Laser Resurfacing Pearls

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Abstract

Ablative skin resurfacing using the carbon dioxide laser was long considered the gold standard for treatment of photoaging, acne scars, and rhytids. However, conventional full-face carbon dioxide resurfacing is associated with significant risk of side effects and a prolonged postoperative recovery period. Fractional resurfacing has recently revolutionized laser surgery by offering close to comparable results with minimal side effects and a more rapid recovery. Although fractional devices have grown in popularity, and have essentially replaced traditional resurfacing, fractional resurfacing can still be a challenging modality to control precisely due to hardware variations across comparable devices, the range of settings that can be used, and patient-specific considerations. Certain precautions and rules of thumb can reduce the risk associated with fractional resurfacing, and increase the likelihood of a good outcome.

Keywords

- ▶ skin resurfacing
- ▶ ablative
- ▶ nonablative
- ▶ fractional lasers

Terminology

- *The terms “nonablative” and “ablative” are poorly descriptive and easily misused. It may be better to describe fractional treatments along the spectrum of “nonablative,” “partially ablative,” and “ablative” (or “fully ablative”).*

The term “nonablative” was first coined to describe treatment that selectively damages the dermal tissue while sparing the epidermis. In contrast to ablative lasers, nonablative fractional devices are associated with minimal side effects and downtime.^{1,2} In recent years, however, the number of devices categorized as “nonablative” has exploded. Although some of these devices provide satisfactory clinical results with no postoperative morbidity, others perform precise skin vaporization with less morbidity than ablative treatment, but greater downtime (7–10 days) than ideal nonablative devices. This discrepancy necessitates the use of subcategories to accurately describe novel devices.

The term “partially ablative” is perhaps more useful for describing treatments in which some, but not all of the epidermis is removed. Such treatments are typically associated with an intermediate downtime of greater than 1 or

2 days, but less than 1 week. Furthermore, whereas postoperative side effects for nonablative treatments are generally limited to erythema and edema, partially ablative treatments may result in focal erosions, fluid loss, crusting, and scabbing. It is important to note that for a given device, the degree of “ablativeness” depends on multiple factors, including the fluence, repetition rate, and the degree of coverage of the device. Other factors including patient skin types and anatomic sites can also affect whether the treatment is “ablative,” “partially ablative,” or “nonablative.”²

Significantly, the percentage of the epidermal surface said by a manufacturer to be treated with a particular set of parameters is often a theoretical statistic that is not borne out in practice. Prior experience with the device, not slavish observance of suggested parameters, should quite setting selection. Even more problematically, selecting a given percent coverage with device A may lead to a markedly different tissue effect than the same percent coverage with device B. The proportion of surface area that is fractionated is not comparable across devices. It is also not the case that if a set of parameters is said to affect 10% of the skin surface, then 10 passes would lead to complete ablation; far fewer passes are likely to cause focal thermal burns.

Preoperative Considerations

- *Topical anesthesia is often sufficient for treatment with fractional non-CO₂ devices, but intralesional anesthesia and nerve blocks may improve the comfort of fractional CO₂ resurfacing.*

When performing nonablative or partially ablative fractional procedures in localized areas, including the periorbital and/or perioral region, local anesthesia may be sufficient. Topical anesthetic agents such as lidocaine and prilocaine cream (EMLA cream) can be used 60 minutes before these superficial laser procedures, with attention paid to the total area treated to avoid toxicity.

The CO₂ fractional laser, however, typically produces more discomfort than non-CO₂ lasers, and this may be caused by greater tissue-heating effect on type C pain fibers.³ For ablative procedures involving broad areas, such as the central forehead, the median cheek/nose and upper lip, and the lower lip and chin, topical anesthetics may be used as supplemental agents to nerve blocks and/or intralesional anesthesia. Nerve blocks may be achieved using lidocaine 1 to 2% with 1:100,000 or 1:200,000 epinephrine, and can be enhanced using bupivacaine 0.5%, 1:10 NaHCO₃ 8.4%, and hyaluronidase.⁴ “Fanning,” or radially spacing subcutaneous injections from a single entry site using a long needle, may help achieve adequate anesthesia at the lateral cheeks, the lateral foreheads, and other sites not well served by nerve blocks.

Although rare, anesthesia-induced toxicity resulting from improper removal of lidocaine gel has been reported.⁵ Symptoms of lidocaine toxicity include agitation, anxiety, light-headedness, palpitations, nausea, and tachycardia. To minimize these risks, physicians are advocated to completely remove topical anesthetics before beginning treatment.

- *As it is possible to cause scarring with fractional resurfacing, especially fractional CO₂ resurfacing, take appropriate precautions to minimize this risk.*

Fractional resurfacing has been used to treat many types of scars, ranging from acne scars to surgical and traumatic scars. However, there have been multiple cases of unexpected hypertrophic scarring on the neck from fractional treatment. This area is especially prone to scarring because of the decrease in vascularity and thinness of the skin.⁶ Because hypertrophic scarring is a well-documented complication of traditional ablative CO₂ laser resurfacing,⁷ techniques already exist to reduce this risk, and these can be applied to fractional resurfacing as well. First, less-experienced physicians may avoid the neck area. Alternatively, the use of low fluences at the neck and other scar-prone areas, coupled with reduced surface area coverage, may reduce the potential for scarring. Multiple passes and heat stacking by applying numerous repeat treatments to the same location should also be curtailed, as these approaches can cause injury to the deep dermis.

Patient- and device-specific factors should be considered. Some patients may be “poor healers,” and it is important to

elicit this in their medical history. Past healing problems, underlying collagen vascular diseases, and prior resurfacing procedures may predispose to scarring with fractional laser. For instance, previous phenol peels or dermabrasion may make the patient's skin more sensitive, and fractional resurfacing may go deeper than anticipated, even with moderate settings. Variations in the true tissue effect of similar sounding settings across different devices should also be assessed. “Five percent” coverage with one device may be equivalent to “15%” coverage with another, which may impact treatment results. In general, it is always a good idea to double check laser settings, and if multiple treatments are used, start low and go to higher settings as tolerated during subsequent treatment sessions.

- *Patients with ethnic skin are at a very high risk of hyperpigmentation with fractional CO₂, and even with non-CO₂ fractional devices should be treated with less aggressive settings to minimize this risk.*

Postinflammatory hyperpigmentation (PIH) is the most common complication in patients with dark skin (IV–VI) who undergo facial resurfacing. Although melanin does not absorb the 1,550-nm wavelength, pigmentary changes still occur.⁸ The rate of PIH has been found to be directly proportional to both the energy and density of the treatment, although density appears to be particularly important.⁹ Thus, it is important to start out using conservative settings—including low density and intensity—on patients with skin of color, even when using nonablative resurfacing techniques.

To reduce the incidence of posttreatment hyperpigmentation, many laser surgeons advocate the pre- and postoperative use of hydroquinone, tretinoin, and/or glycolic acid. Although studies are inconclusive as to whether these topical agents are capable of preventing hyperpigmentation, they may be effective when instituted postoperatively as a component of the skin care regimen.^{10,11} In combination with nonablative devices, these agents may be of more use in preventing and treating hyperpigmentation because the epidermis is similarly maintained.

Physicians should also advise patients of all ethnicities to minimize sun exposure and use a full-spectrum sunblock 2–4 weeks before and after treatment. Patients of mixed ethnicity (e.g., Asian and Caucasian, or Caucasian and Indian) may seem light-skinned, but are often at high risk of hyperpigmentation. Similarly, some Asian and Indian patients may practice extreme sun protection and avoidance that makes them appear very light skinned even though their skin color with even modest sun exposure is significantly darker. A similar process can occur in reverse in lighter-skinned patients, who may appear dark with a semipermanent tan called actinic bronzing due to chronic sun exposure. When treated with fractional CO₂ using so-called stamping handpieces rather than rolling handpieces, both these categories of patients may develop lines of demarcation. In review, it is important to remember that a patient's true Fitzpatrick type may not always be clinically apparent based on casual inspection of their skin color.

Postoperative Considerations

- *Although adverse events are uncommon with fractional resurfacing, early detection can mitigate the risks of delayed healing, infection, and pigmentary abnormality.*

Erythema and edema are expected postoperative consequences of fractional resurfacing, but other adverse events can occur. Some of these clinical complications, including prolonged erythema, pigmentary alternation, and scarring, can be easily avoided by using a lower energy density setting. However, if delayed healing of more than 3 or 4 days for nonablative devices or 1 month with ablative resurfacing occurs, it may be a sign of latent infection.^{12,13} After cultures are obtained, the area may be treated immediately with appropriate antibiotics. If downtime is significantly longer than expected with no signs of infection, it could be a sign of an underlying healing problem in the patient or a deeper than anticipated skin injury from the laser. Adjuvant methods that may be implemented to facilitate wound healing include topical, oral, or intralesional injections of corticosteroids, cold compresses, and persistent use of vinegar soaks followed by petrolatum.

- *Antimicrobial prophylaxis before, during, and after fractional resurfacing treatments may provide both patient and physician with peace of mind, and reduce the risk of serious perioperative problems.*

Meticulous postoperative care is as important as intraoperative technique in achieving optimal results and patient satisfaction. Although complications caused by viruses, bacteria, and fungi are rare, starting antibacterial and antiviral prophylaxis 2 days before a fractional procedure and continuing for 5 days afterwards can afford protection during the perioperative period. Herpes simplex virus infection is the most common type of infection following fractional resurfacing, and has been reported in 0.3 to 2% of cases.¹² Bacterial infection accounts for 0.1% of patients who undergo fractional resurfacing. If a patient complains of extreme pruritus following treatment, this may be caused by *Candida* colonization, and an oral antifungal (e.g., commonly fluconazole) may provide relief and prevent scarring.¹⁴ Vinegar soaks can be a useful adjunct that soothe the skin and provide protection from pseudomonal species.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is now ubiquitous in the hospital and community environments, and other pathogens are becoming increasingly resistant to common antibiotic regimens.¹⁵ Patients who exhibit delayed healing despite a regimen of antimicrobial prophylaxis should have their skin cultured to identify these unusual or resistant organisms, which have been detected in this context and may require treatment with multiple drugs.¹⁶

Treatment Scheduling

- *A single fractional resurfacing treatment is rarely able to produce the desired change. Unlike full-face resurfacing,*

multiple treatments are required for a clinical significant result, with six or more non-CO₂ fractional treatments being a relatively common regimen.

Although the degree of clinical improvement depends on a variety of factors, including the type of device, operative techniques, skin type, proportion of surface area treated, and fluence, multiple treatments are usually necessary for significant improvement. For acne scarring in particular, more treatments may be required. Studies have shown that with 1550 nm fractionated non-ablative laser, acne scarring can be improved by as much as 50% after four or five treatments spaced 1 month apart, but significant lasting effects are rarely achievable following a single treatment.⁸ Similarly, 3 to 5 treatments may be appropriate for amelioration of periorbital rhytides and photoaging. Patients receiving six or more treatments typically notice the most marked improvement during the last few treatments, as treatment settings are typically elevated with subsequent treatments. If fractional carbon dioxide laser is used, somewhat fewer treatments may be required. For even fewer treatments and more dramatic results, fully ablative carbon dioxide devices can be used, but physicians should keep in mind that these benefits are offset by a longer postoperative downtime.^{17,18} Additionally, full-face carbon dioxide resurfacing is now at the edge of the standard of care, and it may be difficult to justify any adverse events that occur after such treatments in view of the availability of fractional devices.

- *Fractional resurfacing treatments can be spaced a month or more apart, depending on the patient's schedule.*

If a patient is likely to have significant sun exposure, as through outdoor activities in the summer or a vacation to a sunny clime, fractional treatments should be postponed for the duration. Patients should be reassured that the benefit from a prior treatment will not regress or disappear if they do not receive their next treatment as per a prearranged schedule. Treatments should provide a cumulative, stepwise improvement even if they are spaced slightly further apart.

Procedural effects should also be taken into consideration. Fractional CO₂ resurfacing should be done when the patient has an upcoming vacation from work or around the holidays, as treatment typically results in 7 to 10 days of crusting, swelling, and an overall undesirable appearance. Most patients undergoing nonablative treatment feel fine immediately after the procedure, but they may experience 2 to 3 days of postoperative redness and mild edema. Patients are often alarmed by their appearance in a mirror; it is important to prepare patients for the postoperative course before treatment.

Treatment Efficacy

- *Deeper penetrating microthermal zones (MTZs) of fractional injury associated with higher laser fluence (i.e., greater depth) may be better at inducing skin tightening and improving acne scarring, whereas shallower but more*

extensive coverage (i.e., greater density) may be better for improving fine photodamage and dyspigmentation.

Variations in fractional laser device settings can significantly affect posttreatment outcomes, and settings may be selected based on the desired effect. Histologic studies have shown that greater depth of injury is associated with more induction of dermal collagen coagulation and neocollagenesis, which may lead to skin tightening and texture improvement.¹⁹ Treatment of a greater proportion of the skin surface with lower fluences is more successful at targeting dyspigmentation.²⁰ In some cases, specifically those involving darker-skinned patients, photodamage may be better treated with intense, lower density treatments because this may mitigate the risk of postinflammatory hyperpigmentation. For instance, Asian patients with photodamage who received a high-energy, low-density treatment (average fluence 16.3 mJ, density 1000 MTZ/cm²) had a lower prevalence of hyperpigmentation than those who received a low-energy, high-density session (fluence 8.2 mJ, density 2000 MTZ/cm²), with the latter exhibiting greater satisfaction.⁹ To minimize the risk of hyperpigmentation and other undesirable affects, treatment settings are often tailored to the needs and vulnerabilities of individual patients.

- *Fractional resurfacing is of significant utility in treatment of acne scarring, especially ice-pick and box-car scars.*

Although full-face resurfacing is clearly superior to fractional CO₂ resurfacing for deep wrinkles, it may not be superior for treatment of punched-out acne scars. For treatment of such scars, great success has been obtained using fractional CO₂ in Caucasian patients.¹⁷ Noncarbon dioxide fractional lasers have also been reported to create significant improvement in scar appearance. In one study using 1550-nm erbium glass fractional laser, 67% of patients showed more than 50% clinical improvement of acne scars after a series of three treatments.²¹

Because darker-skinned patients are at a high risk of developing transient hyperpigmentation, and given the proven effectiveness of nonablative fractional devices in scar treatment, non-CO₂ fractional resurfacing using low-treatment densities and fluences may be most helpful recommended for scar patients with Fitzpatrick types IV–VI. Settings in this context can be gradually increased over successive treatments.

- *Fractional CO₂ is of significant utility for tightening and wrinkle reduction of the lower eyelids and crow's foot area.*

Fractional CO₂ has been shown to cause significant skin tightening and collagen remodeling for at least 3 months posttreatment^{22,23}—a desired cosmetic effect of patients with lower eyelid rhytids and laxity. Up to 2 to 3 mm of tightening has been achieved. Fractional carbon dioxide resurfacing may also be more effective than nonablative fractional devices at reducing fine lines and improving skin texture. Unlike upper lip lines, periorbital lines are on thin, fragile skin that is susceptible to successful treatment with fractional CO₂ lasers.

A comparative split-face trial assessing fractional CO₂ and a nonablative laser found up to 75% and 25% improvement in periorbital rhytids, respectively.¹⁹ For this reason, fractional CO₂ is often the device of choice for the periorbital area.

To reduce the risk of color mismatch, physicians may choose to limit the treatment area to the “half-moon” under the eyes. Even if the lower eyelid is a little lighter after treatment, the line of demarcation can be concealed at the border of a cosmetic subunit.

- *There are very few studies that compare side-by-side the effectiveness of different fractional systems for treating common problems like scarring, striae, and melasma. Despite the associated additional costs, risk, and inconvenience, fractional CO₂ (“ablative”) resurfacing has not been shown to be associated with markedly greater effectiveness than non-CO₂ (nonablative) fractional resurfacing.*

Although fractional CO₂ lasers have consistently been shown to improve rhytids and photoaging better than nonablative lasers in split-face trials,^{24–26} there is little evidence that CO₂ lasers are superior to nonablative fractional devices in other settings. Both have shown marked improvement in treating scars,^{10,27,28} melasma,^{29,30} and striae^{31,32} but studies comparing the effectiveness of nonablative fractional resurfacing with ablative fractional resurfacing are needed.

Another factor to consider is how many fractional CO₂ treatments are functionally equivalent to one treatment of non-CO₂ fractional treatment. In our opinion, a fractional CO₂ treatment may be as effective as 1, 2, or seldom 3 non-CO₂ fractional treatments, depending on the aggressiveness of the settings used. Of course, any such comparison is contingent also on patient- and device-specific factors, and is further complicated by interdevice variation in patient cost and downtime.

- *There is no answer to the question, “What is the best fractional device for me to buy?”*

The difficulty in comparing various treatment outcomes has been exacerbated by the proliferation of many different laser and light devices used for skin resurfacing, and there are no unbiased operators with expertise in using all of these devices. In general, devices with similar underlying technologies (e.g., fractional CO₂ devices) will work in a similar manner. Because settings are not standardized across all devices, comparisons must use the optimal parameters recommended by the manufacturer for each device. Other considerations when purchasing a device may include the reliability of postsales service and support, the financial soundness of the manufacturer, and the presence or absence of so-called disposables that must be purchased on an ongoing basis in addition to the underlying hardware and software.

Limitations and Long-Term Effects

- *Deep rhytids, like upper lip vertical lines in patients with severe photodamage, may not respond to even aggressive settings of fractional CO₂ laser.*

Fractional devices are known to pose a much lower risk of persistent hypopigmentation, lines of demarcation on the neck, and scarring than traditional full-face nonfractional carbon dioxide resurfacing. Still, fractional resurfacing is limited in its effectiveness. A reasonable compromise may entail nonfractional resurfacing to small, resistant, severely wrinkled areas of the face, followed by supplemental treatment with fractional resurfacing to blend this area. It is also important to recognize the limitations of fractional CO₂ when counseling patients so that they do not have unreasonable expectations of rhytid removal. In this process, it can help to emphasize the many safety benefits of fractional resurfacing, and reiterate the importance of minimizing problematic, permanent adverse events when performing a cosmetic procedure. Finally, the perioral and chin area must be treated with great caution, as these areas may be more susceptible to scarring than the mid-cheek. Although high densities are recommended for deep rhytids, low-density settings should be implemented and slowly increased to minimize scarring.

- *Fractional laser treatments have been shown to cause collagen remodeling and thickening of the dermal collagen, but the long-term histologic consequences are not well described.*

There is clinical evidence of improvement of dyspigmentation and textural abnormality after fractional resurfacing. However, it has been provocatively suggested that some of the associated collagen remodeling may really represent the creation of a dermal scar.²⁸ Histologic studies suggest that thermal or light injury to the dermis initiates a cascade of inflammatory events, including fibroblastic proliferation and upregulation of collagen expression. The collagen deposition then assumes a horizontal orientation parallel to the plane of the epidermis, leading to the appearance of dermal thickening. Although the persistence of the alterations is not known, to date, many patients have received numerous fractional treatments without developing any functional or aesthetic sequelae that would be consistent with widespread dermal scarification.

- *Although fractional resurfacing devices may provide temporary amelioration of melasma, this is not cured with resurfacing, and may recur weeks or months after treatment cessation.*

Although the pathogenesis of melasma is not fully understood, sun avoidance and sun protection remain the mainstay of therapy for melasma. Bleaching agents like topical hydroquinones have also been shown to reduce dyspigmentation.³³ Retinoids may be stopped 1 week prior to treatment as they can blunt the heat shock response, which assists with rapid reepithelialization following tissue injury.

Rapid resolution of melasma has been reported after resurfacing with fractional 1550 nm laser and other devices. In one study involving 10 female patients with melasma, 60% reported 75 to 100% clearance after 4 to 6 treatments.²⁵ However, this can be a short-lived remission, especially if

the causative melanocytes and hormonal profile are still present.³¹ Patients undergoing fractional treatment of melasma should understand that the best that can be expected is usually a transient improvement of a few months, laser can sometimes even worsen melasma, and that permanent cure of melasma is unlikely.

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