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CASE REPORTS AND SHORT REPORT

Combined use of fractional CO_2 laser and radiofrequency waves to treat acne scars: A pilot study on 15 patients

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Abstract

Fractional laser resurfacing has become an important technique in the management of a number of skin conditions, such as photoaging and scars. A variety of laser wavelengths and delivery systems have been introduced to improve immediate and long-term therapeutic results. The simultaneous emission of CO_2 laser and radiofrequency waves combines epidermal coagulation for a resurfacing effect and dermal denaturization for deeper remodelling. The authors present this new machine together with a preclinical histological study and pilot study on 15 patients suffering from acne scars.

Key Words: *CO_2 laser, radiofrequency, acne scars, skin resurfacing*

Introduction

Laser CO_2, first introduced in 1964 by Patel, uses a heat beam to destroy the skin surface, inducing renewal and remodelling of all layers. Clinical applications vary from benign skin tumours, to scars and signs of aging. In recent years, the latest laser prototypes of lasers have been designed to decrease thermal damage and increase the stimulating action on the collagen and elastic fibres in the dermis. In particular, fractional lasers have enhanced cosmetic results and reduced recovery times (1). The stratum corneum is left largely intact as thousands of microscopic wounds are created, completely surrounded by viable tissue.

At the same time, new devices have been developed using radiofrequency (RF) to stimulate skin tone and elasticity. RF does in fact achieve deeper thermal stimulus at least in the reticular dermis layer without any cutaneous burns (2,3), stimulating the production of new collagen and elastin.

The aim of this study is to evaluate the application of a new device, in which fractional laser is combined with radiofrequency to treat acne and traumatic scars.

Materials and methods

Description of the device

A new fractional CO_2 laser (SmartXide[2], DEKA M.E.L.A., Calenzano, Italy) combines a scanning system to produce thermal effects in microareas with the emission of a bipolar radiofrequency (Figure 1). The system generates perfectly-controlled energy pulses (DOTs) by managing the "energy per pulse" parameter, the "DOT spacing" between two microscopic wounds, and the pulse duration (known as "dwell time"). This technology also offers different pulse shapes (such as the S-pulse, D-pulse and H-pulse), which play an important role in ensuring both superficial ablation of the epidermis and the release of heat deeper down in the dermis.

The "SmartStack Mode" is an additional parameter which repeats the laser pulse in the same DOT for a maximum of five times before moving on to the next one, so as to increase the thermal effect. Finally bipolar radiofrequency (managing "power" and "time" parameters) can be added simultaneously to the fractional CO_2 laser emission to achieve greater

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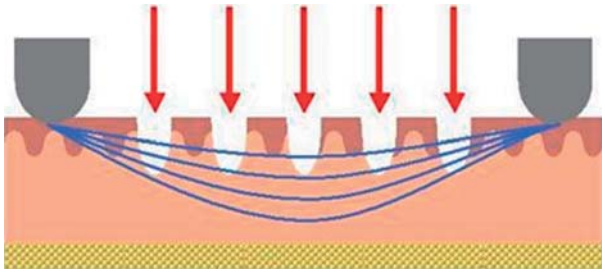

Figure 1. CO_2 and RF bipolar current synergy.

therapeutic efficacy thanks to the synergy of the two methods (Figure 1).

Preclinical study/histological analysis

To evaluate the effects of fractional laser in combination with bipolar radiofrequency, an animal model was developed. A large shaved area of skin in the groin of a sheep and a medial thigh region were chosen due to being quite hairless with a thin epidermal layer similar to human facial skin. The area was treated with the SmartXide[2] laser at different settings as reported in Table I.

Punch biopsies of 2 mm were taken at time 0 (control), immediately after the laser session and at the 7-day follow-up. All the specimens underwent standard histological preparation: fixation in 4% neutral buffered formaldehyde, dehydration on crescent alcohol solutions, inclusion in paraffin and 3 μm-thick cuts on slides. The slides then underwent routine staining (H&E) for histological evaluation and immunohistochemistry for the antibodies indicated below in Table II.

Tissue sections for all the above-mentioned antibodies were previously subjected to epitope retrieval by heating in boiling water for 11 minutes in a microwave oven while placed in citrate buffer, pH 6.5. The sections were subsequently treated with 3% hydrogen peroxide to block endogenous peroxydase activity. After overnight incubation in a moist chamber at 4°C with the primary antibodies, the antibody labelling was revealed with ABC-peroxydase (Vector Laboratories, USA). The enzymatic reaction was developed with 3-3′-diaminobenzidine (DAB, Sigma Chemical, Germany) as chromogen substrate, by using Mayer's haematoxylin as nuclear counter-staining. For the negative controls, the primary antibodies were replaced with TBS or non-immune sera.

Table I. SmartXide[2] laser settings for the preclinical study.

Energy per pulse (mJ)	Dwell time (ms)	Pulse shape	DOT spacing (μm)	Bipolar RF
From 20 to 45	1	SP	500	–
From 20 to 45	1	DP	500	–
From 20 to 45	1	SP	500	50 W–3 s
From 20 to 45	1	DP	500	50 W–3 s

Table II. Our antibody panel.

Ab	Company	Cat. #	Dilution
IL-1β	R&D Systems Inc. (USA)	mAb MAB201	1:100
TGF-β1	R&D Systems Inc. (USA)	mAb MAB240	1:20
Coll I	AbD Serotec (USA)	pAb 2150-0020	1:10
Coll III	AbD Serotec (USA)	pAb 2150-0100	1:10
Factor VIII	Biocare Medical, Llc. (USA)	pAb CP 039 C	1:500
Ki-67	Biocare Medical, Llc. (USA)	pAb CM 080 C	1:50

An analysis of the data demonstrates that the two pulse shapes, S-pulse and D-pulse, make it possible to achieve different spatial heat distribution patterns, ablation area shapes, lateral heat damage distribution (or Thermal Damage Zone: TDZ) and tissue shrinkage profiles (Figure 2). In detail, the S-pulse mode acts more selectively on the papillary dermis with a more circular ablation shape, inducing a homogeneous coagulation of the surrounding tissues.

The D-pulse mode acts more incisively on the reticular dermis, inducing greater shrinkage of the ablation columns and more circumscribed coagulation.

Histological studies of the D-pulse ablation show a depression of the portion of epidermis not involved in the hardening phenomenon caused by the wave of immediate heat. This can be ascribed to the deeper action exerted by this mode, which by also involving the reticular dermis, induces greater shrinkage in a vertical direction as well.

Combined use of laser emission and radiofrequency current induces additional significant tissue shrinkage, which becomes even more evident after 5 days. A complete and physiological re-epithelization has been reported in all settings, achieved with both CO_2 laser (DOT) alone and CO_2 laser + RF

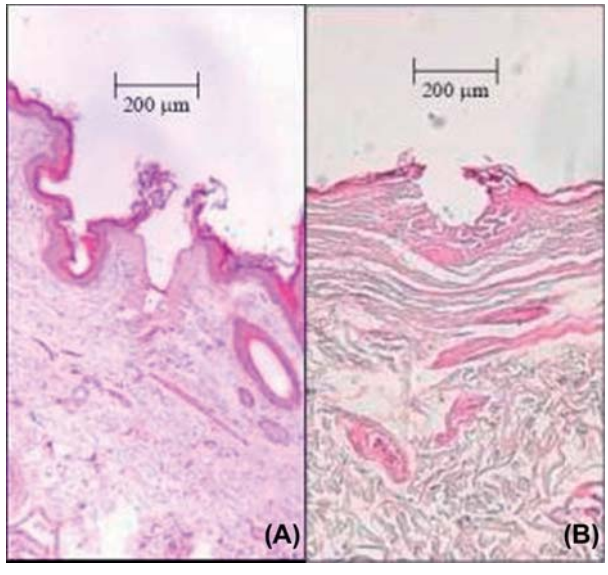

Figure 2. (A) H&E D-pulse and (B) S-pulse.

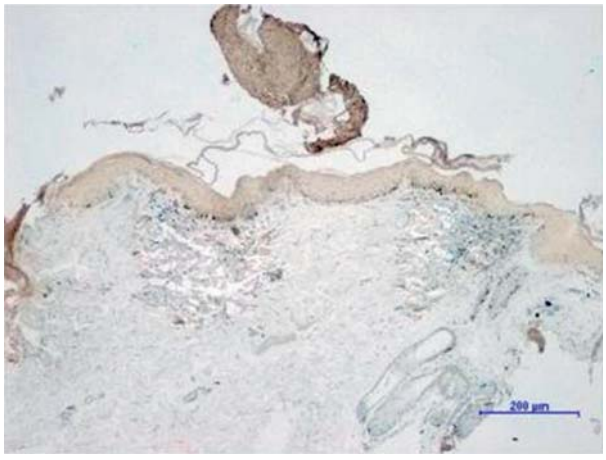

Figure 3. Factor VIII, fractional CO_2 only.

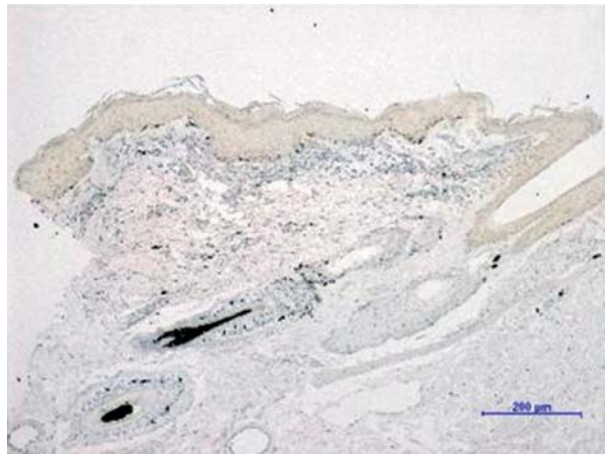

Figure 4. Factor VIII, fractional CO_2 and RF.

(Figures 3 and 4). Samples from CO_2 laser + RF showed widespread biostimulation of the tissue (Figure 4).

Clinical study

The protocol included 15 patients (14 females and 1 male) whose main reason for undergoing the trial was to improve acne scars in 12 cases and traumatic scars in three cases (Table III). All lesions were located on the cheeks. Patients enrolled in the study were treated from November 2010 to January 2011 at the Plastic Surgery Department of University BioMedico Campus of Rome. The patients were aged between 21 and 76 years and 26% were smokers, almost 66.6% had previously been treated with laser therapy and 86.6% had received previous chemical therapy. A total of 26.6% were Fitzpatrick skin type II, 40% were skin type 3 and 33.3% were skin type 4. Exclusion criteria included the presence of active infections or herpes, or active acne in the treatment area.

Treatment and evaluation protocol

Before the procedure, patients were informed in detail about the treatment and possible side effects and complications and each signed an informed consent form. In 12 cases, local anaesthesia with 2% Carbocaine was applied. Patients underwent two treatment sessions 4 weeks apart, with a dwell time of 1 ms, a DOT spacing of 500 μm, SmartStack 2/3 and an energy per DOT of almost 45 mJ. Radiofrequency outputs were 20–30 Watts and duration 2–3 seconds. D-pulse was preferred for a deeper action and S-pulse for the treatment of traumatic scars. A zinc oxide cream was recommended on the first few days after treatment and patients were advised to avoid direct sun exposure for 3 weeks after treatment. All were evaluated and photographed before starting treatment and at the 3-month, 6-month and 12-month follow-ups after the final treatment. Photographs were taken from the front, both sides and three-quarters side on. The objective examination, performed at the 3-month and 12-month follow-ups, was carried out by comparing the results with the

Table III. Patients' characteristics.

Pt ID	Sex	Age	Pathology	Phototype	Smoker	Previous chemical treatments	Previous LASER treatments	Others treatments
L.C.	F	40	Acne	III	No	++	+	No
S.S.	F	26	Acne	II	No	+++	++	No
B.S.	F	37	Acne	II	Yes	++	+	+
R.A.	F	54	Acne	III	Yes	+++	+++	++
C.H.	M	29	Post-traumatic scar	IV	Yes	++	No	No
M.M.S.	F	33	Acne	IV	Yes	+++	+++	+++
D.L.A.	F	44	Acne	II	No	+	No	No
R.F.	F	32	Post-traumatic scar	II	No	+++	++	++
S.L.	F	52	Acne	IV	No	++	+	No
T.L.	F	66	Acne	III	No	++	++	No
B.M.	F	21	Acne	III	No	+++	No	No
M.M.	F	35	Post-traumatic scar	IV	No	No	No	No
G.S.	F	55	Acne	II	No	+	+	+
C.M.	F	56	Acne	III	Yes	+	+	+
R.V.	F	50	Acne	III	Yes	+	+	+

Table IV. Global aesthetic improvement scale (GAIS).

Rating	Description
Very much improved	Excellent cosmetic result
Much improved	Marked improvement in appearance compared to the initial condition but not completely satisfactory
Improved	Obvious improvement in appearance compared to the initial condition, but a touch-up is needed
No change	The appearance is essentially the same as the original condition
Worse	The appearance is worse than the original condition

score of the GAIS (global aesthetic improvement scale) used as a reference parameter (Table IV).

Statistical analysis

A descriptive analysis was carried out using median values and the 95% confidence interval (CI). The differences in the GAIS scores at the different time-points were statistically compared using the Wilcoxon test. We used a $p = 0.05$ as the critical level for statistical significance.

Case 1. A 50-year-old woman came to our department for the treatment of acne scars. The patient, who had no history of recent infections, keloid scar formation or known allergies to Carbocaine, received two sessions 4 weeks apart. The 12-month follow-up revealed a significant clinical improvement in the acne scars and skin texture (Figure 5).

Case 2. A 29-year-old man came to our department for the treatment of acne scars. The patient, who had no history of recent infections, keloid scar formation or known allergies to Carbocaine, received two sessions 4 weeks apart. For several years he had undergone chemical treatment without satisfactory results (Figure 6).

Case 3. A 32-year-old woman came to our department to treat an injury scar on her face. The patient, who had no history of recent infections, keloid scar formation or known allergies to Carbocaine, received two sessions 4 weeks apart. She had previously undergone some laser treatment and chemical peeling (Figure 7).

Table V. The GAIS scores.

Patients	Sex	Gais T 3 months	Gais T 6 months
15	14 F/1 M	3 pt = 1 8 pt = 2 4 pt = 3	2 pt = 1 9 pt = 2 4 pt = 3

Results

All patients completed the study. The treatment caused only minimum discomfort, without any post-treatment pain. The moderate erythema and edema, recorded more frequently in patients with dark phototypes at the end of the session, cleared up within a few hours. No cases of bacterial, viral, fungal or yeast infections were reported. Patients were able to return to their everyday activities immediately after the treatment.

No post-inflammatory hyperpigmentation was been observed.

The GAIS evaluation was 20% "Very Much Improved", 53.3% "Much Improved" and 26.6% "Improved" at the three-month follow-up, and 13.3 "Very Much Improved", 60% "Much Improved" and 26.6% "Improved" at the 12-month follow-up, without a statistically significant difference in the GAIS scores ($p = 0.093$) (Table V).

Discussion

Acne vulgaris is one of the most common skin diseases and mainly affects adolescents and young adults. Ninety-five per cent of these patients may develop disfiguring facial scars (4). Acne scars arise from the disorganized production and deposition of collagen around inflamed follicles resulting in visibly depressed scars (5,6).

The conventional treatment of acne scars includes a variety of topical and oral medications, such as glycolic acid or isotretinoin, but also more invasive approaches, such as dermabrasion, carbon dioxide (CO_2) or erbium-doped yttrium aluminium garnet (Er:YAG) laser resurfacing (7,8).

Traditional resurfacing is unfortunately associated with potential side effects, such as dyspigmentation, scarring and infection, and fractional laser is only capable of producing minor improvements.

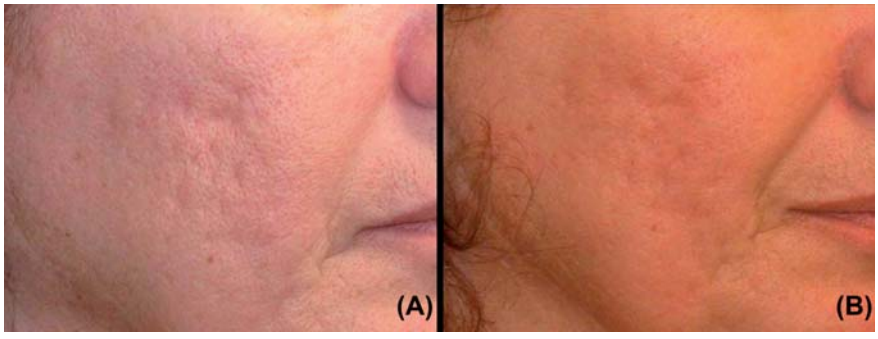

Figure 5. (A) Before and (B) after 12-month follow-up.

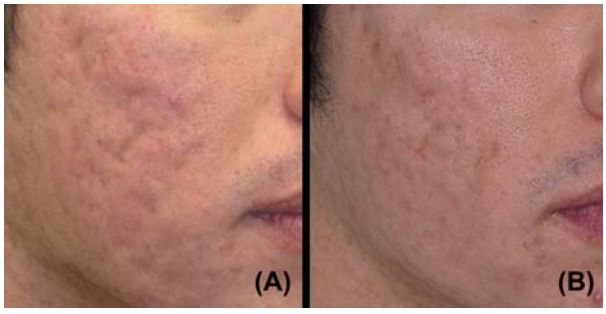

Figure 6. (A) Before and (B) after 6-month follow-up.

Literature shows that in the 66.8% of cases, fractional CO_2 laser improved acne scarring with minimal adverse effects (9); however, a major stimulus is required to create new layers of collagen and remodel the dermal matrix components (10).

This new device in which the fractional CO_2 technology is combined with a RF source provides a synergy of pulses without increasing the side effects.

Thanks to this technology and the range of available modes, different biological effects can be expected on the tissue, such as stimulation of the dermis to produce new collagen, which naturally regenerates the tissue structure and improves skin tightening and softness.

The histological preclinical analysis demonstrates that the two pulse shapes, S-pulse and D-pulse, allow for achieving different spatial heat distribution patterns, ablation area shapes, lateral heat damage distribution and tissue shrinkage profiles.

In detail, by acting more selectively on the papillary dermis with a circular ablation shape, the S-pulse mode induces a homogeneous coagulation of the surrounding tissues, suggesting the validity of its clinical application in the treatment of atrophic scars.

The D-pulse mode, by acting more incisively on the reticular dermis, induces greater shrinkage of the ablation columns and more circumscribed coagulation, thus enhancing skin texture and elasticity.

Moreover, the combination of the pulse shapes with bipolar radiofrequency enhances the effects of CO_2 laser treatment by remodelling the tissues in-depth, toning flabbiness and stimulating fibroblast activity to produce new collagen.

The results of our pilot study confirmed the reduction of surface hyperthermia due to the transfer of energy from the surface strata to the deeper strata, a more than 40% faster post-op recovery time (11) due to enhanced tissue turnover rate, and considerable improvements in skin texture even after only one treatment.

Patient satisfaction and compliance were positive with a significantly high satisfaction rate after only 5 days and the aesthetic improvement evaluation was long lasting.

Conclusions

SmartXide^2 is an interesting new fractional CO_2 laser device that adds bipolar radiofrequency to enhance therapeutic efficacy. Our study demonstrates the safe and effective use of this device with a significant improvement in atrophic acne scars, as well as skin texture. The high degree of efficacy after only one treatment and the absence of any significant adverse side effects make this device a novel and safe tool for use by plastic surgeons. This minimally invasive technology guarantees long-lasting improvement not only in scar treatment but also for facial rejuvenation.

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Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Tierney EP, Kouba DJ, Hanke CW. Review of fractional photothermolysis: Treatment indications and efficacy. Dermatol Surg. 2009;35:1445–1461.

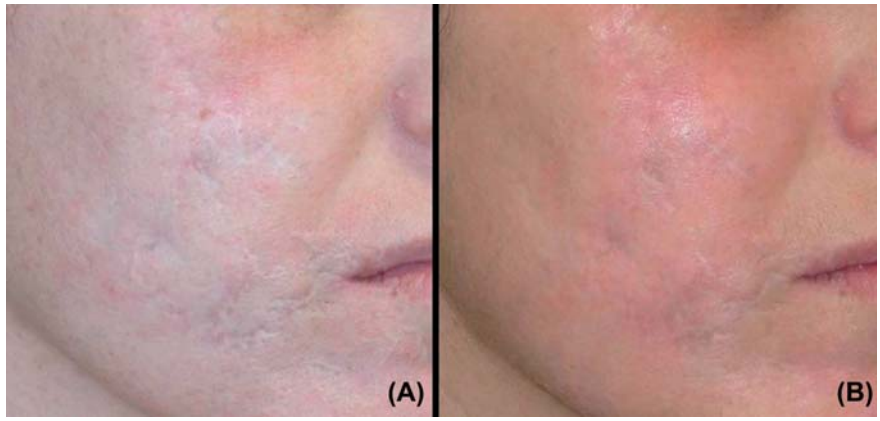

Figure 7. (A) Before and (B) after 3-month follow-up.

2. Sadick NS, Makino Y. Selective electro-thermolysis in aesthetic medicine: A review. Lasers Surg Med. 2004;34:91–97.
3. Hruza G, Taub AF, Collier SL, Mulholland SR. Skin rejuvenation and wrinkle reduction using a fractional radiofrequency system. J Drugs Dermatol. 2009;8:259–265.
4. Gollnick H. Current concepts of the pathogenesis of acne: Implications for drug treatment. Drugs. 2003;63: 1579–1596.
5. Rivera AE. Acne scarring: A review and current treatment modalities. J Am Acad Dermatol. 2008;59:659–676.
6. Khunger N, IADVL Task Force. Standard guidelines of care for acne surgery. Indian J Dermatol Venereol Leprol. 2008;74(Suppl):S28–S36.
7. Jacob CI, Dover JS, Kaminer MS. Acne scarring: A classification system and review of treatment options. J Am Acad Dermatol. 2001;45:109–117.
8. Goodman G. Post acne scarring: A review. J Cosmet Laser Ther. 2003;5:77–95.
9. Chapas AM, Brightman L, Sukal S, Hale E, Daniel D, Bernstein LJ, Geronemus RG. Successful treatment of acneiform scarring with CO_2 ablative fractional resurfacing. Lasers Surg Med. 2008;40:381–386.
10. Manstein D, Herron GS, Sink RK, Tanner H, Anderson RR. et al. Fractional photothermolysis: A new concept for cutaneous remodeling using microscopic patterns of thermal injury. Lasers Surg Med. 2004;34:426.
11. Scientific Report of SmartXide^2 of Feb 2011 at Campus Biomedico Rome – PhotoBioLab Research Unit of El.En. Group. S.p.A.