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ORIGINAL RESEARCH REPORT

Novel post-treatment care after ablative and fractional CO_2 laser resurfacing

J. KEVIN DUPLECHAIN[1], MARK G. RUBIN[2] & KATHERIN KIM[2]

[1]*Department of Otolaryngology and Facial Plastic Surgery, Tulane University Medical Center, New Orleans, LA, USA and* [2]*Lasky Skin Center, Beverly Hills, CA, USA*

Abstract

Objective: This study evaluates a topical oxygen emulsion (TOE) to reduce adverse effects after skin rejuvenation with a fully ablative CO_2 laser alone and in combination with a fractional ablative CO_2 laser. *Materials and methods:* Patients ($n = 100$) seeking skin rejuvenation underwent CO_2 laser resurfacing. Group A patients ($n = 34$) received a single deep fractional laser treatment followed by application of Aquaphor™ immediately after treatment for 24 h and TOE every 6 h for the next 6 days. Group B patients ($n = 66$) underwent both deep fractional and fully ablative laser resurfacing followed by application of TOE every 6 h for 7 consecutive days. *Results:* Patients in both groups showed clinical improvement and a 7.1% overall incidence of adverse effects which included milia (5.1% overall) and hyperpigmentation (3.1% overall). For milia, Group A and Group B individual adverse effect rates were 11.8% and 1.5%, respectively; for hyperpigmentation, individual rates were 0.0% and 3.1%, respectively. *Conclusion:* The elimination of petrolatum products in the post-skin care regimen has significantly reduced the incidence of post-procedure complications when compared with the use of TOE, resulting in the lowest incidence of complications in fully ablative or fractional resurfacing published thus far.

Key Words: *adverse effects, epidermal ablation, oxygen emulsion, postoperative wound care, skin rejuvenation*

Introduction

Ablative resurfacing with a pulsed, 10 600-nm CO_2 laser is the gold standard procedure for rejuvenating skin (1,2). Adverse effects, which include prolonged erythema, pruritis, hypo- and hyperpigmentation, milia, acne flares, infections, contact dermatitis, pain during treatment, and scarring (3,4) have limited use of this modality. The less ablative 2940 nm Er:YAG laser was developed to reduce these adverse effects. Although wounds healed more rapidly, dermal collagen remodeling (5) and efficacy per pass (6) were less than that of the CO_2 laser (5,6). Non-ablative lasers further reduced adverse effects but efficacy was unpredictable and less than that of ablative lasers (7,8).

Fractional lasers offered a novel approach to both improve efficacy and reduce adverse effects. The laser beam, rather than vaporizing superficial tissue like a fully ablative laser beam, creates an array of tiny wounds at specific depths within the epidermis and dermis with little damage to surrounding tissue. This "microablation," first with a non-ablative 1500-nm erbium laser introduced by Manstein et al. (5), resulted in rapid healing, neocollagenesis, and tissue contraction (5,9). Subsequent studies, however, showed that multiple treatments spaced 3–4 weeks apart are necessary to achieve outcomes similar to those of a single treatment with an ablative laser (10,11).

The ablative fractional CO_2 laser soon followed with promising clinical, histological, and molecular effects (12–14). Compared with fully ablative lasers, infections after resurfacing with an ablative fractional laser are less frequent, re-epithelialization is more rapid, fewer acneiform eruptions are observed, and durations for post-treatment skin care and postoperative erythema are shorter (1). Ablative fractional CO_2 lasers, however, are not without adverse effects which include hypertrophic scarring of the neck (15),

Correspondence: Jesse Kevin Duplechain, MD, Department of Otolaryngology and Facial Plastic Surgery, Tulane University Medical Center, 1103 Kaliste Saloom Road, Suite 300, Lafayette, New Orleans, LA 70508, USA. E-mail: jkdmd@drduplechain.com; www.drduplechain.com

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acneiform eruptions (2,15), herpes simplex outbreak (2,11), contact dermatitis (2,11), yeast infection (2), hyperpigmentation (2), and prolonged erythema (2,11). Adverse effects (herpes simplex virus outbreaks, acneiform eruptions, erosions, hyperpigmentation, prolonged erythema and edema, dermatitis, purpuri, and impetigo) with the 1500-nm erbium laser have also been reported (16).

The authors of the present study believe that more physicians would resurface skin with an ablative CO_2 laser if post-treatment adverse effects, though manageable, were reduced. A promising approach may be a topical oxygen emulsion (TOE), which was used in animal models and shown to (1) improve recovery from partial thickness wounds and second-degree burns, (2) upregulate Type I and Type III collagen expression, and (3) increase levels of vascular endothelial growth factor (VEGF), which stimulates angiogenesis (17).

The present report describes a preliminary evaluation of TOE (Cutagenix™, Cutagenesis, LLC, Lafayette, LA) to reduce adverse effects after skin rejuvenation with a fully ablative CO_2 laser alone and in combination with a fractional ablative CO_2 laser.

Materials and methods

In this prospective study, consecutive female patients ($n = 100$, aged 27–69 years, Fitzpatrick skin types I–IV) underwent facial CO_2 laser resurfacing to improve dyschromia, rhytids, sun damage, laxity, and related skin conditions. Procedures were performed from March 2008 through September 2008 by the same group of physicians in two locations. All patients provided signed informed consent to treatment. Procedures included deep fractional (450–500 microns) laser resurfacing or deep fractional followed by superficial (80–120 microns) fully ablative resurfacing.

Patients were placed into two groups and underwent facial CO_2 laser resurfacing according to the protocol shown in Table I. Patients were treated as outpatients and placed under topical, local, and/or general anesthesia. Group A patients (M.G.R., K.K.) underwent deep fractional full face resurfacing with an eCO_2 Laser (Lutronic USA, Princeton Junction, NJ) to a skin depth of 0.500 mm. Treatment parameters were 30 mj and 40% density. Laser treatment was followed by application of Aquaphor™ (Beiersrdorf, Inc., Wilton, CT) immediately after treatment and every 6 h for 24 h and TOE every 6 h for the next 6 days. Patients received prophylactic antiviral therapy and a broad-spectrum antibiotic for 5 days before laser treatment. Group B patients (J.K.D.) were treated with an Ultrapulse CO_2 Laser (Lumenis Inc., Santa Clara, CA) capable of both deep fractional and superficial ablative treatments. Patients first received deep fractional treatment of the entire face (including lower eyelids and excluding upper eyelids) at 15 mj, 15% density, 0.120 mm spot size, and 250 Hz frequency, to a skin depth of 0.450 mm. Patients then underwent fully ablative treatment at 100 mj, 100% density, 1.3 mm spot size, and 250 Hz frequency, to a skin depth of 0.080 mm. Both laser treatments were given during a single session. The combined treatment was followed by application of TOE every 6 h for 7 consecutive days. Patients received prophylactic herpes simplex virus therapy on the day of the procedure and twice daily for the next 5 days. Group B patients received no prophylactic antibiotics.

The author's (J.K.D.) experience has shown that the more aggressive combination of laser treatments increases wrinkle reduction and improvement in tone and texture with little increase in recovery time compared with either deep fractional or fully ablative superficial modalities alone. The authors theorized that treating at two different depths (0.450 and 0.080 mm) would augment collagen synthesis and promote reorganization of both the papillary and reticular dermis. The more superficial fully ablative treatment would also provide immediate improvement in tone and texture.

All patients in both groups were evaluated for adverse events (pustules, impetigo, milia, acneiform eruptions, infection (herpes, bacterial, yeast), hyper-, and hypopigmentation (prolonged erythema, contact dermatitis, scarring) on days 7, 28, and 90. Patients were instructed to avoid skin care products (unless prescribed) for 1 week after laser resurfacing. Photographs were obtained 1 week, 1 month, and 3 months after the final procedure.

Table I. Protocol for evaluation of aftercare treatment.

Treatment group	CO_2 Laser		Aftercare		Evaluation for AEs*		
	Fractional ablative	Fully ablative	Aquaphor	TOE	Day 7	Day 28	Day 90
A ($n = 34$)	X (deep)	—	x	x	x	x	x
B ($n = 66$)	x (deep)	X	—	x	x	x	x

TOE, topical oxygen emulsion; AE, adverse event.
*Pustules, impetigo, milia, infections (herpes, bacterial, yeast), hyperpigmentation, prolonged erythema, acneiform eruptions, contact dermatitis, scarring, hypopigmentation, and other skin irritations.

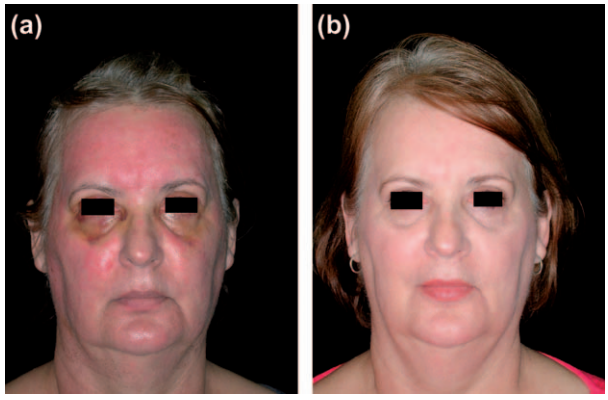

Figure 1. (a) A 59-year-old woman (Group B, deep fractional followed by fully ablative CO_2 laser treatment) with severe acneiform eruptions after using petrolatum for 6 days after laser treatments. On Day 8, the patient was started on TOE without additional therapy. (b) The same patient after using petrolatum for 6 days, having no post-treatment therapy for the next 2 days, and using TOE for the next 6 days. Acneiform eruptions were completely resolved on Day 14.

Results

Ninety-nine patients (99.0%) completed the study. One Group B patient (1.5% of Group B patients and 1.0% of both Group A and Group B) withdrew due to perceived dryness of her treated skin. She discontinued the use of TOE on Day 2 after the procedure and switched to Aquaphor (self-prescribed). After 6 days a severe acneiform eruption developed (Figure 1a). On Day 8 the patient was restarted on TOE without additional therapy. The eruption resolved 6 days later (Figure 1b).

The remaining patients (Groups A and B) completed the study and healed with a 7.1% overall incidence of adverse effects which included milia ($n = 5$, 5.1% overall) and hyperpigmentation ($n = 2$, 2.0% overall). Adverse effects of both treatment groups are shown in Table II. A small focus of milia developed in four Group A patients (11.8%) and in one Group B patient (1.5%) 14–21 days after laser treatment. Milia were removed successfully by unroofing. Hyperpigmentation was observed after treatment in two Group B patients (3.1%) and was resolved within 6 weeks by a combination of retinoid and hydroquinone. Scarring, delayed healing, infection (herpes, bacterial, yeast), prolonged erythema, contact dermatitis, and hypopigmentation were not observed in any patient. Clinical examples are presented in Figures 2–6.

Discussion

Our results indicate that excellent clinical outcomes and acceptable adverse effects can be achieved by including TOE as post-procedure aftercare following CO_2 laser treatment—fully ablative, fractional ablative, or both in combination. Nanni and Alster

Table II. Number and percentage of adverse events in each group.

	No. of adverse events (%)		
Adverse event	Group A ($n = 34$)	Group B ($n = 65$)	Group A + Group B ($n = 99$)
Pustules, impetigo, milia	4 (11.8)	1 (1.5)	5 (5.1)
Acneiform eruption	0 (0)	0 (0)	0 (0)
Infection			
HSV	0 (0)	0 (0)	0 (0)
Bacterial	0 (0)	0 (0)	0 (0)
Yeast	0 (0)	0 (0)	0 (0)
Hyperpigmentation	0 (0)	2 (3.1)	2 (2.0)
Prolonged erythema	0 (0)	0 (0)	0 (0)
Contact dermatitis	0 (0)	0 (0)	0 (0)
Scarring	0 (0)	0 (0)	0 (0)
Hypopigmentation	0 (0)	0 (0)	0 (0)
Total	4 (11.8)	3 (4.6)	7 (7.1)

HSV, herpes simplex virus.

(4) reported adverse effects (Table III) in 500 patients treated with a fully ablative CO_2 laser technique. Percentages of patients with adverse effects ranged from 0% to 100%. Shamsaldeen et al. (2), using a fractionated ablative CO_2 laser procedure, reported adverse event rates ranging from 0% to 5.5% and totaling 13.9%, nearly twice the overall percentage (7.1%) in the present study. Infection was reported in both earlier studies (Table III) and was not observed in any Group A or Group B patient of the present study.

Since most of the skin's oxygen requirements for the outer 400 microns of dermis and epidermis are derived from atmospheric oxygen rather than circulation (18), improving the availability of oxygen to the skin may provide benefits over emollients that may inhibit gaseous exchange. To increase oxygen availability to wounds, several modalities have been

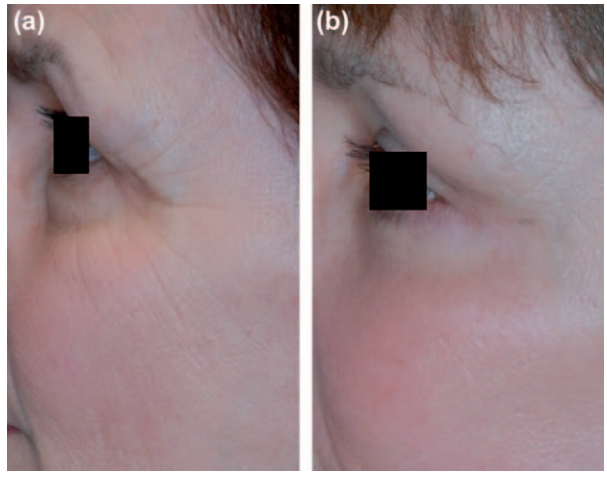

Figure 2. A 54-year-old woman (Group B) before (a) and 3 months after (b) browlift and blepharoplasty followed by deep fractional and fully ablative laser resurfacing and 7 days of post-procedure aftercare using TOE.

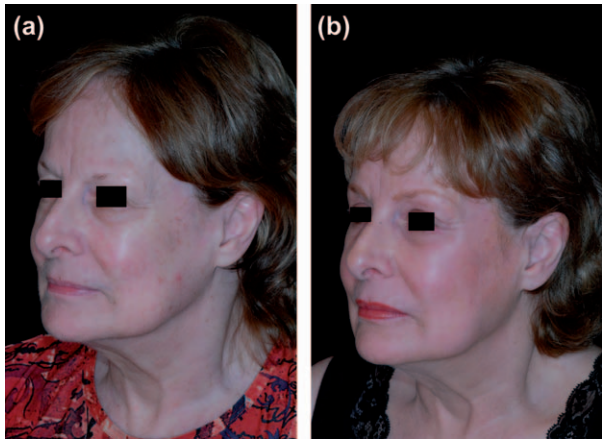

Figure 3. (a) A 67-year-old woman (Group B, deep fractional followed by fully ablative CO_2 laser treatment) before and (b) 3 months after browlift, blepharoplasty, fat transfer, laser treatments, and the use of TOE as post-procedure aftercare for 30 days. Rhytids in (a) are significantly improved in (b).

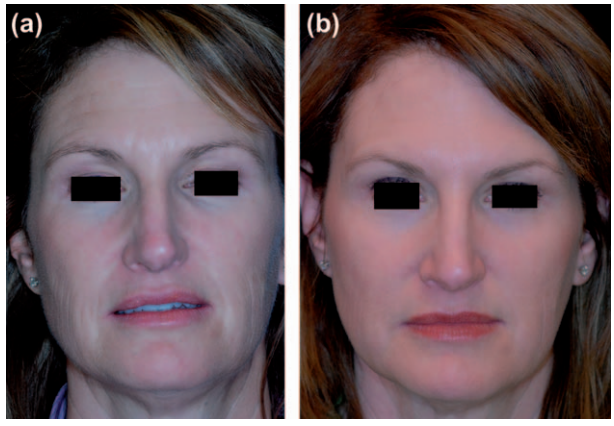

Figure 5. A 47-year-old woman (Group B, deep fractional followed by fully ablative CO_2 laser treatment) before (a) and (b) 3 months after laser treatments and the use of TOE for 30 days as post-procedure aftercare.

developed. Hyperbaric oxygen therapy is costly, it depends on the lungs and systemic delivery of oxygen to the wound, and is not always available. Peroxide formulations, though useful in removing debris, irritate raw tissue and actually delay wound healing. Gaseous oxygen applied topically to wounds has little skin penetration and limited availability to tissues due to formation of microbubbles that may be lost by effervescence (17).

Davis et al. (17), in a randomized study that included vehicle and untreated control, showed that a TOE enhanced the rate of epithelialization of wounds created on the backs of disease-free porcine models. Oxygen was dissolved in a perfluorocarbon emulsion and stored under pressure in a dispensing container capable of slowly releasing oxygen over time when topically dispensed. The wounds were of two types: second-degree burns and partial thickness wounds. Davis et al. (17) also demonstrated upregulation of Type I and Type III collagen expression and increased levels of VEGF, which stimulates angiogenesis. These findings encouraged the authors to evaluate the use of TOE to reduce adverse effects typically observed after fully ablative CO_2 laser resurfacing of skin.

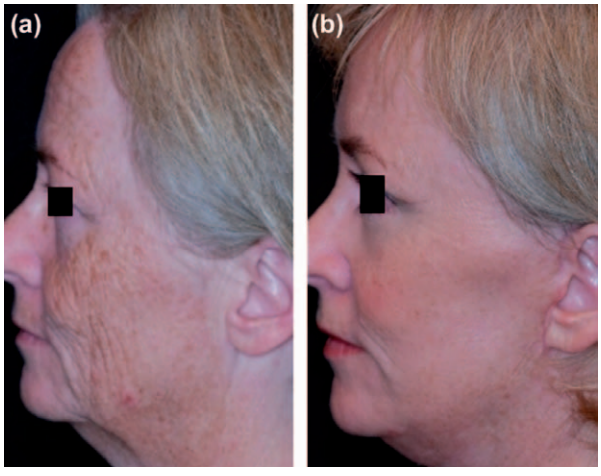

Figure 4. A 54-year-old woman (Group B) before (a) and 3 months after (b) deep fractional and aggressive fully ablative CO_2 laser treatment followed by 7 days use of TOE as part of post-procedure aftercare. The post-treatment photograph shows significant improvement in tone, texture, and sun damage.

Both fractionated and fully ablative CO_2 resurfacing are safe procedures when post-procedure adverse events are minimized. Two recent reports (15,19) describing adverse events after ablative fractional resurfacing (AFR) of the neck and face demonstrate the importance of intra-operative and post-procedure care, even with the fractional modality. Although standardized treatment protocols offer guidelines for AFR, adverse events may still occur, even when the procedures are performed by qualified and experienced physicians.

Ours is the first prospective study in which infection was not observed when antibiotics were not used before or after treatment (Group B). The use of antibiotics in AFR, however, is still controversial. In a retrospective study of 133 patients, Walia and Alster (20) could not link the use of antibiotics to a decreased risk of infection after full-face CO_2 laser resurfacing. In contrast, Ross et al. (21) reported focal *Staphylococcus aureus* infection in 2 of 4 patients who underwent laser skin resurfacing without oral or topical antibiotic prophylaxis and culture negativity 2 days after laser skin resurfacing in patients who had received narrow-spectrum oral antibiotic prophylaxis. In the present study infection was not observed in either treatment group. Since Group A patients received antibiotics for 5 days and Group B received no antibiotics, it is unlikely that prophylactic antibiotics in Group A eliminated the risk of infection or contributed to the low incidence of milia. However, the use of Aquaphor during the first 24 h after the procedure may have contributed to the incidence of milia. As shown in Table II, milia

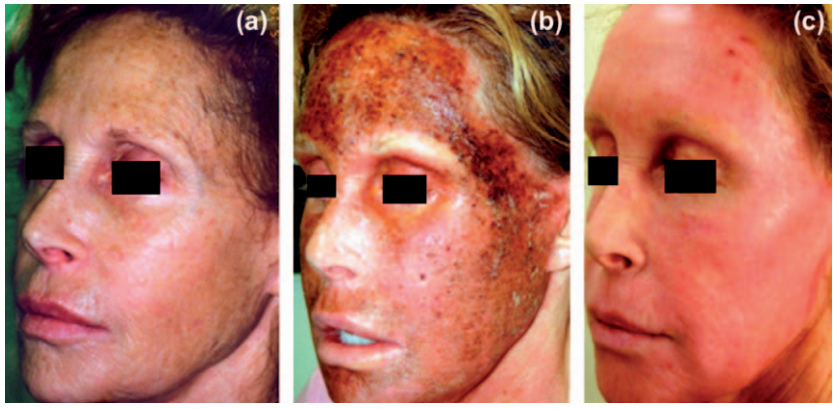

Figure 6. A 49-year-old woman (Group A) before deep fractional CO_2 laser treatment (a), 3 days after laser treatment, and (c) 7 days after laser treatment. The patient used petrolatum immediately after treatment and for 24 h followed by TOE for the next 6 days as post-procedure aftercare.

were observed in 5 of 99 patients (5.1%) and were the most common adverse event in either treatment group. In considering Group B patients, the incidence of post-procedure complications is lower than previously published studies whether treatment was fully ablative, fractional, or combined fractional and fully ablative. This has led the authors to abandon the use of petrolatum products in the management of lasered skin.

Differences in pre- and post-treatment care may account, at least in part, for the relatively low incidence of adverse effects in the present study compared with two earlier studies. In the study of Nanni and Alster (4), patients received both HSV and antibiotic prophylaxis before and after laser treatment. Postoperative care included the frequent use of topical ointment (Catrix-10, Donnell Inc., New York, NY), petrolatum (Vaseline or Aquaphor), ice water soaks, and compresses followed by daily cleansing. Shamsaldeen et al. (2) instructed patients to avoid sun exposure before and 4 days after treatment. Post-treatment care included cool compresses and thermal spring water used frequently during the day, twice daily washing with gentle cleanser, and re-application of healing ointment such as Aquaphor for 4 days. On the evening of Day 3, patients were instructed to apply 0.025% fluocinolone acetonide ointment (Nycomed US, Inc., Melville, NY). Pre-operative care in the present study consisted of antibiotic and antiviral prophylaxis for 5 days (Group A) and antiviral therapy on the day of the procedure (Group B). Postoperative care included Aquaphor (Group A), TOE (Groups A and B), and antiviral therapy for 5 days (Group B) as described earlier. Group B patients received no antibiotics before or after the procedure.

Table III. Comparison of number and percentage of adverse events after CO_2 laser resurfacing.

	No. of adverse events (%)		
Adverse event	TOE ($n = 99$, Aftercare)	Shamsaldeen et al. (2) ($n = 490$, Deep fractional ablative)	Nanni and Alster (4) ($n = 500$, Fully ablative)
Milia	5 (5.1)	0 (0)	(11.0)
Acneiform eruption	0 (0)	26 (5.3)	(15.0)
Infection	0 (0)	27 (5.5)	(8.4)
HSV	0 (0)	11 (2.2)	(7.4)
Bacterial	0 (0)	11 (2.2)	(0.0)
Yeast	0 (0)	6 (1.2)	(< 1.0)
Hyperpigmentation	2 (2.0)	6 (1.2)	(37.0)
Prolonged erythema	0 (0)	4 (0.8)	(100.0)
Contact dermatitis	0 (0)	4 (0.8)	(11.0)
Scarring	0 (0)	0 (0)	(0.0)
Hypopigmentation	0 (0)	0 (0)	(1.0)
Erythema	—	—	(100.0)
Acne exacerbation	—	—	(15.0)
Total	7 (7.1)	68 (13.9)	—

TOE, topical oxygen emulsion; HSV, herpes simplex virus.

Skin rejuvenation procedures are widely accepted and sought after in today's esthetic practice. Various laser wavelengths and procedures provide excellent results when post-procedure adverse events are minimized. Although this study is ongoing, our results suggest that TOE may play a role in successful post-procedure aftercare. In our study, patients recovered and healed without antibiotic (Group B) or steroid therapy. The low (7.1%) incidence of adverse events included only milia and hyperpigmentation. To the authors' knowledge this is the first report of healing without infection after fully ablative laser resurfacing without antibiotic prophylaxis before or after treatment.

The encouraging results justify additional studies with more patients with varying degrees of photodamage and other conditions treatable by ablative CO_2 laser resurfacing. The results also suggest that physicians acquaint themselves with the novel post-treatment option described in the present report, and then revisit the use of fully ablative CO_2 resurfacing techniques as a technique to provide the best possible clinical outcomes for their resurfacing

patients. The use of aquaphor should be avoided if minimal complications are to be expected.

Conclusion

Skin rejuvenation with either fractional CO_2 or fractional CO_2 followed by fully ablative CO_2 resurfacing and post-treatment care with TOE optimizes clinical outcomes and reduces adverse events compared with other studies with fully ablative CO_2 lasers and conventional post-treatment care. The current findings have led the authors to adopt the practice of utilizing the TOE in all fractional and fully ablative resurfacing procedures without the use of antibiotics, steroids, or other emollient ointments.

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

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