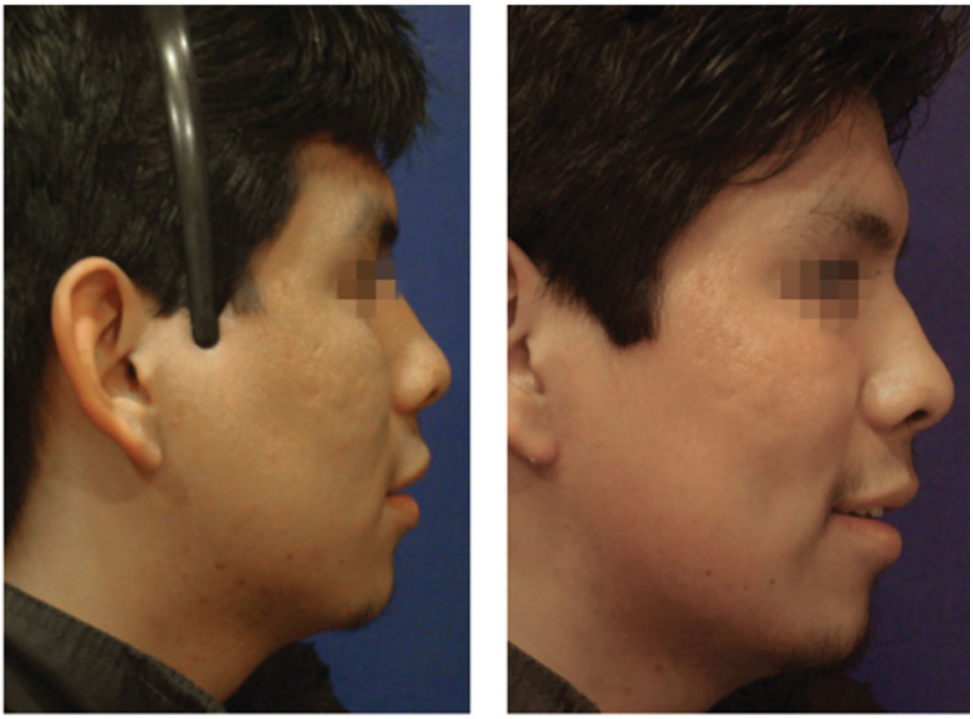

Fig. 2 **a-b** Digital photography of a patient with skin type IV before (3a-left) and 6 months after (3b-right) fractional CO_2 laser treatment

Fig. 3 **a-b** Digital photography of a patient with skin type III before (4a-left) and 6 months after (4b-right) fractional CO_2 laser treatment

Discussion

Acne scars have received increasing attention because of their negative impact and persistence, with reported risk factors varying widely [17]. Nevertheless, CO_2 lasers have been proven to be particularly effective for this condition [18]. The CO_2 laser precisely targets water, a primary component of the epidermis, thereby providing excellent skin resurfacing, and fractional technology has further revolutionized this therapy [7, 9]. While this newer technology is safe and effective for all skin types, treating scars on darker skin types is considered more challenging and often requires less aggressive laser settings to avoid epidermal damage [14]. Previous studies have shown that higher

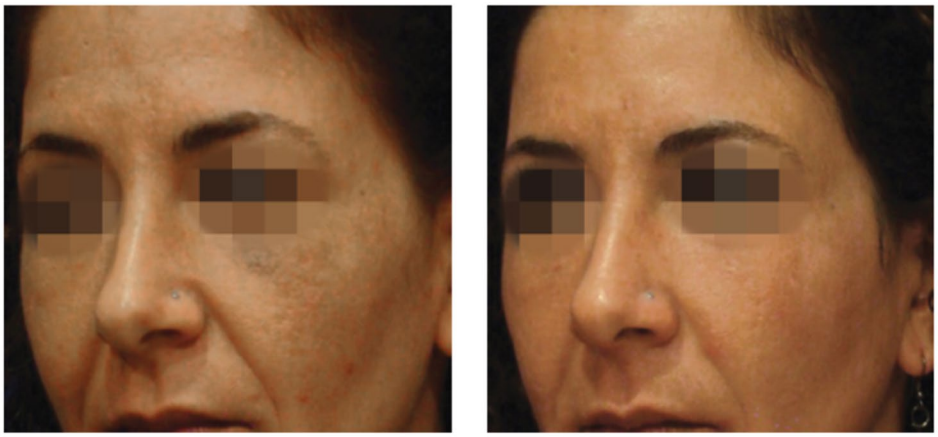

Fig. 4 **a-b** Digital photography of a patient with skin type IV before (5a-left) and 6 months after (5b-right) fractional CO_2 laser treatment

Fig. 5 **a-b** Digital photography of a patient with skin type III before (6a-left) and 6 months after (6b-right) fractional CO_2 laser treatment

energy levels are associated with greater clinical efficacy. However, a delicate balance between the modulation and suppression of wound healing responses is needed. The properties of the MTZs are closely related to the laser settings, with more laser passes producing more MTZs per unit area. At higher MTZ densities, the amount of unaffected tissue decreases, potentially leading to less effective scar improvement, longer recovery times, and an increased risk of side effects. Several techniques have been described to improve the efficacy and reduce the side effects of fractional CO_2 laser treatment. These include various combinations of treatment modes, modalities, and therapies [19] (Fig. 7).

The handpieces used in this study allow a uniform distribution of MTZs, rolling 7 × 1 handpiece and 9 × 9 resurfacing handpiece, promoting precision and preventing overtreatment areas from passing several times. Treatment efficacy was consistent across demographic groups, with 21% of patients being Fitzpatrick type IV or above and approximately half of patients requiring only a single treatment session owing to higher parameters, several passes, different skin-deep actions, and the use of two different handpieces. Similar to our findings, in a comparative split-face pilot study of 13 patients with Fitzpatrick skin types III and IV, Jung et al. reported greater patient satisfaction with the CO_2 laser for treating scars than did the Er:YAG laser [20].

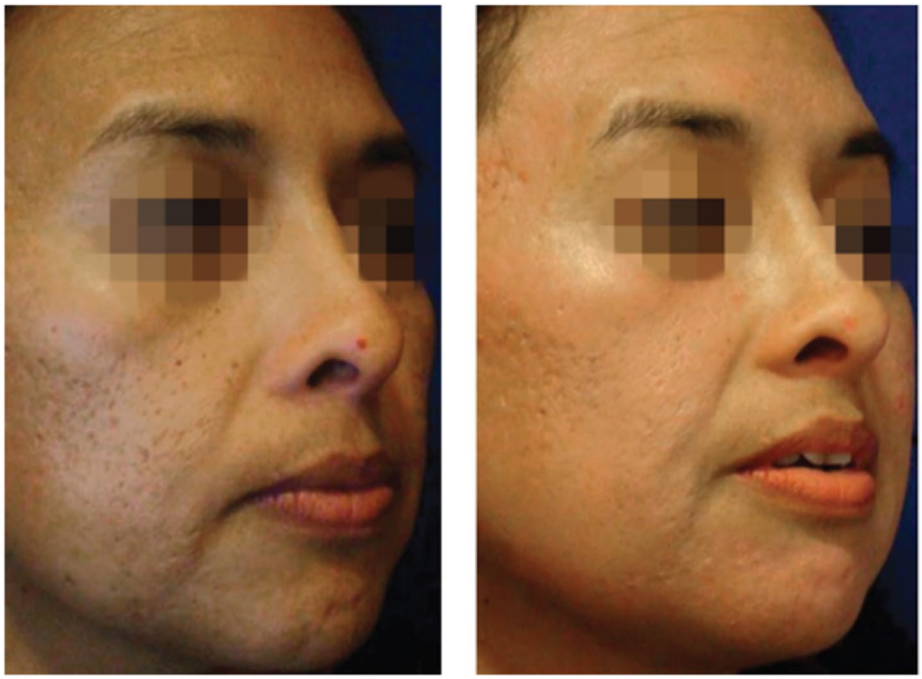

Fig. 6 **a-b** Digital photography of a patient with skin type V before (7a-left) and 6 months after (7b-right) fractional CO_2 laser treatment

Table 2 Statistics of Performance Outcomes

Statistic	*Reduction in GB*	*Patients Satisfaction*	*Physician evaluation (GAIS)*
Median	1	4	4
Mean	0.84	4.09	3.95
SD	0.43	0.75	0.62
Min	0	2	3
Max	2	5	5

Measuring and grading the severity of acne scarring is a well-known challenge that can complicate research and treatment. Several grading scales have been used in clinical trials, but no single scale is considered the gold standard. Current grading scales focus primarily on subjective assessments of the overall area and appearance. There are four broad approaches for assessing acne scarring: 1) scar subtype counting, 2) subjective self-assessment, 3) global acne scar severity scoring, and 4) multimodal imaging [21]. Early studies quantified scarring severity via a lesion count-based scoring system, where scars were defined clinically and counted by type (ice pick, boxcar, rolling), with hypertrophic scars quantified separately. However, this method is time-consuming and subjective, varies with lighting and visual acuity, and does not account for scar concentration, size, or color, making it impractical for clinical practice. Self-assessment with patient perspective questionnaires aligns with quality of life but has high variability and is less reliable than physician-rated scales. Using specialized equipment and computer algorithms to analyze lesions can provide an objective measure. Nevertheless, this technology is unavailable at our clinic and may be inaccessible to most physicians. The Global acne severity scoring system is a simplified system that allows for objective discussion and understanding of the efficacy of various interventions or therapies. The qualitative scar grading system proposed by Goodman and Baron is simple and universally applicable. Despite some challenges in differentiating severe cases, it facilitates easy grading and enhances communication of disease severity among practitioners [21].

In our study, the mean Goodman and Baron Acne Qualitative Grading Scale score was 3.6 ± 0.8 at baseline, which decreased to 2.8 ± 0.7 after the treatment. Similarly, Sharma et al. reported a mean score of 3.8 ± 0.40 at baseline, which decreased to 2.76 ± 0.49 after treatment, indicating a statistically significant difference [22]. Bhat et al. also reported a statistically significant improvement, with mean baseline scores decreasing from 3.43 ± 0.49 to 1.83 ± 0.86 [23]. However, in this study four sessions of fractional CO_2 laser treatment were conducted, in contrast with our series which 86% of the patients had only one or two sessions, due to higher parameters, several passes, depths of action, hteuse of two types of handpieces and pre-and post-melanocytic inhibitor formulas.

Following the use of a fractional CO_2 laser in this study, over 81% of patients with acne scars presented a reduction in the GB score after treatment compared with baseline, and the difference was statistically significant. Both the

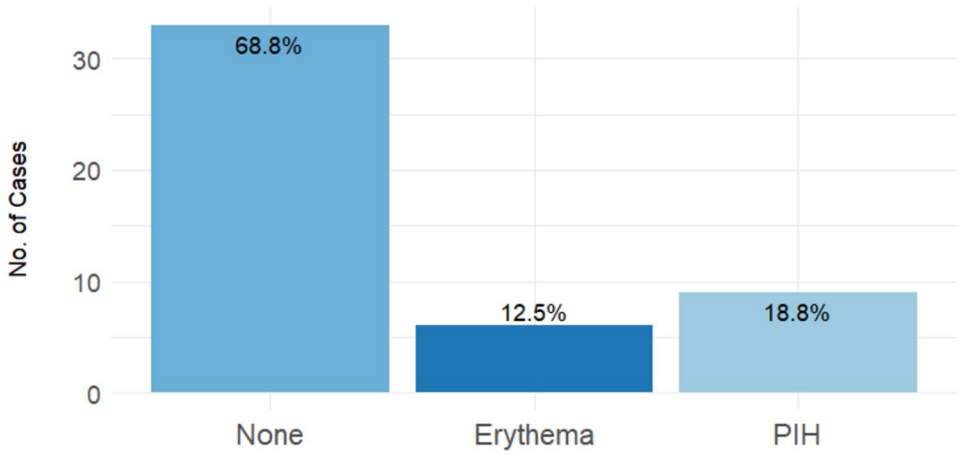

Fig. 7 Number and frequency of adverse events

physician and the patients reported a substantial improvement in scarring. In addition, the low incidence of adverse events, which resolved within up to 3 weeks in patients with erythema and three to six months in patients with PIH, further demonstrates the high safety profile of the procedure. Nonpermanent AEs have appeared.

Limitations

The study design had several limitations, including retrospective data collection, variability in follow-up periods, and noncontrolled analyses. Prospective randomized or controlled studies with larger patient cohorts and consistent follow-up periods are warranted.

Conclusions

This study demonstrated the high satisfaction level, safety, and efficacy of a fractional CO_2 laser with relatively high parameters and several passes, different skin depths of action, associated with two different handpieces for treating acne scars over Argentinien skin types with only one or two sessions, including those with relatively high Fitzpatrick skin types, and the importance of using pre and posttreatment melanogenesis inhibitors to prevent and treat PIH.

Author contributions Non co author´s contribution.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Patient consent The patients enrolled in this study were all adults. All of them provided their consent, declaring permission for the use of their photos and data in scientific publications.

Ethics All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this kind of retrospective study no ethical approval is required.

Competing interests The author declares no competing interests.

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