Dual-Depth Fractional Carbon Dioxide Laser Resurfacing for Periocular Rhytidosis

Brett S. Kotlus, MD, MS*

BACKGROUND  Laxity and rhytidosis of eyelid skin as a result of photoaging is a frequent cosmetic concern. Fine lines and deep wrinkles may not be optimally addressed with traditional ablative carbon dioxide (CO₂) resurfacing. Modern devices allow for surface fractional ablation and deep fractional ablation with narrow treatment columns that target deep dermal layers.

OBJECTIVES  To examine the efficacy and safety of a combination of deep fractional CO₂ ablation and superficial fractional ablation of eyelid and periorbital skin for improvement of rhytidosis and redundancy.

MATERIALS AND METHODS  Fifteen patients underwent dual-depth fractional CO₂ resurfacing of eyelid and periorbital skin. Blinded, independent investigators evaluated rhytidosis and skin redundancy as evident in pretreatment and 6-month post-treatment digital images.

RESULTS  Excellent post-treatment improvements were noted for eyelid skin rhytidosis and redundancy, which improved 53.1% and 42.0%, respectively. No serious complications were noted, and the recovery profile was favorable.

CONCLUSION  Dual-depth fractional CO₂ resurfacing of eyelid and periorbital skin, including areas within the boundaries of the orbital rim, is safe and effective for the treatment of eyelid photoaging.

Brett S. Kotlus, MD, MS, has indicated no significant interest with commercial supporters.

Eyelid skin resurfacing has been a mainstay in periocular rejuvenation as a primary procedure and as an adjunct to surgical blepharoplasty and browplasty. Resurfacing techniques have included mechanical dermabrasion, chemical peels, and more recently, erbium-doped yttrium aluminum garnet (Er:YAG) and carbon dioxide (CO₂) laser resurfacing. Significant periocular risks have been reported with each modality, including cicatricial ectropion and hypopigmentation. The ideal restorative procedure is predictable, safe, and effective, with minimal downtime.

Fractional laser delivery systems have been used for facial skin resurfacing with excellent results. These devices feature a better recovery and side-effect profile than nonfractional devices. Treatment depth can be varied along with treatment spot diameter, thus targeting specific skin layers where conditions are known to exist. This has been shown to be efficacious in the treatment of facial acneiform scars and photoaging, which can extend to deeper skin layers than reached with superficial ablation zones. The treatment of deep rhytides similarly requires deep laser penetration to stimulate remodeling at the appropriate dermal level.

Water absorbs the CO₂ laser energy (10,600 nm), which is capable of rapid tissue vaporization with surrounding coagulation due to thermal conduction. It has been demonstrated that nonsequential, superficial fractional CO₂ ablation induces neocollagenesis in the papillary dermis, which has been postulated to result in improved skin tightness and appearance, but the depth of superficial CO₂ ablation is generally bound to the limits of the papillary dermis, which may not reach the depth of deeper wrinkles. There are several fractional CO₂...
devices available that allow for deep ablation. Adjustable density settings allow for customized percentages of ablated versus intervening nonablated skin. One histologic investigation of a deep fractional CO₂ device has shown ablation depths up to 1,100 μm with subsequent dermal remodeling.

Tissue ablation at superficial and deep layers can potentially address shallower elastotic damage and deeper, configurational rhytides in the same treatment session.

A prospective evaluation of a fractional CO₂ laser device (Encore UltraPulse, Lumenis Inc., Santa Clara, CA) with dual-depth parameters for improvement of eyelid and periorbital rhytidosis was performed.

Materials and Methods

Fifteen consecutive patients who presented with concerns regarding periorbital wrinkles were enrolled in the study. This prospective study was performed according to the guidelines of the 1975 Helsinki Declaration. Skin phototypes were I to III, and mean patient age was 52.7 ± 9.3. Exclusions included botulinum toxin administration within 4 months, facial cosmetic procedures within 6 months, oral isotretinoin use, and pregnancy. Standard pretreatment and 6-month post-treatment digital photographs were obtained with the patient in repose.

All patients received periprocedural oral valacyclovir and cephalixin. Tetracaine ophthalmic solution was instilled in both lower fornices, and stainless steel, nonreflective ocular shields coated with ophthalmic lubricant ointment were placed before treatment. The facial skin was washed with a mild cleanser and carefully degreased with disposable pads saturated with 70% isopropyl alcohol. Infraorbital, supraorbital, zygomaticofacial, zygomatico-temporal, lacrimal, and trochlear nerve blocks were performed with lidocaine 1% with epinephrine. Intraprocedural cooled air was administered for patient comfort as needed. The first laser treatment pass was performed with a spot size of 0.12 mm (DeepFX handpiece) with no overlap. Within the boundary of the bony orbit (eyelid skin), a pulse energy of 5 to 7.5 mJ was delivered on the upper eyelid and 7.5 to 10 mJ on the lower eyelid with a density of 2 to 3 (10–15%). The laser operator manually stretched the eyelid skin using a cotton-tipped applicator with gentle traction adjacent to the eyelid margin or using the plastic spacer of the laser handpiece (DeepFX only) during energy delivery. Eyelid skin stretching avoided “skip areas” due to folding of the skin and allowed for a perpendicular laser–skin interaction. Pretarsal and preseptal eyelid skin was most easily placed on stretch while maintaining the lid position within the border bony orbit. At times, the patient was instructed to gaze upward or downward, and skin was braced against the corneal protector to assist in these maneuvers. Treatment to eyelid cilia was avoided so as not to induce madarosis. A wooden tongue depressor or cotton-tipped applicator was used to reposition cilia and create a mechanical barrier to unwanted treatment areas. The treatment boundary of the upper eyelid was within 1 mm of the brow cilia to within 1 mm of the eyelash line and the lower eyelid was treated within 2 mm of the eyelash line. On non-eyelid skin, a pulse energy of 15 mJ with a density of 3 to 4 (15–20%) was delivered. Pinpoint bleeding was wiped with saline-soaked gauze before proceeding. The second treatment pass was performed with a spot size of 1.25 mm (ActiveFX protocol) with a pulse energy of 80 to 90 mJ and a density of 3 (82%) with a randomized pattern to achieve longer thermal relaxation times. Devitalized skin was not debrided after laser treatment, and Aquaphor ointment (Beiersdorf, Wilton, CT) was applied.

Two oculofacial surgeons performed qualitative independent assessment of eyelid skin wrinkles and redundancy in a blinded manner on a 5-point scale (0–4) for pre- and postprocedural photographs. The rating scale for rhytidosis and redundancy was 0 = absent, 1 = minimal, 2 = mild, 3 = moderate, 4 = severe (Table 1).
Results

At 6 months, statistically significant improvements in eyelid rhytidosis \((p<0.01)\) and redundancy \((p<0.01)\) were noted according to qualitative physician assessment (Table 2, Figure 1). The mean improvement in rhytidosis was \(1.67 \pm 0.62\) scale points, and the mean improvement in redundancy was \(1.27 \pm 0.46\) scale points. The mean percentage improvement in rhytidosis was 53.1% and for skin redundancy was 42.0%.

Re-epithelialization occurred within 4 to 7 days (mean 5.2), and detectable erythema was present for 13 to 40 days (mean 21). Two patients experienced postinflammatory hyperpigmentation (PIH) that resolved in 3 months with topical hydroquinone 4% and sunscreen. There were no occurrences of hypopigmentation, infection, scarring, ectropion, or lagophthalmos.

Discussion

Deep fractional CO2 laser resurfacing with fractional surface ablation of eyelid and periorbital skin is

<table>
<thead>
<tr>
<th>Rating</th>
<th>Eyelid skin rhytidosis</th>
<th>Eyelid skin redundancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (absent)</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>1 (minimal)</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>2 (mild)</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>3 (moderate)</td>
<td>![Image]</td>
<td>![Image]</td>
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<tr>
<td>4 (severe)</td>
<td>![Image]</td>
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</tbody>
</table>

TABLE 1. Eyelid Skin Rhytidosis and Redundancy Rating Scale

<table>
<thead>
<tr>
<th>Pretreatment Grade</th>
<th>n (%)</th>
<th>Mean ± Standard Deviation Post-Treatment Improvement According to Investigator Rating (%)</th>
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<tbody>
<tr>
<td>Rhytidosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 (20)</td>
<td>50 ± 0</td>
</tr>
<tr>
<td>3</td>
<td>7 (47)</td>
<td>57 ± 16</td>
</tr>
<tr>
<td>4</td>
<td>5 (33)</td>
<td>50 ± 18</td>
</tr>
<tr>
<td>Redundancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 (20)</td>
<td>50 ± 0</td>
</tr>
<tr>
<td>3</td>
<td>8 (53)</td>
<td>41 ± 15</td>
</tr>
<tr>
<td>4</td>
<td>4 (27)</td>
<td>38 ± 14</td>
</tr>
</tbody>
</table>

TABLE 2. Post-Treatment Improvement According to Independent Investigator Rating Using the Eyelid Skin Rhytidosis and Redundancy Scale (0-4)
safe and effective for improvement of rhytidosis and skin laxity. Treatment of skin within the boundary of the bony orbit is safe with the parameters used in this series. No serious complications were noted, and the rate of patient satisfaction was high.

Successful eyelid skin rejuvenation has been described separately with laser devices that target superficial\textsuperscript{12} and deep\textsuperscript{13} skin layers. It is logical that a procedure that simultaneously addresses both zones can offer significant aesthetic improvement, particularly in patients with manifest photoaging in multiple skin levels.

This series demonstrates that fractional ablation can be safely performed on eyelid skin within the boundaries of the bony orbit with appropriate treatment parameters. The deep fractional handpiece used in this study can potentially deliver energy to a depth of 2,000 \( \mu \text{m} \), whereas the upper eyelid skin thickness, for example, is approximately 800 \( \mu \text{m} \).\textsuperscript{14} The total eyelid thickness is greater than 2,000 \( \mu \text{m} \),\textsuperscript{15} so complete eyelid penetration is not achieved with maximum energy settings with the laser used in this series. Pretarsal and preseptal eyelid skin treatments require more conservative parameters than other facial skin areas because of the differences in thickness. Orbital skin thickness is equivalent to other non-eyelid facial skin. A single pass of superficial ablation mode as performed in this study at 90 J of energy with a treatment density of 3 (82\%) creates a thermal injury to a depth of 90 \( \mu \text{m} \),\textsuperscript{16} whereas deep ablation with the parameters used on pretarsal and preseptal skin limits the ablative column depth to less than 500 \( \mu \text{m} \). These settings were selected based on eyelid skin thickness. Future work may allow for further parameter optimization.

The length of time to reepithelialization was not longer than in other patients treated with deep

\textbf{Figure 1.} Before (A) and 6 months (B) after dual-depth fractional carbon dioxide resurfacing.
fractional resurfacing or superficial fractional resurfacing alone. This can be attributed to the regeneration that originates in untreated skin located between treatment zones. With the dual-depth treatment parameters used in this study, it is likely that healing takes place in each of these zones simultaneously and independently.

The relatively low incidence of hyperpigmentation in patients with Fitzpatrick skin types I to III after fractional CO₂ resurfacing has been described. In contrast, hyperpigmentation can be common after traditional CO₂ resurfacing, with greater frequency in darker skin types and after multiple treatment passes. Successful management has been demonstrated with treatment regimens including hydroquinone 4% and sunscreen. Two of 15 patients in this study demonstrated PIH that subsided with a similar approach (Figure 2). The difference in incidence of PIH after dual-depth resurfacing versus single-depth fractional resurfacing has not been ascertained.

Dual-depth fractional CO₂ periorbital resurfacing appears to be safe and beneficial for the treatment of photoaging, rhytidosis, and laxity. Further studies with more varied treatment settings and larger patient numbers will help to further elucidate the utility of this technology for eyelid and facial rejuvenation.

References

Figure 2. Postinflammatory hyperpigmentation before (A) and after (B) resurfacing, demonstrating improvement with topical therapy.


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