Single-pass CO₂ laser skin resurfacing of light and dark skin: extended experience with 52 patients

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**Introduction**

The goal of cutaneous resurfacing is to render the skin as smooth as possible. While there are many different treatments available to achieve this goal, the carbon dioxide (CO₂) laser remains the gold standard of laser skin resurfacing.¹⁻³ With a wavelength of 10,600 nm, the CO₂ laser is well suited for cutaneous resurfacing because of the strong absorption of its infrared wavelength by water-containing tissue in the skin. Such tissue comprises 70% of total skin volume.

The success of CO₂ laser skin resurfacing was historically limited by the emission of light in a continuous wave mode that produced zones of thermal destruction ranging from 200 μm to 2 mm beyond the target tissue, resulting in unintended scarring and fibrosis. With the application of the modern theory of selective photothermolysis, as first
described by Anderson and Parrish in 1983,4 controlled destruction of target tissues could be achieved while limiting unwanted thermal damage to the surrounding skin. This is accomplished in part by limiting the pulse duration to a time shorter than the thermal relaxation time of the target. Consequently, when short pulsed (<1 ms) CO2 lasers were introduced in the mid-1990s, vaporization of very thin layers of skin (20–30 μm per pass) was made possible.5,6

Cutaneous resurfacing with the CO2 laser has since been shown to be highly effective in the treatment of photodamaged and acne-scarred skin, as well as for removal of a variety of epidermal and dermal lesions.7–15 Despite its high clinical satisfaction rate, CO2 laser resurfacing has been associated with multiple side effects and complications, ranging from prolonged erythema to fibrosis and scarring.16,17 One of the most common postoperative sequelae is transient cutaneous dyspigmentation. Over one-third of all patients who undergo CO2 laser resurfacing develop moderate hyperpigmentation lasting several months, with a near universal occurrence in patients with darker skin photo types (Fitzpatrick type III or greater).18 Hypopigmentation is a far less frequent side effect and tends to be permanent. Patients must be clearly motivated to tolerate the extended recuperation from CO2 laser resurfacing, which includes 7–10 days of intense erythema, edema, crusting, and discomfort. Viral, bacterial, and fungal infections can be seen during the first postoperative week before full re-epithelialization has been effected. Prompt, aggressive intervention with an emphasis on prevention is mandatory.

The depth of ablation and residual thermal necrosis seen in the dermis correlates directly with the number of laser passes performed.5,6,18,19 With increasing depth and degree of thermal damage, the risk of pigmentary alteration rises.20–23 It stands to reason that limiting the ablation depth and extent of residual thermal necrosis would lower the incidence of postoperative side effects and complications.

The purpose of this study was to evaluate the clinical efficacy and associated complication rates of single-pass CO2 laser resurfacing in a large series of patients with light and dark skin and to compare the results with those previously reported in the literature for traditional multi-pass CO2 laser treatment.

**Materials and methods**

A total of 52 consecutive patients (47 females, 5 males; aged 15–67 years, mean 52 years) with mild to moderate rhytides, infraorbital hyperpigmentation, or atrophic scars were included for study evaluation. Skin phototypes I–VI were represented (Table 1).

Cutaneous anesthesia was obtained with appropriate facial nerve blocks using 1% lidocaine with 1:200,000 units epinephrine. For full-face procedures, intravenous anesthesia was administered by a certified nurse anesthetist using a combination of propofol, Versed®, fentanyl, and ketamine.

<table>
<thead>
<tr>
<th>Skin type</th>
<th>No. of patients</th>
<th>Facial rhytides</th>
<th>Infraorbital hyperpigmentation</th>
<th>Atrophic scars</th>
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<td>I</td>
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Table 1

Patient characteristics.

The entire treatment area received adjacent non-overlapping 8 mm laser scans with a high-energy, pulsed CO2 laser (UltraPulse; Coherent Laser, Inc., Palo Alto, CA, USA) at 300 mJ of energy, 60 watts of power, and a CPG density of 5 by a single operator (TSA). Treatment edges and 'skip' areas were finished with single 3 mm spots (300 mJ of energy, 5 watts of power). Partially desiccated tissue was left intact to serve as a biologic wound dressing (rather than being removed with saline or water-soaked gauze). Concomitant chemical peeling of the adjacent neck skin was performed in all patients undergoing full-face laser treatment using 25% trichloracetic acid (TCA) to achieve a light frost (2 minute acid application followed by cool water rinse).

Immediately following treatment, healing ointment (Aquaphor; Beiersdorf, Inc., Norwalk, CT, USA) was applied to the irradiated skin. Each patient was instructed to perform gentle facial rinses with cool water several times daily, followed by liberal ointment application. Ice packs and round-the-clock acetaminophen were prescribed during the first 24–48 hours postoperatively to reduce swelling and discomfort. Full-face laser patients received a prednisone taper for 5 days. All patients were prescribed twice daily oral prophylactic antiviral treatment (valacyclovir 500 mg) beginning on the day of surgery and continuing for 10 days. No other antibiotic prophylaxis was used. Patients were followed closely in the first postoperative week, during which time any residual coagulated debris was removed with dilute acetic acid compresses. Side effects and complications of treatment were monitored and treated as appropriate. All patients were able to apply camouflage makeup by 7–10 days postoperatively.

Clinical response to treatment was documented by sequential digital photographs using identical camera settings, lighting, and patient positioning. Assessments of treated areas compared with baseline pretreatment photographs were performed by two masked medical evaluators preoperatively and at 1, 3, 6, and 12 months postoperatively using a quartile rating scale (0 = <25% improvement, 1 = 25–50% improvement, 2 = 51–75% improvement, 3 = >75% improvement).

**Results**

Significant improvement in skin tone, texture, and appearance of skin was noted in all patients. Average
clinical improvement scores peaked at 12 months regardless of skin type (Figure 1).

Greater clinical improvement was seen in patients with darker skin tones (phototypes III–VI) (Figure 2). Postoperative erythema was rated as mild and lasted an average of 3.5 weeks (range 2–5 weeks). Hyperpigmentation was the most common side effect (average incidence of 46%, mean duration of 12.7 weeks), with 100% incidence in patients with skin phototypes III or darker, and was the reason for lower early clinical improvement scores in these patients (Table 2).

Bacterial infections were observed in five patients (9%) within 3–5 days of the procedure. Four patients cultured positive for *Staphylococcus aureus* and one patient had superficial *Enterococcus*. All infections cleared on a 7-day course of appropriate oral antibiotics without sequelae. No herpetic or other infections were seen.

**Discussion**

By utilizing a single-pass CO\textsubscript{2} laser technique without post-treatment removal of desiccated epidermal debris, a biological (tissue) wound dressing is created. Ross et al previously reported speedier re-epithelialization in a pig model when partially desiccated tissue was left intact.\textsuperscript{21} The results of our study support this observation, with patients demonstrating complete re-epithelialization within 5–7 days postoperatively (compared to 7–10 days following multi-pass CO\textsubscript{2} laser resurfacing procedures). In addition, the severity and duration of postoperative erythema seen in our patients was less than that typically observed after multi-pass CO\textsubscript{2} and erbium:YAG laser procedures - a finding also reported by others.\textsuperscript{18,22,23} In our study, erythema was more pronounced in patients with paler skin tones and lasted for a longer period of time, presumably due to the fact that it was easier to observe, rather than because of any differences in the extent of thermal damage.

Postoperative pigmentary changes remain a dreaded side effect of laser resurfacing, particularly in patients with darker complexions. As a consequence, individuals with dark skin phototypes have often not been considered to be suitable candidates for laser skin resurfacing procedures.\textsuperscript{24–27} Analysis of our treatment series indicates that single-pass CO\textsubscript{2} laser resurfacing may offer a possible solution to this problem. While the incidence of

<table>
<thead>
<tr>
<th>Skin type</th>
<th>Total no. of patients (n)</th>
<th>Hyperpigmentation (n)</th>
<th>Onset (weeks)</th>
<th>Duration (weeks)</th>
<th>Infection (n)</th>
<th>Onset (postoperative day)</th>
<th>Organisms cultured</th>
<th>Duration (days)</th>
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Table 2

Incidence of side effects and complications.
hyperpigmentation remained high in our patients with dark skin tones, its intensity and duration were less than that reported after multi-pass CO₂ laser procedures (3–6 months). In contrast to the findings reported by Ross and colleagues,¹⁸ where increased hyperpigmentation was observed in periorbital regions (compared with perioral areas), no differences in the rate of hyperpigmentation were seen in different facial areas in this study.

Conclusions

Single-pass CO₂ laser skin resurfacing can improve the appearance of fine rhytides, mild atrophic scars, and infraorbital hyperpigmentation in all skin types. The severity and duration of side effects and complications are reduced with this procedure compared with those previously reported for multi-pass CO₂ laser procedures.

References