A Prospective Study of the Improvement in Periorbital Wrinkles and Eyebrow Elevation With a Novel Fractional CO_2 Laser—The Fractional Eyelift

Dvora Ancona MD[a] and Bruce E. Katz MD[b]

[a]University of Pavia; Juva Medical Center, Milan, Italy
[b]Mount Sinai School of Medicine; Cosmetic Surgery & Laser Clinic; JUVA Skin & Laser Center, New York, NY

ABSTRACT

Background and Objective: The purpose of this study was to assess the efficacy and safety of a new fractional CO_2 laser system for improving periorbital rhytids, tightening skin and elevating the eyebrow.

Materials and Methods: One hundred subjects with periocular wrinkles, tissue laxity, photoaged skin and moderate dermatochalasis of the face were prospectively treated one to four times in the periorbital area with a fractional CO_2 laser device equipped with a scanning handpiece. Improvements in eyelid wrinkles, crow's feet and skin laxity were evaluated photographically by two blinded, independent observers. Eyebrow elevation was measured by the investigators. Subjects also scored satisfaction and tolerability.

Results: Approximately half of subjects achieved or maintained 26–50% improvement at 12 months. Nearly 40% of subjects maintained 1–2 mm elevation of the brow at six and 12 months after treatment. Subject satisfaction was high and the procedure was well tolerated. Mild-to-moderate erythema and edema persisted for up to three to four days.

Conclusion: Treatment with a fractional CO_2 laser device improves periorbital rhytids, tightens skin and elevates the eyebrow with minimal adverse effects.

INTRODUCTION

Traditional surgical treatments to improve facial wrinkles and skin laxity include face-lifting and blepharoplasty, alone or combined with chemical peels and dermabrasion.[1] Chemical peels and dermabrasion are effective, but their use around the eyes and mouth is limited[1] and the risks of scarring, pigmentation problems and unpredictability in the depth of tissue injury are considerable. Surgical techniques to tighten the lower eyelid may have complications such as overcorrection, undercorrection, exposed sutures, suture abscesses, or temporary point tenderness over the orbital rim where the suture is anchored.[2]

CO_2 laser devices, though highly effective, are associated with a three-to-12-month healing time and treatment-induced erythema that occurs in practically all patients.[3] In one study[4] in which periorbital wrinkles were treated with a CO_2 laser device, scar formation was apparent in 52% of subjects, resulting in mild scleral show or a slight thickening of the lower eyelid. Another disadvantage of the CO_2 laser device is that its operation requires considerable technical skill and experience.[1]

The periorbital area is difficult to treat because of its important function in vision and the delicate nature of its skin. The epidermis of eyelid skin, for example, is only 0.04 mm thick.[5] Periorbital laser resurfacing carries a risk that lower lid ectropion may develop that may require surgical correction.[5]

These considerations have led to the development of fractional photothermolysis (FP), in which delivery of laser energy to skin produces arrays of microscopic thermal wounds at specified depths without damaging the surrounding tissue. The first FP device was a 1550 nm erbium-doped laser system.[6] Unlike traditional laser devices that produce layers of thermal injury, FP devices produce columns of injury called microscopic treatment zones (MTZs). Since these MTZs are surrounded by normal tissue, keratinocyte migration distance is shorter, healing is faster, and the risk of adverse effects is reduced.[6,7]

The success of FP and the time-honored efficacy of the CO_2 laser device led manufacturers to develop fractional CO_2 laser devices[8–16] now considered state-of-the-art technology for micro-ablative skin rejuvenation.[15]The purpose of this study was to assess the efficacy and safety of two new fractional CO_2 laser systems for improving periorbital rhytids, tightening skin and elevating the eyebrow.

MATERIALS AND METHODS

One hundred subjects (91 women, 9 men; mean age 45 years) with periocular wrinkles, tissue laxity, photoaged skin and moderate dermatochalasis of the face enrolled in the prospective two-center study. Subjects with recent sun exposure and who had undergone chemical peeling, laser treatment, botulinum toxin injections or isotretinoin therapy during the previous six months were excluded. No subject had extropion or eye dryness. All subjects provided informed consent to treatment.

Subjects were treated in the periorbital area with a SmartXide DOT (DEKA, Calenzano, Italy) or Affirm (Cynosure, Westford, Mass) fractional CO_2 laser device. Both devices are similar and include a fractional CO_2 laser and scanning handpiece that produces multiple tiny wounds to the epidermis and dermis. Although manufactured by the same company (DEKA), there are minor differences which include: 1) the articulated arm on the Affirm is spring loaded whereas the arm on the SmartXide has a bar tension system; 2) the controls for changing pitch, dwell and other parameters are situated on the scanner handpiece in the SmartXide but are placed on the user interface in the Affirm; and 3) the settings to use the ablative mode in the Affirm are set at 200 µm pitch and in the SmartXide set at 0 µm pitch. The power (up to 30 W), pulse duration (200–2000 µsec.) and DOT pitch (200–2000 µm, the spacing between tiny wounds) are controlled by the user. Penetration depth, which ranges from superficial to deep dermal, depends on skin thickness and treatment parameters.[17]

Each treatment consisted of a single pass with no pulse stacking. Treated areas included the upper and lower eyelids, from the eyebrow to the eyelashes and lower orbital rim; and the lateral periorbital areas (crow's feet). Subjects wore corneal shields during treatment. Tetracaine ophthalmic anesthetic was applied to both eyes 30 minutes before treatment. An ophthalmic antibiotic ointment was applied to the inner concave surfaces of the corneal shield prior to treatment. Subjects received an average of two treatments (1–4) at three- to four-week intervals to allow time for eyelids to recover from each treatment. Subjects were instructed to apply an antibiotic ointment to the target areas for three to four days after each treatment. Settings at both centers were the following: power, 10 to 15 watts (W); pitch, 500–700 µm); and pulse duration, 500–900 microseconds. After the initial treatment with a low power setting, energies were increased at subsequent sessions as tolerated by the subjects. For example, the first treatment settings might be 10 watts, 500 microseconds pulse duration and 700 microns pitch. The second session would have energies increased to 11 watts, pulse duration increased to 600 microseconds, and pitch reduced to 600 microns. Initial settings were determined by thickness of eyelid skin and amount of downtime the subject was willing to tolerate. Photographs were taken before treatment and at one month (n=100), three months (n=100), six months (n=16), and 12 months (n=51) after the final treatment.

Improvements in eyelid wrinkles, crow's feet and skin laxity were evaluated by two blinded, independent observers who compared pre- and posttreatment digital photographs Observers graded improvement on a quartile scale (1=0–25%; 2=26% –50%; 3 51%–75%; 4=76–100%). Subjects rated satisfaction with results as poor, fair, good or excellent and graded pain during treatment on a scale of 0 (no pain) to 4 (very painful).

Eyebrow elevation was assessed by the investigators from standardized photographs obtained with a digital camera (Canon Powershot Pro1 with 8.0 megapixels imaging power or a Nikon Coolpix, Canfield, OH) before treatment and at each follow-up visit. To measure elevation, a horizontal line was drawn from the medial to the lateral canthus, and then a vertical line perpendicular to the horizontal line was drawn from the pupil to the midpoint of the eyebrow. The perpendicular distance (mm) from the center of the pupil to the eyebrow midpoint was considered the eyebrow elevation. Elevation was scored before and after treatment using the following scale: 1=0–1 mm; 2=1–2 mm; 3=2–3 mm; 4=3 or more mm.

RESULTS

Average improvement grades assigned by independent observers are shown in Table 1. Sixty percent of subjects showed 26–50% improvement at three months, and approximately half achieved or maintained 26–50% improvement at 12 months. Subject satisfaction was high (Table 2) and the procedure was well tolerated (Table 3). Brow elevation is shown in Figure 1. Approximately 45% of subjects achieved 1–2 mm elevation at three months and 22% had 2–3 mm elevation. Nearly 40% maintained 1–2 mm elevation at six and 12 months after the final treatment. Clinical examples are shown in Figures 2 and 3.

Downtime was one day. Figure 4 shows minimal redness and swelling in a subject 24 hours after treatment. Erythema and

TABLE 1.

Percentage of Subjects Showing Improvement in Eyelid Wrinkles, Crow's Feet and Skin Laxity

Score	Months		
	3	6	12
1	30.5	28	51
2	60	53	44
3	9.5	16	4
4	0	3	1

1=0–25%; 2=26–50%; 3=51–75%; 4=76–100%

TABLE 2.

Subject Satisfaction With Results

	Satisfaction Level*		
	Excellent	Good	Fair
Percentage of Subjects	10	85	5

*No subject rated satisfaction level as "poor."

TABLE 3.

Pain Score* During Treatment

	Score			
	0	1	2	3
Percentage of Subjects	15	45	35	5

*0=no pain; 4=very painful. No subject rated pain at 4.

edema persisted for up to three to four days. Two subjects experienced hyperpigmentation of the lateral periorbital areas one month after the first treatment; this was attributed to excessive sun exposure. No other adverse events were observed.

DISCUSSION

Facial wrinkles may arise from age and solar-related changes in dermal collagen or by tension in underlying mimetic muscles. Since only the latter can be corrected by botulinum toxin injections,[18] there is a need for a method to treat age-induced wrinkles. The present study shows that the SmartXide DOT and Affirm fractional CO_2 laser devices provide measurable improvement in periorbital wrinkles, skin laxity and eyebrow elevation. Subject satisfaction was overwhelmingly high and the procedure was well tolerated. The advantage of multiple treatments is that downtime and adverse effects, especially pain during and after treatment, are kept to a minimum. Subjects in the present study did not receive herpes prophylaxis because none had evidence of this condition.

Since the study was completed two herpes cases have emerged in the authors' practices. The authors now routinely treat patients with valacyclovir if they have a clinical history of herpes infection and are undergoing laser treatment of all facial areas. Attempts to treat periorbital wrinkles with radiofrequency (RF)[3,19,20] and other fractional resurfacing devices[13,16] have been reported.

In the six-month, 86-patient study of Fitzpatrick and colleagues,[3] the authors safely achieved skin contraction, reductions in periorbital wrinkles, and, in 61.5% (40/65) of eyebrows, at least a 0.5-mm lift after a single treatment with an RF device. Duration and rates of edema and erythema were less than with ablative procedures and three patients had evidence of scarring at six months.

Ruiz-Esparza and colleagues,[19] using a nonablative RF device, achieved improvement in lower eyelid laxity by treating extraorbital areas of nine patients. The authors postulated that the temporal and zygomatic skin after treatment would act as anchoring points to produce vectors of skin improvement that would eventually stretch the lax skin of the lower eyelids. Treating these areas outside the orbital rim and lateral to the lower eyelid would also reduce the risk of ectropion. The authors cautioned that the treatment would not correct muscle hypertrophy or fat herniation of the lower eyelid.

FIGURE 1. Brow elevation scores at three (n=100), six (n=16), and 12 (n=51) months after the final treatment. Scale: 1=0–1 mm; 2=1–2 mm; 3=2–3 mm; 4=3–4 mm.

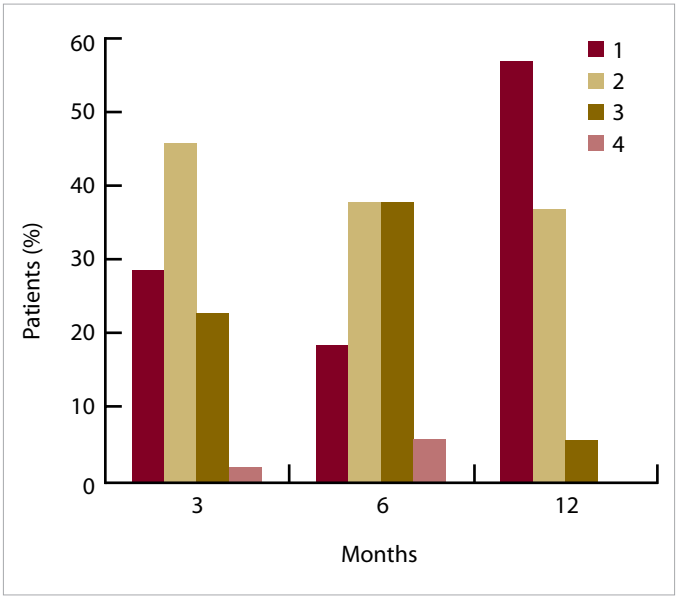
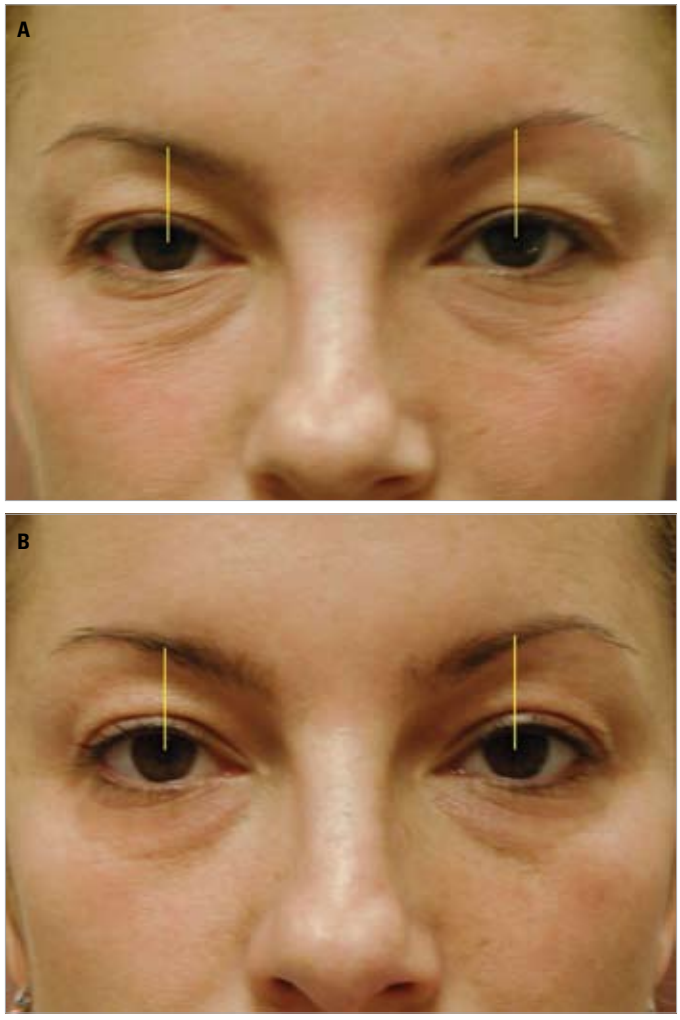


FIGURE 2. A 38-year-old woman before **a)** and three months after the final of two treatments **b)** with the Affirm (Cynosure, Westford, Mass) fractional CO2 laser device, showing 3 mm increased eyebrow elevation and skin tightening. Settings: 14 watts, 500 microseconds dwell time, 500 microns dot pitch. Photographs courtesy of Bruce E. Katz, MD.



Two years later Biesman and colleagues[20] reported the results of a single treatment of the eyelid itself with the same device, this time with a 0.2 cm^2 tip. The 0.25 cm^2 tip provides maximum heating at "shallow" depths approximately 1.2 mm beneath the skin surface, thus minimizing the risk of injury to vital structures in the eyelid or to the eye itself.[20] In their 72-patient study, the authors achieved lower eyelid tightening in 71–74% of patients, upper eyelid tightening in 88%, and hooding reduction in 86%. Upper eyelid tightening was greater than lower eyelid tightening. However, treatment outcomes were variable and unpredictable for unknown reasons.

An ablative fractional CO_2 laser device has also been used to treat facial rhytids, including crow's feet.[13] Among eight patients with coarse wrinkles in the crow's feet area, Clementoni and colleagues reported 75–100% improvement in three patients, 50% to 75% improvement in three patients, and 25–50% improvement in two patients. Healing required eight days and posttreatment erythema persisted for 17 days. A more recent study[21] showed that the risk of postinflammatory hyperpigmentation after single-pass treatment with a fractional CO_2 laser device was low in patients with skin types IV and V.

In a retrospective study 16 of 31 patients treated three to seven times with a nonablative 1550 nm erbium-doped fractional laser resurfacing device, Sukal and colleagues reported eyelid tightening to some degree in all patients; 1–25% tightening was achieved in 19%, 25–50% in 26%, 50–75% in 26%, and 75–100% in 29% of patients. Twenty-six percent showed an elevation in brow position and 44% showed a lifting of the supraorbital fold. Wounding, downtime and long-term complications were not observed.

The present study was the first to prospectively evaluate the use of a fractional CO_2 laser device for the treatment of eyelid wrinkles. The strengths of the study are in the large number of subjects treated and the 12-month follow-up. It is difficult to compare our results with those of other studies because of different numbers of treatment sessions and methods used to evaluate results. However, our technique is safe enough to permit direct treatment of the eyelid. Sixty percent of subjects showed 26–50% improvement in eyelid wrinkles and skin laxity at three months, and approximately half achieved or maintained 26–50% improvement at 12 months. With fractional ablative resurfacing, these changes are thought to be due to stimulation of new collagen formation.

Approximately 45% of subjects achieved a 1–2 mm brow elevation at three months and 22% had an impressive 2–3 mm elevation. Nearly 40% maintained a 1 to 2 mm eleva-

FIGURE 3. A 42-year-old woman before **a)** and 3 months after the final of two treatments **b)** with the SmartXide DOT (DEKA, Calenzano, Italy) fractional CO2 laser device, showing 3 to 4 mm increased eyebrow elevation and skin tightening. Settings: 15 watts, 600 microseconds dwell time, 700 microns dot pitch. Photographs courtesy of Dvora Ancona, MD.

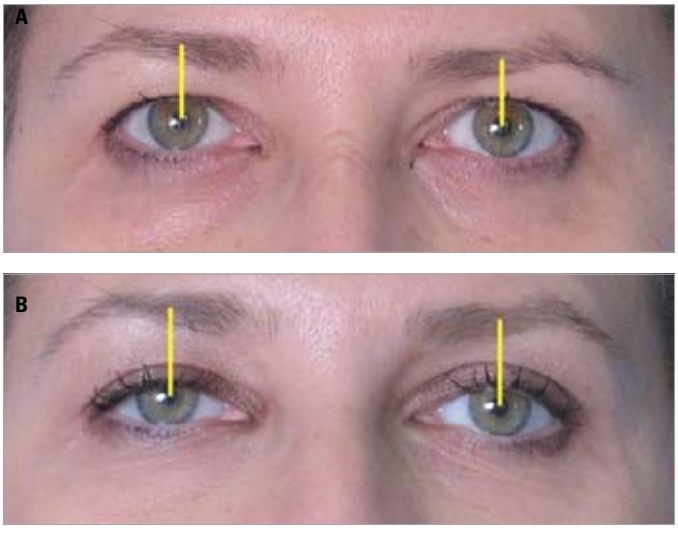
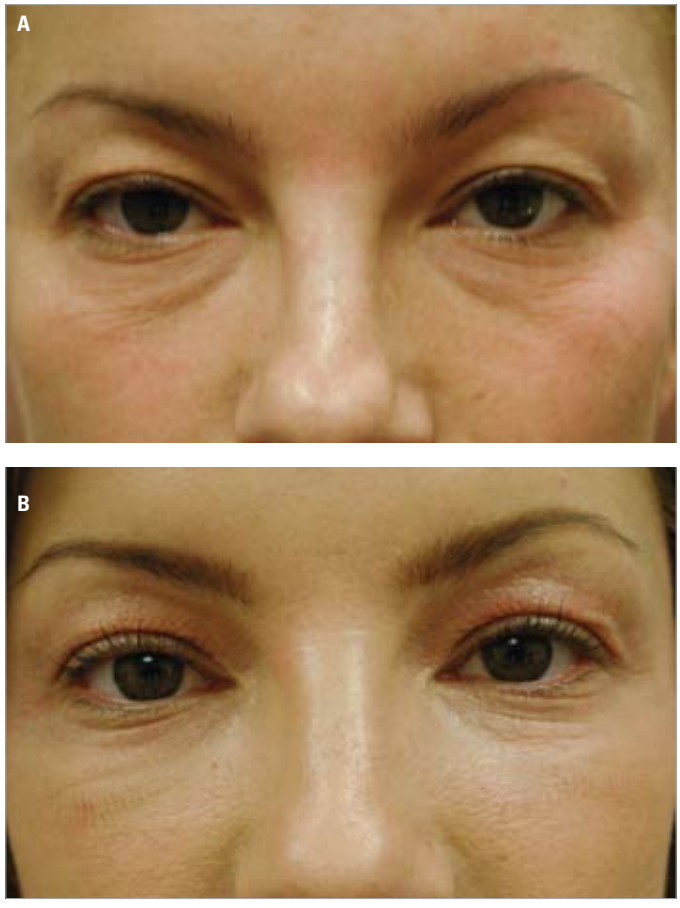


FIGURE 4. A 38-year-old woman before (upper) and 24 hours after (lower) a single treatment with the Affirm fractional CO2 laser device, showing mild erythema and edema of the eyelids. Photographs courtesy of Bruce E. Katz, MD.



tion at six and 12 months after the final treatment. These results show that overall improvement and brow elevation are achieved quickly and persist for at least 12 months. Erythema and edema cleared in four days or less. Of particular interest is the brow elevation, which our society regards as a means of brow and upper-eyelid rejuvenation.[22] It is not completely clear what was responsible for the eyebrow elevation in our study. However, Sukal and colleagues[16] noted similar eyebrow lifting effect in 26% of subjects who had full-face treatments. Treatment of the lateral periorbital areas (and skin of the superior and lateral orbital rim) in our study may have created skin-tightening vectors that were responsible for the elevation in the eyebrows. Further investigation in which treatment is localized only to this area may shed more light on this question.

The minimal downtime experienced by subjects in this study contrasts with other studies utilizing fractional CO_2 technologies where the downtime was often three to five days. The reason for this difference is likely due to the low wattages used in the initial treatments and the very gradual increases in energies utilized in subsequent sessions. Also, the ability to vary the lasers' parameters such as pulse duration and pitch attenuated the amount of erythema and edema. Most subjects had significant downtime for only one day with only mild erythema and edema for several days after the treatments.

The authors agree with Biesman and colleagues,[20] who state that setting appropriate expectations is the key to patient satisfaction. The procedure in the present study, although not an alternative to blepharoplastic surgery, is a viable non-surgical option for rejuvenating the periorbital areas of facial skin.

The authors will continue to follow subjects in this study to further evaluate the longevity of clinical benefits.

CONCLUSIONS

Treatment with a fractional CO_2 laser device produces long-lasting improvement in periorbital rhytids, skin laxity and eyebrow elevation after an average of two treatments spaced three to four weeks apart. Adverse events are minimal.

DISCLOSURES

Dr. Katz is a consultant to El-En Engineering, the parent company of Deka.

Dr. Ancona has no relevant conflicts of interest to disclose.

REFERENCES

1. Alster TS, Garg S. Treatment of facial rhytides with a high-energy pulsed carbon dioxide laser. *Plast Reconstr Surg*. 1996;98(5):791-794.
2. Liu D. Lower eyelid tightening: A comparative study. *Ophthal Plast Reconstr Surg*. 1997;13(3):199-203.
3. Fitzpatrick R, Geronemus R, Goldberg D, et al. Multicenter study of noninvasive radiofrequency for periorbital tissue tightening. *Lasers Surg Med*. 2003;33(4):232-242.
4. Reed JT, Joseph AK, Bridenstine JB. Treatment of periorbital wrinkles. A comparison of the SilkTouch carbon dioxide laser with a medium-depth chemical peel. *Dermatol Surg*. 1997;23(8):643-648.
5. Manaloto RM, Alster TS. Periorbital rejuvenation: A review of dermatologic treatments. *Dermatol Surg*. 1999;25(1):1-9.
6. Manstein D, Herron GS, Sink RK, et al. Fractional photothermolysis: A new concept for cutaneous remodeling using microscopic patterns of thermal injury. *Lasers Surg Med*. 2004;34(5):426-438.
7. Geronemus RG. Fractional photothermolysis: Current and future applications. *Lasers Surg Med*. 2006;(3):169-176.
8. Rahman Z, Tanner H, Tournas J, et al. Ablative fractional resurfacing for the treatment of photodamage and laxity. *Laser Surg Med*. 2007;39(Suppl 19):S15.
9. Weiss RA, Weiss MA, Beasley KL. Prospective clinical trial of a fixed spacing array computer scanned fractional CO_2 laser for rhytids. *Laser Surg Med*. 2007;39(Suppl 19):16.
10. Levy JL, Journier N, Mordon S. CO_2 fractional resurfacing combined with air cooling: Histologic investigation and optimal parameters determination. *Laser Surg Med*. 2007;39(Suppl 19):17.
11. Hantash BM, Bedi VP, Kapadia B, et al. In vivo histological evaluation of a novel ablative fractional resurfacing device. *Lasers Surg Med*. 2007;39(2):96-107.
12. Hantash BM, Bedi VP, Chan KF, et al. Ex vivo histological characterization of a novel ablative fractional resurfacing device. *Lasers Surg Med*. 2007;39(2):87-95.
13. Clementoni MT, Gilardino P, Muti GF, et al. Non-sequential fractional ultrapulsed CO_2 resurfacing of photoaged facial skin: Preliminary clinical report. *J Cosmet Laser Ther*. 2007;9(4):218-225.
14. Chapas AM, Brightman L, Sukal S, et al. Successful treatment of acneiform scarring with CO_2 ablative fractional resurfacing. *Lasers Surg Med*. 2008;40(6):381-386.
15. Christiansen K, Bjerring P. Low density, non-ablative fractional CO_2 laser rejuvenation. *Lasers Surg Med*. 2008;40(7):454-460.
16. Sukal SA, Chapas AM, Bernstein LJ, et al. Eyelid tightening and improved eyelid aperture through nonablative fractional resurfacing. *Dermatol Surg*. 2008;34(11):1454-1458. Epub 2008 Sep 15.
17. Gotkin RH, Sarnoff DS, Cannarozzo G, et al. Ablative skin resurfacing with a novel microablative CO_2 laser. *J Drugs Dermatol*. 2009;8(2):138-144.
18. Keen M, Blitzer A, Aviv J, et al. Botulinum toxin A for hyperkinetic facial lines: results of a double-blind, placebo-controlled study. *Plast Reconstr Surg*. 1994;94(1):94-99.
19. Ruiz-Esparza J. Noninvasive lower eyelid blepharoplasty: a new technique using nonablative radiofrequency on periorbital skin. *Dermatol Surg*. 2004;30(2 Pt 1):125-129.
20. Biesman BS, Baker SS, Carruthers J, et al. Monopolar radiofrequency treatment of human eyelids: a prospective, multicenter, efficacy trial. *Lasers Surg Med*. 2006;38(10):890-898.
21. Tan KL, Kurniawati C, Gold MH. Low risk of postinflammatory hy-