



Fractionated Mid-Infrared Resurfacing

Melissa A. Bogle, MD^{a,b}

Fractional resurfacing devices thermally alter microscopic treatment columns in the skin, leaving intervening areas between the columns untouched. Because only a fraction of the skin is being modified, untreated areas are able to rapidly repopulate the treatment columns to greatly reduce recovery time and adverse events. Mid-infrared fractional systems have shown improvement in treating photoaging, scars, rhytides, dyschromia, and textural disorders. An additional advantage is that they are safe and effective for the treatment of nonfacial areas such as the neck, chest, and extremities.

Semin Cutan Med Surg 27:252-258 © 2008 Elsevier Inc. All rights reserved.

The concept of fractional photothermolysis was introduced in 2004 in an attempt to deliver results approaching that of traditional ablative laser resurfacing without the associated risks and lengthy recovery period.¹ Whereas traditional laser resurfacing removes the entire top layer of the skin surface, creating a visible wound and loss of the skin's protective function, fractional laser resurfacing treats a small "fraction" of the skin at each session. Intact, undamaged skin around each treated area theoretically serves as a barrier to infection and a reservoir for rapid healing by keratinocyte migration into the treatment column.

Mid-Infrared Fractional Resurfacing Devices

The Fraxel SR750 (Reliant Technologies Inc., Mountain View, CA), the first fractional resurfacing laser developed, uses a diode pumped erbium fiber laser emitting light at 1540 nm to target water in the skin. The beam is delivered through an optically tracked, microprocessor controlled hand piece to produce an array of microthermal thermal zones (MTZs), each about 100 μm in diameter, or about the size of a human hair. During each treatment, 125 or 250 columns of MTZs are created per centimeter squared per pass, depending on operator settings. With this version of the Fraxel, a water-soluble dye is applied to the treatment area to allow the laser's optical tracking system to detect contact with the skin and adjust the laser repetition rate depending on hand velocity.

When the hand piece moves more quickly, the laser repetition rate is greater, and when the hand piece moves more slowly, the laser repetition rate is lower. This assures a uniform, reproducible pattern of treatment columns.

Although the original Fraxel SR750 device is still in use, the second-generation Fraxel SR1500 (now termed the Fraxel Re:Store) debuted in late 2006 with a software upgrade in 2007. The second-generation Fraxel incorporates several changes, including a telescoping zoom lens that adjusts the diameter of the treatment column with respect to the treatment energy and a roller tip that uses a scanning LED to track the surface of skin without optical blue dye. Lower energy, more superficial treatment columns are smaller in diameter, and higher energy, deeper treatment columns are larger in diameter. The software upgrade permitted a maximum energy of 70 mJ, allowing for a greater penetration depth up to 1.4 mm. The first-generation Fraxel SR750 had treatment energies up to 40 mJ, with column depths ranging from 400 to 700 μm . The Fraxel Re:Store has varying treatment levels (1 through 12 and advanced levels R1-R3) which control the coverage area ranging from 5% to 50% of the skin surface area.

Other companies have incorporated the fractional concept into laser technology. Competing approaches to fractional delivery of laser and light devices use either a lens in the hand piece to break up the light into fractionated beams, emit the light in an array of fractionated beams, or use a scanner to deliver treatment columns to the skin with sparing in between.

The Lux 1540 Fractional Er:YAG (Palomar Medical Technologies Inc., Burlington, MA) contains a multilensed hand piece that divides pulsed light at 1540 nm into microbeams that heat the epidermis and upper dermis in a fractional fashion, penetrating up to 1 mm. It is approved by the FDA for soft tissue coagulation.

^aThe Laser & Cosmetic Surgery Center of Houston, Houston, TX.

^bDepartment of Dermatology, The University of Texas M.D. Anderson Cancer Center, Houston, TX.

Address reprint requests to Melissa A. Bogle, MD, The Laser & Cosmetic Surgery Center of Houston, 3700 Buffalo Speedway, Suite 700, Houston, TX 77098.

Another laser which uses a multilensed hand piece to fractionate delivery of energy to the skin is the Affirm (Cynosure Inc., Westford MA). This laser sequentially emits 1320 nm and 1440 nm mid-infrared wavelengths at fixed intervals. A microlens array in the hand piece diffuses the light into an array of fractional microbeams targeting superficial and deeper penetration depths with the two wavelengths. The Affirm laser has received Food and Drug Administration approval for the treatment of periorbital and perioral rhytides and pigmented lesions.

The StarLux Fractional IR (Palomar Medical Technologies, Inc., Burlington, MA) takes a slightly different approach in that it uses a fractional infrared hand piece to deliver noncoherent light in the 825- to 1350-nm range as a regular array of small hyperthermic beams with contact cooling to heat the deep dermis to induce collagen change and skin tightening.

The Matrix IR fractional applicator (Syneron Medical Ltd, Yokneam, Israel) is a hand piece compatible for use with the company's eMax or eLaser treatment systems. The device preheats the skin with fractional 915-nm diode optical energy and then adds additional nonfractionated bipolar radiofrequency to produce deep dermal heating to target collagen growth and remodeling.

The Mosaic (Lutronic Inc, Ilsan, Korea) uses what the company terms controlled chaos technology (CCT) to deliver an array of randomized Erbium:Glass microbeams to the skin surface in what ends up looking like a "spray paint" pattern. This random scanning pattern is thought to minimize cross-thermal diffusion between adjacent wounds. Treatments can be delivered in 2 treatment modes: a dynamic mode with continuously delivered CCT beams or a static stamping mode. Treatment columns are 100 μm to 200 μm wide and are able to penetrate up to 1.2 mm.

The devices discussed above are all nonablative fractional mid-infrared systems. The ProFractional (Sciton, Inc., Palo Alto, CA) is an ablative fractional Erbium:YAG laser. It uses a scanner to deliver light at 2940 nm to create 250 μm wide microchannels in the skin at depths ranging from 20 μm to 1500 μm . Treatments are done in a single pass and most patients require one to two treatments.

The Pixel (Alma Lasers, Buffalo Grove, IL) is another ablative fractional Erbium:YAG laser that delivers light at 2940 nm and is a module of the Harmony platform. The Pixel has a penetration depth of 20 μm to 50 μm . The operator can choose whether the treatment energy is divided between 49 to 81 pixels within a given spot size ($11 \times 11 \text{ cm}^2$) using a microoptic lens. With the 49 pixel pattern, the energy is split between fewer pixels, so each pixel receives more energy and the depth of penetration is higher. Conversely, with the 81 pixel pattern, the energy is split over more pixels, and the depth of penetration is shallower.

The field of fractional lasers is rapidly changing and many more devices will be available in the coming years. A fractional version of the 2790 nm YSGG (Yttrium Scandium Gallium Garnet) Pearl laser (Cutera Inc, Brisbane, CA) was previewed at the annual meeting of the American Society for Laser Medicine and Surgery in 2008. The 2790 nm wavelength has a hybrid mechanism of ablation and coagulation to

create micro wounds that target the dermal layers of the skin for the treatment of fine lines, texture and pigment. The device is pending Food and Drug Administration clearance and should be commercially available by the end of the year.

Clinical Applications

Concepts to consider in fractional laser treatment protocols include depth and diameter of the treatment column, density, percent coverage, total energy delivered, treatment interval, and number of treatments. The first concept to understand is that the depth of the treatment column is proportional to the pulse energy in a quasi-linear fashion such that increasing the pulse energy will cause deeper thermal wounding.² With some devices, such as the Fraxel Re:Store, increasing the pulse energy will also increase the diameter of the treatment column; however, with other devices, such as the Sciton ProFractional, the width of the treatment column will remain constant.

Treatment density is related to the pitch of the treatment columns, or how close they are spaced from one another. In general, for greater-pulse energy treatments, the density should be lowered to avoid excessive bulk heating, especially with a device that has a variable diameter treatment column. Delivering more passes can compensate for the lower density settings in cases where a greater percent coverage is the treatment goal. Treatment density should be reduced and a longer time period between treatment sessions is advised when treating darker skin type patients and patients at risk for postinflammatory hyperpigmentation.

Percent coverage relates to what proportion of the skin surface has been thermally altered. This is a 2-dimensional skin surface concept and should not be confused with treatment volume. For example, a 20-mJ, 1000-MTZ/cm² treatment and a 10-mJ, 2000-MTZ/cm² treatment have an equal percent coverage of 20%. Yet, in terms of volume, the 20 mJ treatment had twice the skin amount treated because of the difference in column depth.

Total energy delivered is the total energy transferred to the treatment area at the end of a procedure and is a good measure of whether an adequate treatment was performed. If the total energy is too low, the hand piece velocity may have been too fast with a scanning device or too many skip areas may have occurred with a stamping device.

Fractional photothermolysis can be used for the treatment of photodamaged skin, facial rhytides, acne scars, surgical scars, melasma, and photodamaged skin.³ Evidence suggests it is also beneficial in the treatment of striae distensae.^{4,5}

Photodamage (Rhytides, Pigmentation)

The most extensively studied of the mid-infrared fractional resurfacing devices is the Fraxel SR750 laser. Early studies with this device for the treatment of periorbital rhytides revealed mild improvement in 12% of patients, noticeable improvement in 30%, and moderate-to-significant improvement in 54% 1 month after 4 treatments.¹ The device appears to work better on fine-to-moderate rhytides than deeper

lines.³ Perioral vertical rhytides are particularly resistant. As with other lower recovery time procedures, rhytides are not improved to the same degree as traditional ablative resurfacing.³

Evidence has demonstrated improvement of lentiginos and dyschromia with fractional photothermolysis to be similar to that of Q-switched lasers and intense pulsed light.⁶ Patients with dyspigmentation and lentiginos require 2 to 3 treatments, whereas those with significant rhytides require 5 or more treatment sessions.

Scars (Acne Scarring, Surgical Scars, Posttraumatic Scars)

Fractional photothermolysis has been studied in the treatment of acne scars. Seventeen subjects with ice-pick, boxcar, and rolling type acne scars were treated with 5 Fraxel SR750 treatments at 1- to 3-week intervals. Mean improvement in acne scarring measured by typographic imaging was found to be 22% to 62%.³ Higher energy treatments appear to improve results in comparison to low energy treatments.

In a large study evaluating fractional photothermolysis for the treatment of atrophic acne scars in 53 patients using energies of 8 to 16 J/cm² at 125 to 250 MTZ/cm² and 8 to 10 passes (total energy 4 to 6 kJ per session), 91% of participants were found to have a 25% to 50% improvement after just 1 treatment session.⁷ Mean improvement scores increased incrementally after each additional treatment session, with 87% of study participants having 51% to 75% improvement after 3 treatments at monthly intervals.⁷

Melasma

The efficacy of the Fraxel SR750 laser for melasma was evaluated in a study of 10 patients with Fitzpatrick skin types III to V using energies of 6 to 12 mJ/MTZ with 2000 to 3500 MTZ/cm².⁸ Patients received 4 to 6 sessions 1 to 2 weeks apart. Six patients achieved 75% to 100% clearance, 1 patient achieved 50% to 75% clearance, and 3 patients had a less than 25% clearance. One patient developed postinflammatory hyperpigmentation. Long-term follow-up was not done.⁸

The Lux 1540 Fractional device was studied in 12 patients with melasma receiving 4 treatments with 4 passes at 320 mb/cm² per pass.⁹ Patients had an average 40% to 50% improvement with follow up to 3 months.⁹ When skin histology is examined 2 to 3 days after fractional resurfacing, the tops of the wounded treatment columns have microepidermal necrotic debris (MENDs). These small debris mounds have been found to contain melanin and are thought to act like elimination channels which expel pigment and explain the clinical lightening of lentiginos and melasma.¹⁰

Combination Therapy

Combination therapy is a dominant theme in cosmetic dermatology. Patients are able to achieve a more complete result when procedures such as fractional resurfacing are combined with other therapies such as botulinum toxin, fillers, and other modalities.

Rhytides in areas of excessive muscle activity such as the glabella and forehead tend not to respond as well to traditional ablative and fractional resurfacing. Results may improve with the long-term adjunctive use of botulinum toxin. Although some studies have shown botulinum toxin injections can be safely administered after fractional resurfacing on the same day,¹¹ it is safest to administer injections at least 24 to 48 hours prior to the laser procedure or to wait until after post-procedure edema has subsided to avoid any risk of diffusion. Performing injections following the laser procedure appears to avoid diffusion.¹¹

Synergistic effects between botulinum toxin and intense pulsed light have been well documented.¹² Dilute amounts of botulinum toxin have been suggested as a synergistic treatment with the Lux 1540 Fractional device for resurfacing of the midface.¹³ The author performed injections of botulinum toxin (1 unit at a total of 4 injection sites on each cheek) 1 day before the patient's first fractional resurfacing session. The author suggested that the botulinum toxin may have either relaxed muscles contributing to a dynamic component of the cheek rhytides or allowed a more static cheek which enhanced the collagen stimulation and remodeling phase.¹³

Experience indicates that there does not appear to be a reduction in the duration of fillers with nonablative fractional resurfacing treatments. There may even be a synergistic effect between fillers and fractional resurfacing. Hyaluronic acid dermal filler injections have been shown to increase de novo collagen synthesis in the skin by mechanically stretching and activating fibroblasts.¹⁴ Performing nonablative fractional resurfacing during this time may take advantage of this phenomenon, stimulating even more growth, although studies need to be done for confirmation. This would be extremely useful not only for prolonging the duration of fillers in photoaging, but for atrophic acne scars on the cheeks which could be filled first and then treated with fractional devices to enhance overall improvement.

Preoperative Considerations

During the initial consultation, a complete medical and surgical history should be obtained from the patient. It is particularly important to establish any contraindications to fractional laser resurfacing including isotretinoin use within 6 to 12 months of surgery, a tendency toward keloid or hypertrophic scar formation, active skin infection, and unrealistic patient expectations. Any conditions that may cause reduced numbers of adnexal structures such as scleroderma, burn scars, or history of ionizing radiation to the skin should be noted.

All patients undergoing ablative fractional resurfacing should receive antiviral prophylaxis against herpes infection before full-face or perioral procedures because of the high prevalence of latent virus, even in persons who have never been symptomatic. Antiviral prophylaxis is not routinely given for nonablative fractional resurfacing unless the patient has a known history of herpes simplex.

Prophylactic antibiotics are generally not needed for bacterial reasons; however, some physicians may choose to pre-

treat patients for 1 week before high-energy procedures to help avoid acne flares. This can be particularly important in patients being treated for more severe acne scarring in whom even a few short term blemishes can bring apprehension and anxiety.

Darker-skinned patients have the highest risk of postprocedure hyperpigmentation. Some physicians choose to pretreat at-risk patients with topical retinoic acids, hydroquinone bleaching agents, and alpha-hydroxy acids for several weeks to reduce the risk of postoperative hyperpigmentation and enhance wound healing.¹⁵ The usefulness of such regimens is debatable, and studies have not shown them to have a significant effect.¹⁶ Treating hyperpigmentation if it appears after treatment may be a more effective approach.^{16,17}

Treatment Technique

Some fractional resurfacing procedures can be quite uncomfortable for the patient, depending on the device and energy used. For the Fraxel Re:Store, topical anesthesia applied 45 to 90 minutes before the procedure appears to be sufficient. Some patients may require additional oral sedation, oral analgesia, or regional nerve blocks. Additional analgesia is obtained from forced air cooling with the Zimmer device (Zimmer MedizinSysteme, Ulm, Germany) at the time of treatment. Many of the competing fractional devices on the market are reportedly less painful and require little or no anesthetic.

To prepare a patient for fractional photothermolysis with the Fraxel Re:Store, the skin should be washed with cleanser and prepped with alcohol. A lipid-based topical anesthetic (eg, 20% betacaine/8% lidocaine/4% tetracaine) is then applied for 1 hour. Care should be taken not to get anesthetic cream near the eye area as a corneal burn can arise. Any patient that complains of eye stinging or burning during the numbing process should have the area rinsed in the eye wash for several minutes. Before laser treatment, the anesthetic is removed and a very thin layer of tracking gel (Reliant Technologies, Mountain View, CA) is applied to highlight the contours of the skin. If too much tracking gel is applied, the roller tip will goop up and the laser will not lay down columns evenly (Fig. 1).

The Fraxel laser is then calibrated by placing the hand piece into a self calibration portal on the top of the device mainframe. When calibrated, a disposable tip can be inserted onto the hand piece and settings can be selected based on the patient's skin type and condition by programming them in on a touch pad screen. Protective eye shields should be applied before treatment.

The most comfortable position for facial treatment is with the patient fully reclined and the laser operator sitting at the head of the bed directly superior. If an assistant is available to hold the air cooling device, they can sit to one side or the other. If an assistant is not available, the cooling nozzle can be snapped to an arm on the Zimmer or held by the patient themselves. Concomitant forced air cooling with the Zimmer device is useful to prevent bulk heating and achieve a greater degree of analgesia. It should be noted that the diameter of



Figure 1 After all anesthetic has been removed, tracking gel is applied in a thin layer before beginning treatment with the Fraxel Re:Store. Other nonablative fractional systems do not require use of tracking gel.

the treatment columns has been shown to be temperature sensitive, with colder temperatures causing a reduction in the size and surface area of the treatment columns.¹⁸ It is unclear, however, whether this has a significant clinical impact.

When ready to begin, the treatment tip is gently placed perpendicular on the skin's surface and the foot pedal is depressed. The hand piece should be moved in a straight line consisting of one stroke until the end of the cosmetic unit is reached. At this point the treatment operator can either retrace the hand piece back over the same row to return to the starting point, completing 2 passes, or he can pick up the hand piece, go back to the start point, and repeat the stroke a second time in the same direction to complete the second pass. The first method is called the "back and forth" technique and the second method is called the "paw" technique. The paw technique may cause less risk of bulk heating.

After a cosmetic unit has been treated entirely from side to side, the direction of the rows should change by 90°, and the process repeated from top to bottom. Changing direction helps to avoid skip areas (Fig. 2). Rows can also be made in a diagonal direction in addition to the horizontal and vertical. This is continued until the desired number of passes (and goal total energy) is delivered. In thin skinned areas such as the eyelids, it helps to stretch the skin using the nondominant hand and a piece of gauze to stabilize the field during the laser pass (Fig. 3). The paw technique is especially useful for these areas (Fig. 4). There is no need to feather the treatment area or to be concerned about lines of demarcation.

It is important to watch the treatment hand velocity and position during the treatment. The Fraxel Re:Store has a velocity meter on the screen as well as an audible sound variance that alerts the clinician when they are moving too fast for the laser to keep up (Fig. 5). Tilting or lifting the hand piece



Figure 2 Passes should be performed holding the hand piece lightly on the skin surface in a vertical orientation. A horizontally oriented pass is illustrated on the left and a corresponding vertical pass is illustrated on the right. Changing direction helps to ensure an even distribution of treatment columns.

from the skin can create laser nicks. In addition, rapid movement will result in increased patient discomfort. General treatment guidelines for the Fraxel Re:Store can be found in Table 1. It is best to start a patient's treatment course at the gentler range to avoid excessive edema and risks such as postinflammatory hyperpigmentation. Energy and coverage density can be increased as tolerated as the treatment series progresses.



Figure 3 When treating areas with skin laxity such as the upper cheek and lower eyelid, it is helpful to use the nondominant hand to gently increase skin tension. Gauze helps the hand not slip with the use of tracking gel.



Figure 4 Eyelid treatments can be performed over the entire lid down to the lash margin. The author finds the paw technique particularly valuable in this area as a result of the laxity of skin and confined space. The counter hand may be used to apply traction to the skin, but the operator must be careful not to apply too much pressure over the globe to avoid injury. The patient is wearing protective corneal shields.



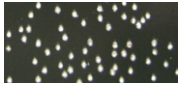





Postoperative Considerations

Recovery time after fractional laser resurfacing is minimal in comparison to traditional ablative resurfacing lasers. Immediately posttreatment, patients should apply ice in the office



Figure 5 The treatment screen on the Fraxel Re:Store device allows the user to set the energy (depth) and treatment level (total density of treatment columns for the given number of passes). Total energy delivered is recorded on the lower left portion of the screen. Note that the device keeps track of the hand piece velocity on the lower right to alert the user if they are moving too fast for the device scanner to keep up.

Table 1 General Treatment Guidelines for the Fraxel Re:Store (SR1500)*

Condition	Energy (mJ)	Depth (μ)	Treatment Level	No. Passes	Total % Coverage	Column Pattern: Gentler Range (Single Pass)†	Column Pattern: More Aggressive Range (Single Pass)†
Melasma	6–12	442–608	5–8	4–8	14–23	 Energy 6 mJ Treatment Level 5	 Energy 12 mJ Treatment Level 8
Acne and hypertrophic scars, deep rhytides	40–70	1120–1359	5–11	4–8	14–32	 Energy 40 mJ Treatment Level 5	 Energy 70 mJ Treatment Level 11
Atrophic scars, mild-to-moderate rhytides, off-face rejuvenation	6–45	442–1176	6–8	4–8	17–23	 Energy 6 mJ Treatment Level 6	 Energy 45 mJ Treatment Level 8
Eyelid rejuvenation	8–25	500–893	6–8	4–8	17–23	 Energy 8 mJ Treatment Level 6	 Energy 25 mJ Treatment Level 8

*Treatment guidelines are general and should be adjusted for use in individual patient cases. It is best to start a patient's treatment course at the gentler range to avoid excessive edema and risks such as postinflammatory hyperpigmentation. Energy and coverage density can be increased as tolerated as the treatment series progresses.

†Photos are 1 pass of the hand piece over pattern preview paper (Reliant Technologies Inc., Mountain View, CA). Typical treatments will be 4 to 8 passes total.

for 10 to 20 minutes. The use of Biafine topical emulsion (OrthoNeutrogena, Skillman, NJ) twice daily for 4 to 7 days posttreatment has been shown to accelerate wound healing and recovery after fractional resurfacing procedures.¹¹

Redness lasts an average of 3 to 5 days, but it can be longer with high energy treatments. Discomfort is generally mild, similar to a sunburn, and easily relieved by cool compresses or acetaminophen. Swelling is common at high treatment energies and may last 1 to 5 days. Elevation of the treated area on the evening of treatment will help keep edema to a minimum.

Within the first few days after treatment, some patients develop a bronzed appearance due to the presence of melanin containing MENDS. MENDS form beneath the intact stratum corneum in each MTZ and gradually slough off within the first week. Most patients will have some degree of fine roughness and dry flaking. Other than the application of Biafine or a light moisturizer, postoperative skin care is generally not required and most patients can return to normal activities, including make-up application, in 2 to 3 days.

Immediate and short-term side effects of fractional photothermolysis in patients undergoing treatment on the face, neck, chest, and hands include transient erythema (100%), xerosis (87%), edema (82%), flaking (60%), superficial scratches (47%), pruritus (37%), and bronzing (27%).¹⁹ Re-activation of herpes simplex virus can occasionally be seen and may require prophylaxis in at-risk patients.¹⁹ Acneiform lesions can be treated with topical acne medications or a short course of oral antibiotics. Hyperpigmentation may occur and usually responds well to treatment with topical retinoic acid,

hydroquinone, or a series of light chemical peels.^{17,20,21} Long-term adverse events including hypopigmentation and scarring have not been reported.³

References

1. 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* 34:426-438, 2004
2. Bedi VP, Chan KF, Sink RK, et al: The effects of pulse energy variations on the dimensions of microscopic thermal treatment zones in nonablative fractional resurfacing. *Lasers Surg Med* 39:145-55, 2007
3. Geronemus RG: Fractional photothermolysis: Current and future applications. *Lasers Surg Med* 38:169-176, 2006
4. Bernstein LJ, Kim K, Chapas A, et al: Treatment of striae distensae with fractional photothermolysis. Paper presented at: 25th Annual Scientific Meeting of the American Society of Laser Medicine and Surgery held in Orlando, Florida, March 30 to April 1, 2005
5. Kawashita MY, Niwa ABM, Alves EV, et al: Treatment of stretch marks with Fraxel laser. *Lasers Surg Med* S19:72, 2007 (abstr)
6. Alexiades-Armenakas MR, Dover JS, Arndt JS. The spectrum of laser skin resurfacing: Nonablative, fractional, and ablative laser resurfacing. *J Am Acad Dermatol* 58:719-77, 2008
7. Alster TS, Tanzi EL, Lazarus M: The use of fractional photothermolysis for the treatment of atrophic scars. *Dermatol Surg* 33:295–29, 2007
8. Rokhsar CK, Fitzpatrick R: The treatment of melasma with fractional photothermolysis: A pilot study. *Dermatol Surg* 31:1645–16, 2005
9. Vasily DB: Treatment of melasma using the Starlux 1540 nm fractional handpiece. *Lasers Surg Med* S19:23, 2007 (abstr)
10. Behroozan DS, Goldberg LH, Glaich AS, et al: Fractional photothermolysis for treatment of poikiloderma of civatte. *Dermatol Surg* 32: 298-301, 2006
11. Narurkar VA: Nonablative fractional resurfacing for total body rejuvenation. *J Drugs Dermatol* 7:352-355, 2008

12. Carruthers J, Carruthers A: The effect of full-face broadband light treatments alone and in combination with bilateral crow's feet botulinum toxin type A chemodenervation. *Derm Surg* 30:355-366, 2004
13. Beer K: Botulinum toxin type A enhances the outcome of fractional resurfacing of the cheek. *J Drugs Dermatol* 6:1151-1152, 2007
14. Wang F, Garza L, Kang S: In vivo stimulation of de novo collagen production caused by cross-linked hyaluronic acid dermal filler injections in photodamaged human skin. *Arch Dermatol* 143:155-163, 2007
15. Ratner D, Yardy T, Marchell N, et al: Cutaneous laser resurfacing. *J Am Acad Dermatol* 41:365-389, 1999
16. West TB, Alster TS: Effect of pretreatment on the incidence of hyperpigmentation following cutaneous CO₂ laser resurfacing. *Dermatol Surg* 25:15-17, 1999
17. Alster TS: Cutaneous resurfacing with CO₂ and erbium:YAG lasers: Preoperative, intraoperative, and postoperative considerations. *Plast Reconstr Surg* 103:619-632, 1999
18. Laubach H, Chan HH, Rius F, et al: Effects of skin temperature on lesion size in fractional photothermolysis. *Lasers Surg Med* 39:14-18, 2007
19. Fisher GH, Geronemus RG: Short-term side effects of fractional photothermolysis. *Dermatol Surg* 31:1245-1249, 2005
20. Kilmer SL: Laser resurfacing complications: How to treat them and how to avoid them. *Int J Aesth Restor Surg* 5:41-45, 1997
21. Tanzi EL, Alster TS: Side effects and complications of variable-pulsed erbium:yttrium-aluminum-garnet laser skin resurfacing: Extended experience with 50 patients. *Plast Reconstr Surg* 111:1524-1529, 2003