Laser Resurfacing
Full Field and Fractional

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INTRODUCTION
Data from The American Society of Aesthetic Plastic Surgery\textsuperscript{1} collected yearly from core specialists since 1997 through 2014 have shown the increase, decrease, and increase again of laser resurfacing. In 2014 more than 583,000 full field and fractional laser resurfacings were performed in core offices making this the fourth most popular procedure overall after botulinum toxins, hyaluronic acid fillers, and laser hair removal.

HISTORY
Full Field Resurfacing
The introduction of carbon dioxide lasers for skin resurfacing in the mid 1990s started the era of laser resurfacing. Lasers quickly replaced chemical peels and dermabration in many offices. These devices are used for full field resurfacing, which means that 100% of the target area from the epidermis down is treated (Fig. 1A). Continuous mode carbon dioxide lasers (10,600 nm) were initially used, but complications due to excessive depths of ablation and thermal damage led to discontinuous or pulsed systems. The water chromophore of the carbon dioxide laser allowed tissue vaporization and left behind in the tissues some resultant thermal injury. The initial discontinuous systems delivered either short pulses (Ultra-pulse laser, Lumenis lasers, Yokneam, Israel) or scanned pulses (Silk-touch and Feather-touch lasers, Lumenis lasers, Yokneam, Israel). Both methods created a short exposure time to ablate tissue (approximately 75–100 μm) and limited the thermal damage (approximately 75–100 μm) that was created with the continuous systems. Spectacular results of eradicating wrinkles and tightening lax tissue were excellent in many patients, but as long-term experience was obtained there was noted to be an unacceptably high hypopigmentation rate. The pigmentary complications, scarring in some patients, and the considerable patient healing period led to the demise of full field carbon dioxide laser resurfacing around the turn of the century.\textsuperscript{1}

Erbium:YAG lasers (2940 nm) have a higher water absorption coefficient than carbon dioxide lasers (about 10 times more efficient) and ablate tissue with much less thermal damage (5–10 μm).\textsuperscript{2} These lasers were introduced around the end of the carbon dioxide full field era and were initially marketed for superficial resurfacing as the initial machines were low powered and it was

KEYWORDS
- Laser resurfacing • Full field resurfacing • Fractional resurfacing • Hybrid fractional laser
- Carbon dioxide laser • Erbium laser • Laser complications

KEY POINTS
- Full field means 100% of the treated area is removed to the selected depth.
- Fractional means discontinuous portions of the treated area are removed.
- Recovery time is linked to the amount of damage created.
- Fractional treatments usually have less downtime than full field treatments.
- Complications can arise with all of these laser treatments.
No zones of spared epidermal tissue remain.

Zones of spared tissue contain clusters of epidermal stem cells and Transit Amplifying (TA) cells

Healing occurs from viable tissue

Fig. 1. (A–C) Full field versus nonablative and ablative fractional resurfacing. SubQ, subcutaneous.
difficult to achieve deeper depths of ablation. Subsequent systems had more significant power and had pattern generators similar to the more advanced carbon dioxide systems. Complications seemed to be less than with carbon dioxide systems, although comparative studies showed recovery time and results to be determined by depth of injury rather than the laser used. Combination systems of carbon dioxide and erbium lasers were also used (Derma-K, Lumenis lasers, Yokneam, Israel).

The authors’ favorite full field laser is the Sciton variable pulse width erbium laser (Sciton Inc, Palo Alto, CA). This device blends the best concepts of the carbon dioxide lasers with the best of the erbium lasers by having a very-high-power erbium laser and by allowing variation of the erbium pulse width, which controls the amount of residual thermal injury. This system creates very precise ablation and where needed/wanted controlled thermal damage (less then with carbon dioxide systems). The clinical results are excellent with a much shorter period of erythema and much lower risk of hypopigmentation (Figs. 2–4).

Other wavelengths for skin resurfacing have been introduced (2780 nm and 2790 nm) (Cutera Lasers, Cutera, Brisbane, CA; Palomar Lasers, Cynosure Inc, Westford, MA) but have not had significant commercial success.

### Fractional Resurfacing

Fractional lasers create an array of injury and treat a fraction of the skin at any one time leaving intact skin bridges adjacent to the treated area (see Fig. 1B). This method differs from full field resurfacing in which 100% of the skin surface treated is removed. Manstein and colleagues introduced this concept in 2004. The first generation of these devices was nonablative and created a zone of desiccated tissue called a microthermal zone (MTZ) (Fig. 5). The first of these devices was at 1550 nm (Reliant technologies, Mountain View, CA, now Solta Medical part of Valeant Pharmaceuticals International). Currently other nonablative wavelengths are also used (1440 nm, 1470 nm, 1540 nm). After an MTZ was created, healing occurred from deeper structures as well as from adjacent structures. This method differs from full field resurfacing in which healing occurred from only deeper structures, that is, hair follicles and sebaceous glands. Deeper treatments and body treatments can safely be performed with nonablative fractional lasers. After the injury was created, the epidermal basal layer was restored within 24 hours and the skin expelled the MTZ over the next week. The expelled MTZ containing melanin was called the microscopic epidermal necrotic debris. New collagen was created and the skin rejuvenated. Advantages of nonablative fractional resurfacing were avoidance of an open wound and very low risk of complications, including pigment disturbance or scarring. Disadvantages include the need for multiple treatments and somewhat less clinical response than with full field ablative resurfacing.

The next advance in laser resurfacing was the development of fractional ablative resurfacing (Fig. 1C). These lasers in wavelengths of carbon dioxide, erbium, and YSGG systems created a column of tissue ablation in the skin instead of a column of desiccated tissue like the fractional nonablative systems (see Fig. 5). The varying fractional ablative devices differ not only in wavelength but also in system power, spot size, and amount of thermal damage created adjacent to and deep to the ablated hole. Carbon dioxide ablative fractional lasers ablate tissue and leave a ring of adjacent thermal tissue. The erbium lasers leave less thermal damage but with usually more bleeding. The Sciton ProFractional erbium fractional laser allows one to vary the amount of thermal damage similarly to their full field system (Fig. 6). Other newer carbon dioxide fractional lasers allow variation of the thermal damage zones (Deka Medical, San Francisco, CA), whereas others allow superficial and deeper penetration with a single scan (Syneron, Yokneam, Israel). These ablative fractional lasers are more efficacious than the nonablative fractional lasers but create more patient healing time albeit much less then the full field ablative variants. Experiments with both ablative and nonablative fractional lasers in same session treatment proved promising.

The Thulium device (1927 nm) by Solta Medical is a nonablative fractional device marketed as especially effective in removing superficial

![Fig. 2. Before and 8 years after full field eyelid resurfacing (Sciton erbium).](image)
pigment. This device is generally used with their nonablative 1550-nm laser.

The newest fractional laser on the market is a hybrid fractional laser made by Sciton (Palo Alto, CA) and called the Halo. This device is very interesting as it allows coincident delivery of first their erbium fractional laser then a nonablative 1440-nm pulse in the same hole. This device is

Fig. 3. Before and 6 years after full field perioral resurfacing (Sciton erbium).

Fig. 4. Before and 3 years after full face full field erbium resurfacing (Sciton erbium).
very efficacious and creates very minimal healing times. This laser is the authors’ laser choice for skin rejuvenation when recovery time is limited (Figs. 6 and 7).

PATIENT SELECTION

Patient selection is critical to successful outcomes. Indications for both full field and fractional
laser resurfacing are superficial dyschromias, textural anomalies, superficial to deep rhytids, acne scars, and surgical scars. Other conditions that may respond favorably include sebaceous hyperplasia, xanthelasma, syringomas, actinic cheilitis, and diffuse actinic keratosis. Melasma has been successfully treated with fractional resurfacing, but results are not consistent. The face is the usual area to be treated, but body and neck skin may be treated with variations of technique. Nonfacial areas lack the appendages necessary for skin rejuvenation, and treatment must be modified to avoid complications. Patients with Fitzpatrick skin types I to IV are generally treated, but the lasers can be used in skin types V and VI with modifications of technique.

The patient assessment includes Fitzpatrick skin type, ethnicity, wrinkles versus pigment, etc, to be treated. Some problems, such as perioral rhytids, may be treated by one deep full field resurfacing; but other pathology, such as acne scarring, responds better to multiple fractional treatments. The patients’ healing period is a very critical component of the laser consultation, as some patients may not be able to spend the week off to heal from a deep full field treatment but may be able to have a few fractional ablative laser treatments with a few periods of limited recovery spaced monthly. Another consideration is laser resurfacing while patients are undergoing other procedures, such as facelift, abdominoplasty, or aesthetic breast surgery. These patients often have built-in downtime from other procedures and have the recovery time available for deep resurfacing.

OVERVIEW OF TREATMENT STRATEGY

Laser Safety

Laser safety is critical to both practitioners and patients. There are excellent published guidelines on laser safety. Specifically relevant to ablative and nonablative resurfacing is the risk of fire and that of eye safety. Fire is an extremely rare occurrence; one must be cognizant not to fire an ablative laser in the presence of exposed oxygen sources, such as nasal cannulas, or test on paper products or gauze. Some recommend the use of wet towels around the patients’ face to prevent a fire hazard.

Eye protection is critical for all personnel and patients. Laser-specific eyewear is used for the treating practitioner and all people in the treatment room. External or internal contact lens–type laser-specific eye shields must be used on patients.

Absolute Contraindications

Active infection

This is pretty much the rule for most of surgery and elective aesthetic procedures should not be performed in the face of active infection. This is true
for bacterial, viral or fungal infections whether localized to the treated area or not.

**Appendageal abnormality**

Patients with abnormalities of the hair follicles and sebaceous glands may have problems with wound healing as laser wounds heal in full field resurfacing from the deep tissues towards the surface from precursor cells in the hair follicles and sebaceous glands and in fractional resurfacing from those areas and adjacent normal tissue. Concurrent or recent oral retinoid use is generally considered an absolute contraindication to laser resurfacing. The data are confusing as to whether fractional resurfacing is safe with oral retinoid use. Most experts agree that it is safe to perform deep full field resurfacing after cessation of oral retinoids with return of sebaceous function a (usually 6 months to 2 years after cessation).

**Skin grafts**

Deep full field resurfacing is contraindicated in the presence of skin grafts, as the appendages mentioned earlier are not present in those areas.

**Extensive electrolysis**

Extensive electrolysis may also be an absolute contraindication for deep full field resurfacing, but fractional or superficial full field resurfacing should be safe.

**Relative Contraindications**

**Unrealistic expectations**

Unrealistic expectations are a problem we deal with regularly in plastic surgery and aesthetic dermatology. Laser resurfacing in all its variations can produce some remarkable results but should not be overstated and oversold. Acne scarring especially can be improved dramatically but may require multiple treatments.

**Keloid or scarring history**

Patients with a history of abnormal scarring may create scars with laser resurfacing. They should be approached with caution, and a test treatment area (test spot) may be helpful.

**Regional resurfacing in darker-skinned individuals**

Deep full field resurfacing in darker-skinned patients may create color differences in adjacent areas. Superficial or fractional regional resurfacing is generally considered safe.

**Previous deep chemical peel**

Caution needs to be taken in patients with previous deep phenol peels as appendages may be damaged and skin may not heal normally.

**History of cold sores**

Patients with a strong history of cold sores need a modified prophylaxis regimen compared with patients with no history of cold sores. This regimen should start earlier, by 2 to 3 days, and extend longer after healing. Even once fully epithelialized, recently resurfaced skin seems to have increased susceptibility to viral infection, unlike bacterial infection risk, which seems largely eliminated by full epithelialization.

**Laser Treatment**

The laser procedure is treated as any other office or operating procedure. Following the initial consultation, a proper history and physical examination is obtained. Informed consent specific to the laser used is obtained. Patients usually start antiviral medications before the procedure. The skin is cleaned of makeup; eye precautions, as outlined earlier, are placed. Most fractional treatments or very superficial full field treatments are usually performed with topical anesthetics and a cold air chiller (Zimmer USA, Zimmer Medizin Systems, Irvine, CA) for added comfort. Deeper full field procedures or aggressive fractional procedures are performed under facial nerve blocks, intravenous (IV) sedation, or general anesthesia. It is very common in the authors’ office to perform deep laser full field resurfacing with an oral benzodiazepine, intramuscular (IM) meperidine, facial blocks, and a Zimmer chiller. General anesthesia or IV sedation (monitored anesthesia care) is usually used when combined with other more invasive procedures. Following the treatment postprocedure care as outlined next is performed.

**Pretreatment and Posttreatment Regimens**

There are numerous pre- and post-treatment regimens. Pretreatment with topical retinoids and bleaching creams is another controversial subject with proponents on either side of this debate with data from chemical peel and laser literature being mixed. The authors’ think that in full field resurfacing greater than 100 μm, the treated melanocytes are ablated so no benefit to pretreatment is seen. In superficial full field and fractional resurfacing, pretreatment may be beneficial in preventing hypopigmentation. Most recommend cessation of these products a few days before treatment.

The use of antiviral prophylaxis is important with ablative resurfacing. There is debate in the literature as to when to start antiviral therapy, with some proposing 3 days before treatment, whereas others recommend starting on the day of treatment. Most agree that therapy should continue until complete re-epithelialization occurs. This time
is laser, patient, and treatment parameter dependent. The use of antiviral therapy with fractional treatments is controversial. The authors recommend its use, as the risk of these medications is low.

Prophylactic antibiotic use is often recommended, although the authors know of no controlled studies of their use. Bacterial infection is extremely rare and is covered in the next section.

After laser treatment there are a myriad of ways to care for the treated skin. For full field procedures most recommend an occlusive ointment or dressing until epithelialization is complete. The authors find that occlusive, work well for carbon dioxide full field resurfacing but are difficult to keep on erbium patients because of the transudate that occurs following this procedure. The authors’ recommendation is to use Aquaphor or Vaseline until epithelialization is complete and then a nonocclusive moisturizer, such as Cetaphil lotion. Deep ablative fractional treatments are usually treated with a similar occlusive regimen for 24 to 48 hours, although some may prefer a nonocclusive dressing because of the incomplete epidermal removal.

Use of sunblock is mandatory for all laser-resurfacing patients in the authors’ practices after epithelialization is complete. The authors also recommend institution of a skin care regimen after epithelialization is complete and the skin has had a chance to calm down, which may mean a few days for fractional treatments to a few weeks for full field treatments. There are many good skin care regimens appropriate after laser resurfacing. The combination of 4% hydroquinone and low-strength tretinoin (Retin-A) is still used, although newer regimens with added growth factors are favored by some. The key is to start these regimens slowly to avoid irritation of the skin (see later discussion: irritant dermatitis).

Complications and Treatment

Infection
Infection after laser resurfacing can be viral, bacterial, or fungal. The most well-known complication is due to herpes simplex virus (Fig. 8). Many patients have been infected previously or are carriers. The current recommendation as outlined earlier is for all patients to be protected against herpes viral infections. Some patients may avoid taking the antiviral medications, whereas others may experience breakthrough infection. The treatment is early recognition of the infection and treatment with oral antiviral agents. For very severe infections with herpes simplex or zoster, IV antiviral medication may be needed.

Fig. 8. Herpes infection after laser resurfacing.

Bacterial infection after laser resurfacing using open treatment is uncommon, but with increasing methicillin-resistant Staphylococcus aureus there have been patients who have had infection after laser resurfacing. The treatment is administration of broad-spectrum antibiotics with culture of the skin and targeted antibiotic treatment after culture results are obtained.

True fungal infection is rare, but infection with yeast (Candida albicans) is common. Patients usually present with an extremely red face with a history of having improvement in the healing and suddenly appearing much redder. Treatment is topical antifungal therapy with a rare need for an oral antifungal medication, such as fluconazole (Diflucan).

Erythema
Erythema after laser resurfacing is a normal part of the inflammatory healing process. It is directly related to depth of laser resurfacing and to the amount of thermal damage created. Some patients will experience an amount of erythema disproportionate to the treatment. They may be left untreated for the erythema to resolve spontaneously (which it will) or else they may be treated with mild topical steroids, light-emitting diode treatments, intense pulsed light (IPL) treatments, or with a vascular laser.

Skin eruptions
Skin eruptions due to acne or milia are common following laser resurfacing. This response may be due to overocclusion with topical products or due to activation of gland function. Acne may be treated with discontinuation of occlusive agents. If this fails, oral antibiotics and/or acne laser treatment with mini-infrared lasers may be used. Milia are treated with opening with a small-gauge needle.

Telangiectasia
Increased appearance of telangiectasia after laser resurfacing is common. This appearance is
due to eradication of overlying photodamage and unmasking of the vasculature. Treatment is with a vascular laser.

**Dermatitis**

Two types of dermatitis are seen following laser resurfacing: irritant and allergic. Irritant dermatitis, as mentioned previously, may be due to starting topical skin care treatments, such as retinoids, too early or too aggressively. Allergic dermatitis is due to true allergy usually to one of the topical agents but may also be due to one of the oral antibiotics. Treatment of both conditions is discontinuation of the offending agent and application of a mild topical steroid.

**Hypopigmentation**

Hypopigmentation is a dreaded complication of deep laser resurfacing and has been reported with both carbon dioxide and erbium treatment and with both full field and fractional treatment. It is not uncommon with deep carbon dioxide resurfacing, with some series reporting up to 70% of patients getting hypopigmentation. It is very rare with deep erbium full field resurfacing and very rare with all fractional treatments. There are not many treatments, but some have reported improvement with excimer laser therapy. Blending, by treating the adjacent area may be helpful.

**Hyperpigmentation**

Postinflammatory pigmentation (PIH) is a very common problem following laser resurfacing (Fig. 9). It is more common in darker skin types and in patients who have had early sun exposure. Prevention as outlined earlier is key. Treatment is with topical bleaching creams (the authors like to combine with retinoids). Failures of this regimen are usually treated with IPL treatments.

**Scarring**

Scarring after laser resurfacing may occur because of overly aggressive full field or fractional treatment, infection, or even scratching by patients (Fig. 10). Full field resurfacing is a controlled first-degree or second-degree burn and anything, such as infection, may convert that controlled second-degree burn into a third-degree burn with resultant scarring. Overaggressive fractional resurfacing may be due to too-deep treatment or too much density, creating a full field defect when a fractional treatment was intended. The authors prefer early treatment of thickened areas that seem to be heading towards scarring with topical potent steroids, such as a pulsed regimen with clobetasol. Intraligosomal steroids, intraligosomal 5-fluorouracil, vascular laser or IPL treatment, and fractional lasers have all been used to improve hypertrophic scars after laser resurfacing.

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**Fig. 9.** Hyperpigmentation after laser resurfacing and correction with skin care.
Ectropion
Ectropion is caused by laser resurfacing by tightening of the lower eyelid skin in the face of a weak lower eyelid canthal support. A snap test or other measurement of lower eyelid laxity is recommended before laser resurfacing. Patients with significant laxity are offered either canthal support surgery (rare) or canthal temporary support (temporary tarsorrhaphy, common).

Synechia
Synechia is caused by healing of 2 epidermal surfaces and appears as a line (usually in the lower eyelid). If untreated this may lead to cyst formation. Treatment is to manually stretch the edges of the synechia until the line opens.

REFERENCES


