Laser Treatment for Improvement and Minimization of Facial Scars

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The psychosocial impact of cutaneous scarring can be profound. Scars inflicted by traumatic incidents, surgical procedures, and severe acne bear a heavy emotional burden on patients, particularly when present on visible areas such as the face.1–3 The quality of life of patients may be affected from aesthetic concerns in addition to chronic symptoms such as pruritus and pain.4 In addition, substantial anxiety and self-consciousness has been noted in men and women when trauma or elective procedures result in even nominal scarring.3,5 Cutaneous injuries that result in scar tissue formation are relatively common and lead patients to seek treatment for cosmetic or functional improvement. It is imperative for physicians to recognize that physical improvement of scars can translate into improved psychosocial well-being and behavior of patients.6,7

Scars are the result of a deviation in the orderly pattern of healing and can be caused by a variety of factors, such as excessive wound tension, improper surgical repair, delayed reepithelialization, or a history of radiation to the affected area. The underlying pathophysiologic mechanism appears to be an imbalance of matrix degradation and collagen biosynthesis.8 An overzealous healing response can create a raised nodule of fibrotic tissue, whereas “pitted” and atrophic scars may result from inadequate replacement of deleted collagen fibers. Although vascular and pigment alterations associated with wound healing are typically transient, the textural changes caused by collagen disruption are often permanent. Histologically, what makes scars unique is the relative absence of skin appendages and elastic fibers—constituents of normal skin that may account for the loss of flexibility seen in scar tissue.9

There are several currently available scar-reducing therapies and many other agents that
may emerge to have the potential to eliminate scarring.10–12 Some of the most commonly used modalities to improve scar appearance include intralesional corticosteroids, 5-fluorouracil, and bleomycin. It is likely that these agents exert their effect on scars by suppressing inflammation and/or collagen production.13–15 Combination therapy is often advocated as a means of increasing efficacy and decreasing total medication dosage, thereby decreasing the likelihood of adverse effects.16,17 Radiation therapy and surgical intervention, particularly in combination with one another, are sometimes used for refractory and recurrent scars.18 Unfortunately, each of these methods has been associated with unacceptably high incidences of scar recurrence and other untoward sequelae such as skin atrophy, dyspigmentation, and pain. Laser scar revision is a safe procedure with clinically demonstrable efficacy and minimal side effects that may be used in combination with the aforementioned scar treatments. The remainder of this article addresses the use of lasers for the treatment of scars.

HISTORY OF LASER SCAR REVISION

The principles of selective photothermolysis help guide the laser surgeon in choosing the proper laser wavelength and treatment parameters for scar revision. Proper scar classification is essential for optimizing treatment results.

Although laser surgery is more than 5 decades old, the field was revolutionized in 1983 when Anderson and Parrish19 elucidated the principles of selective photothermolysis. This basic theory of laser-tissue interaction explains how selective tissue destruction is possible. To effect precise thermal destruction of target tissue without unwanted conduction of heat to surrounding structures, the proper laser wavelength must be selected for preferential absorption by the intended tissue chromophore. Furthermore, the pulse duration of laser emission must be shorter than the thermal relaxation time of the target, thermal relaxation time (T_R) being defined as the amount of time necessary for the targeted structure to cool to one-half of its peak temperature immediately after laser irradiation. The delivered fluence (energy density) must also be sufficiently high to cause the desired degree of thermal injury to the skin. Thus the laser wavelength, pulse duration, and fluence must each be carefully chosen to achieve maximal target ablation while minimizing surrounding tissue damage.

Laser systems are versatile tools that allow for a broad range of cutaneous maladies to be treated. Scar improvement with a pulsed dye laser (PDL) was first reported in 1993,20 and over the past decade laser scar revision has progressed tremendously, due to advances in technology. Laser treatment of scars is optimized by proper scar categorization. Several qualities of the scar including size, color, texture, and prior treatments influence choice of laser wavelength and treatment parameters.

SCAR CLASSIFICATION

Take-home points: Clinical appearance of scars

- Categorization of scars by clinical appearance can be difficult, but is a helpful guide to proper laser treatment
- Although similar in many respects, hypertrophic scars and keloids should be distinguished from one another to optimize clinical outcome
- Atrophic scars are dermal depressions and result in significant contour abnormalities
- Recognition of skin prone to scarring is one tool of evaluation that can be helpful in scar prevention

Numerous scar classification systems and evaluation tools have been described.21–24 At present, no universal model for objective scar assessment has been accepted.25 In medical literature, scars are often analyzed by their etiology, the most common sources being surgery, trauma, burns, and acne or inflammatory processes. For the purposes of practicality and ease in treatment selection, the authors advocate scar classification as determined by clinical appearance rather than by causation.

Hypertrophic scars are erythematous, raised, firm nodular growths that occur more commonly in areas subject to increased pressure or movement or in body sites that exhibit slow wound healing. The growth of hypertrophic scars is limited to the site of original tissue injury, unlike keloids, which proliferate beyond the boundaries of the initial wound and often continue to grow without regression. Keloids present as deep reddish-purple papules and nodules, often on the earlobes, anterior chest, shoulders, and upper back. These lesions are more common in darker-skinned
Lasers were subsequently studied on hypertrophic scars and keloids with early promising results, but high recurrence rates were observed. It was not until PDLs were studied that it was shown that scar size, erythema, pliability, pruritus, and texture could be improved. A wealth of published clinical data over 2 decades has shown that PDL is effective for all forms of hypertrophic scarring and keloids, regardless of etiology. Burn scars, steroidotomy scars, acne scars, and facial scars resulting from cutaneous surgery all appear to respond well to PDL. As a consequence of this research, the laser of choice in treating hypertrophic scars and keloids is the vascular-specific 585-nm PDL (Fig. 1).

There is no consensus on the precise mechanism whereby the PDL exerts its effect on scars. The PDL has been demonstrated to reduce expression of transforming growth factor-β, fibroblast proliferation, and collagen type III deposition. Other plausible explanations include selective photothermolysis of vasculature, released mast cell constituents (such as histamine and interleukins) that could affect collagen metabolism, and the heating of collagen fibers and breaking of disulfide bonds with subsequent collagen realignment.

Scar revision with the PDL is typically performed on an outpatient basis without anesthesia. All persons present in the room must wear protective eyewear capable of filtering light of 585 to 595 nm to avoid retinal damage.

Any concern regarding patient response to treatment should prompt a test spot or patch in a small area before irradiation of the entire lesion. If postoperative crusting or vesiculation is observed, the fluence applied on subsequent visits should be decreased and retreatment postponed until the skin has completely healed. The fluence and pulse duration can be adjusted if scar proliferation continues despite laser irradiation. Generally speaking, higher fluences and shorter pulse durations result in improved scar size and pliability. However, more aggressive laser settings must be carefully considered in patients with darker skin and for scars in more delicate or thin-skinned locations (eg, eyelids, neck, chest). The use of concomitant intralesional corticosteroids or 5-fluorouracil has been shown to provide additional benefit in proliferative scars. Intraleisonal injections of corticosteroids (20 mg/mL triamcinolone) are more easily delivered immediately after (rather than before) PDL irradiation because the laser-irradiated scar becomes edematous (making needle penetration easier). An additional consideration is that when steroid injection is performed before laser irradiation the skin blanches, rendering the skin a potentially less amenable target for vascular-specific irradiation.

Atrophic scars, on the other hand, are dermal depressions that result from an acute inflammatory process affecting the skin, such as cystic acne or varicella. The inflammation associated with atrophic scars leads to collagen destruction with dermal atrophy. Surgery or other forms of skin trauma may also result in atrophic scars, which are initially erythematous and become increasingly hypopigmented and fibrotic over time. Based on their width, depth, and 3-dimensional architecture, acne scars are sometimes further subclassified into icepick, rolling, and boxcar scars.

Prescars are early wounds in scar-prone skin. Prophylactic or early laser treatment of traumatized skin concomitant with or shortly after cutaneous wounding has been shown to reduce or even prevent scar formation in patients at high risk for scarring. Laser therapy may improve the appearance of wounded skin by promoting better collagen organization in healing wounds.

**LASER SCAR REVISION**

**Hypertrophic Scars and Keloids**

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**Take-home points: Pulsed dye laser**

- PDL is the laser of choice for hypertrophic scars and keloids, though the mechanism by which it works is yet to be fully elucidated.
- PDL may be used alone or in combination with other scar treatments.
- PDL is relatively safe, but a series of treatments is often necessary.
- The most common adverse events of PDL irradiation are transient purpura and hyperpigmentation.

Detailed reviews of laser scar revision have previously been published. Early in vitro experimentation with a 1064-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser demonstrated that fibroblasts irradiated with this wavelength produced decreased amounts of collagen. The Nd:YAG, argon, and carbon dioxide (CO₂) lasers were subsequently studied on hypertrophic
The most common side effect of treatment with the PDL is postoperative purpura, which often persists for several days. Pulse durations shorter than 6 milliseconds are almost certain to bruise the skin. Edema of treated skin may also occur, but usually subsides within 48 hours. A topical healing ointment under a nonstick bandage can be applied for the first few postoperative days to protect the skin. Treated areas should be gently cleansed daily with water and mild soap. Strict sun avoidance and photoprotection should be advocated between treatment sessions to reduce the risk of pigment alteration. Hyperpigmentation has been reported with varying frequencies (1%–24%). If skin darkening occurs, further laser treatment should be suspended until resolution of the dyspigmentation has occurred in order to reduce the risk of cutaneous melanin interference with laser energy penetration. Topical bleaching agents (such as hydroquinone or kojic acid) may be applied to hasten pigment resolution.

Although no studies regarding the use of 532-nm potassium titanyl phosphate (KTP) lasers have been published, some practitioners advocate their use for erythematous scars because of their ability to reduce erythema. Similarly, intense pulsed light systems have been demonstrated to improve scar erythema. The 532-nm frequency-doubled Q-switched Nd:YAG may be used to treat pigmented hypertrophic scars. Vaporization of keloid scars by CO2 laser irradiation almost universally results in scar recurrences, but there is growing evidence that fractional lasers may improve hypertrophic scarring (see later discussions).

### Atrophic Scars

#### Ablative lasers
Successful recontouring of atrophic scars has been achieved with CO2 or erbium:yttrium-aluminum-garnet (Er:YAG or erbium) laser vaporization. Although other treatments such as dermabrasion and injection of various filler materials can also be used for atrophic scars, their operator-dependent efficacy and side-effect profile, as well as temporary clinical effect (in the case of most filler injections), limit their usefulness and widespread acceptance for the longer term.
What popularized laser skin resurfacing treatment for atrophic scar revision was its ability to selectively and reproducibly vaporize skin with improved operator control and clinical efficacy.\textsuperscript{60–63} Clinical and histologic comparisons with dermabrasion and chemical peels showed that a predictable amount of skin vaporization and residual thermal damage could only be achieved through lasers, thereby demonstrating the superiority of laser treatment for skin resurfacing.\textsuperscript{64}

\textsuperscript{CO}_2\textsuperscript{ and Er:YAG lasers work to selectively heat and vaporize superficial skin by emitting energy that is absorbed by intracellular tissue water. Cutaneous laser resurfacing produces an additional skin-tightening benefit through controlled heating of dermal collagen. The depth of ablation correlates directly with the number of passes performed, and usually is confined to the epidermis and upper papillary dermis; however, stacking of laser pulses by treating an area with multiple passes in rapid succession or by using a high overlap setting on a scanning device can lead to excessive thermal injury with subsequent increased risk of scarring.\textsuperscript{65} An ablative plateau is reached with less effective tissue ablation and accumulation of thermal injury due to reduced tissue water content after initial desiccation. The avoidance of pulse stacking and incomplete removal of partially desiccated tissue is paramount to prevention of excessive thermal accumulation with any laser system. Persistent collagen shrinkage and dermal remodeling are responsible for much of the continued clinical

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<td>• Fully ablative and fractional laser systems are the systems of choice to improve atrophic scars</td>
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<td>• The choice of laser is primarily determined by the severity of scarring and the patient’s ability to tolerate postoperative recovery</td>
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<td>• It appears that ablative and nonablative fractional lasers produce similar clinical results to ablative lasers with significantly fewer adverse effects</td>
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\textsuperscript{Fig. 1. Hypertrophic scars on the nose before (left) and after 2 pulsed dye laser (PDL) treatments (right).}
benefits observed after ablative laser resurfacing. The photothermal effect of ablative lasers on the skin account for shrinkage of collagen and noticeable clinical skin tightening, as well as neocollagenesis and collagen remodeling that leads to marked reduction of skin textural irregularities.66

Laser treatment of atrophic scars is aimed at reducing the depth of the scar borders and stimulating neocollagenesis to fill in the depressions. Although spot (or local) vaporization of isolated scars is a viable treatment option, extended treatment (at least an entire cosmetic unit) is recommended for more widely distributed defects to avoid obvious lines of demarcation between treated and untreated sites. In addition, treatment of a larger surface area increases the overall collagen-tightening effect, thereby improving clinical response by making scars appear shallower.

Absolute contraindications to ablative laser skin resurfacing include an active cutaneous bacterial, viral, or fungal infection. Patients with an inflammatory skin condition (eg, psoriasis, eczema) involving the skin areas to be treated should be avoided. Isotretinoin use within the preceding 6-month period and a history of keloids are also considered contraindications to ablative laser treatment because of the unpredictable tissue-healing response and greater risk for scarring.67 Ablative laser scar revision is typically performed on an outpatient basis and requires a thoughtful approach by both doctor and patient, including thorough preoperative counseling related to the postoperative recovery period. All persons in the room must be wearing protective eyewear. If patients are wearing protective contact lens shields, sandblasted metal ones must be chosen because plastic shields do not meet safety standards for ocular protection during periorcular laser irradiation. The concave surface of the shields should be liberally lubricated with an ophthalmic ointment, and care must be taken while inserting and removing the shields so as to prevent corneal abrasions.

Immediately after ablation the vaporized skin appears erythematous and edematous, with copious serous discharge and generalized worsening of the skin’s appearance over the first few days. It is imperative that patients be monitored closely for appropriate healing responses and potential complications, such as dermatitis or infection, during the 7- to 10-day reepithelialization process.68–70 Full-face procedures or large treatment areas often necessitate the use of prophylactic antibiotics.

### How I Do It: Ablative lasers for atrophic scars

- The ideal patient for ablative laser skin resurfacing has a fair complexion (skin phototype I or II), although darker skin tones may also be treated.
- Various anesthetic options can be employed, including topical, intralesional, intravenous, and general anesthesia.
- In general, larger treatment areas (eg, full face) require the use of intravenous or general anesthesia for maximal patient comfort.
- Prophylactic antibiotics may be used for full-face procedures or large treatment areas.
- When choosing treatment parameters, the surgeon must consider factors such as the anatomic location to be resurfaced, the skin phototype of the patient, and previous treatments delivered to the area.
- The requisite protective eyewear and other safety precautions (eg, smoke evacuator to capture laser plume) should be used.
- The CO2 laser is generally used at fluences of 250 to 350 mJ to ablate the epidermis in a single pass.
- Short-pulsed Er:YAG lasers that are operated at 5 to 15 J/cm2 often require several passes to result in a similar depth of penetration as CO2, whereas longer-pulsed Er:YAG systems can be operated at higher fluences (22.5 J/cm2) to achieve comparable results in a single pass.
- Areas with thinner skin (eg, periorbital) require fewer laser passes and nonfacial (eg, neck, chest) laser resurfacing should be avoided, due to the relative paucity of pilosebaceous units in these areas.
- Because of their depth and fibrotic nature, most atrophic scars will require at least 2 laser passes regardless of the laser system chosen for treatment.
- It is important that any partially desiccated tissue be removed with saline-soaked or water-soaked gauze between laser passes for char formation to be avoided.
- Patients should be seen in-office within 24 to 48 hours then at weekly intervals for 1 month for close monitoring of adverse events.
antibiotics and/or antiviral medications to reduce the risk of infection. The use of topical antibiotics is avoided because of the potential development of contact dermatitis. Application of topical ointments, semiocclusive dressings, and/or cooling masks promote healing and reduce swelling.

Postoperative erythema typically lasts several weeks after ablative laser treatment, due to tissue necrosis. Hyperpigmentation is transient and generally appears 3 to 4 weeks after treatment. Its resolution can be hastened with the use of topical bleaching agents. Although hyperpigmentation is relatively common (particularly in patients with darker skin tones), hypopigmentation is rare. The most severe complications of ablative skin resurfacing include hypertrophic scarring and ectropion formation, both related to overly aggressive laser techniques and/or undiagnosed/uncontrolled suprainfections. Hypertrophic burn scars can be effectively treated with the PDL as previously described, whereas ectropion typically requires surgical reconstruction. Retreatment without epidermal disruption has been observed after the series completed postoperative recovery associated with the skin. The wound-healing response differs from that after ablative laser techniques because the epidermis contains viable keratinocytes at the lateral margin of the MTZ. The necrotic debris exfoliates over the next several days, producing a bronzed appearance to the skin. The wound-healing response differs from that after ablative laser techniques because the epidermis is treated during a single session. Significant clinical improvement can be obtained after ablative laser treatment.

### Nonablative lasers

As a consequence of the side effects and prolonged postoperative recovery associated with ablative laser treatment, nonablative lasers were subsequently developed to provide a noninvasive option for atrophic scar revision. The most popular and widely used of these nonablative systems include the 1320-nm Nd:YAG, 1450-nm diode, and 1064-nm Nd:YAG lasers. These devices deliver concomitant epidermal surface cooling with deeply penetrating infrared wavelengths that target tissue water and stimulate collagen production via controlled dermal heating without epidermal disruption. A series of 3 to 5 treatments are typically performed on a monthly basis, with optimal clinical efficacy appreciated several (3–6) months after the final laser treatment session. Sustained clinical improvement of scars by 40% to 50% has been observed after the series of treatments. The low side-effect profile of these nonablative systems (limited to local erythema and edema and, rarely, vesiculation or herpes simplex reactivation) compensates for their reduced clinical efficacy (relative to ablative lasers).

### Fractional lasers

Due to a need for more noticeable clinical improvement than the aforementioned nonablative systems, fractional photothermolysis was developed. In its relatively short history, fractional laser technology has progressed rapidly, with nearly 30 commercially available fractional systems on the market. These laser systems may best be classified into two categories: (1) nonablative fractional lasers (NAFL) and (2) ablative fractional lasers (AFL).

The initial fractional laser (Fraxel; Reliant Technologies, Mountain View, CA, USA) involved the use of a mid-infrared (1550 nm) wavelength erbium-doped fiber laser to create microscopic noncontiguous columns of thermal injury in the skin. The spatially precise columns of thermal injury produce localized epidermal necrosis and collagen denaturation at 125 or 250 MTZ/cm². Because the tissue surrounding each MTZ is intact, residual epidermal and dermal cells contribute to rapid healing. Maintenance of the stratum corneum ensures continued epidermal barrier function. Histologic evaluation of the MTZ demonstrates homogenization of the dermal matrix and the presence of epidermal necrotic debris, representing the extrusion of damaged epidermal keratinocytes by viable keratinocytes at the lateral margin of the MTZ. The necrotic debris exfoliates over the next several days, producing a bronzed appearance to the skin. The wound-healing response differs from that after ablative laser techniques because the epidermis contains viable transient amplifying cells capable of rapid re-epithelialization. Furthermore, because the stratum corneum has low water content, it remains intact immediately after treatment. Therefore, the coagulative wound created by NAFL resurfacing is unique and not simply that of an ablative laser used to make “holes” in the skin. In addition, NAFL resurfacing can provide an advantage over purely nonablative laser treatments, due to the gradual exfoliation of the epidermis with resultant improvement in superficial dyspigmentation. A series of NAFL treatments is required to achieve optimal clinical improvement because only a fraction of the skin is treated during a single session.

Significant clinical improvement can be obtained when nonablative fractional photothermolysis is applied to atrophic facial acne scars of mild to moderate severity. After a series of 3 consecutive NAFL treatments, clinical improvement of 50% or more is observed in acne scars (Fig. 2). Similar results have been obtained in scars resulting from other injuries, including surgery and burns (Fig. 3). Patients are treated on a monthly basis, with greater clinical improvement seen with successive treatments. It has been shown that higher energy settings and multiple laser passes translate into improved clinical results while...
Fig. 2. Atrophic facial acne scars before (left) and after 3 consecutive monthly nonablative fractional laser (NAFL) treatments (right).

Fig. 3. Surgical facial scar before (left) and after one combination 585-nm PDL and NAFL treatment (right).
increased density is more likely to result in increased rates and severity of erythema, edema, and hyperpigmentation. By contrast, AFLs (fractionated CO₂ and erbium lasers) not only create similar columns of thermal coagulation through the epidermis and dermis, but also vaporize the stratum corneum. Because of the absence of a protective cap overlying the coagulated columnar regions, the immediate postoperative appearance of treated areas appear more similar to an ablative treatment than that observed with NAFL. Unlike fully ablative treatments, AFLs not only deliver sufficient energy to effect immediate contraction, but intact islands of viable epidermis that facilitate rapid healing remain post treatment. Intense erythema and serosanguinous drainage are evident for 2 to 3 days, followed by complete re-reepithelialization and diminution of erythema by days 6 or 7.

A variety of atrophic scars on facial and nonfacial skin can be improved significantly by AFL resurfacing techniques (Fig. 4). Clinical improvement of atrophic scarring results from collagen contraction and neocollagenesis. Given that AFL energy penetrates more deeply (1.5–1.6 mm) into the dermis, it is likely that these systems will prove to be more effective than NAFLs for atrophic scars. Thermal burn injuries have also shown textural improvement of skin after AFL treatment.

While the ideal patient for fractional laser skin resurfacing has a fair complexion (skin phototype I, II, or III), darker skin tones (IV–VI) can also be treated. Adequate preoperative patient evaluation and education are necessary to discern unrealistic patient expectations, avoid pitfalls, and optimize clinical outcomes. Prolonged postoperative recovery, pigmentary alteration, or unexpected scarring is much less likely to occur with fractionated technology than with fully ablative lasers, but patients must nevertheless be forewarned. For patients unable or unwilling to withstand the anticipated 3 to 7 days of postoperative healing, a series of nonablative (fractionated or infrared) laser procedures may be a more suitable choice.

Fig. 4. Atrophic facial acne scars before (left) and several months after one ablative fractional laser (AFL) skin resurfacing treatment (right).
The optimal settings will vary depending on the laser used and the severity and type of scarring present. Higher energy settings may result in improved clinical efficacy, but are also associated with increased adverse events (pain, erythema, postoperative dyspigmentation). Patients who receive NAFL treatment should use a mild cleanser and moisturizer several times daily for

### How I Do It: Fractional lasers for atrophic scars

- The ideal patient for fractional laser skin resurfacing has a fair complexion (skin phototype I, II, or III), but darker skin tones (IV–VI) can also be treated.
- Adequate preoperative patient evaluation and education are essential.
- Sun exposure should be avoided prior to treatment in order to decrease the risk of postoperative dyspigmentation.
- For patients with a strong history of herpes labialis, prophylactic oral antiviral medications should be considered when treating the perioral skin. Reactivation of prior herpes simplex infection can occur despite absence of an external wound, due to the intense dermal heat produced by the laser.
- The treatment areas should be cleansed of debris (including dirt, makeup, and powder) using a mild cleanser and 70% alcohol.
- A topical anesthetic cream is applied to the treatment sites for 60 minutes before treatment. For full-face AFL treatments oral sedation, nerve blocks, tumescent anesthesia, topical anesthetic creams, and intravenous sedation may be required.
- NAFL treatment is delivered concomitantly with forced air cooling. The most commonly used NAFL (Fraxel re:store) is employed at energy settings of 40 to 60 mJ but may be increased to as high as 70 mJ. Total energies of 3 to 5 kJ are typically applied for full-face treatment. Retreatments with gradually higher fluences should be performed at 4-week intervals until patients are satisfied with clinical outcomes (typically 3 to 5 sessions are necessary to produce substantial clinical improvement).
- AFL devices often require only one treatment but reappraisal of photodamage, rhytides, or scarring can be performed at the 6- to 12-month postoperative period and, if necessary, a second AFL treatment can be performed if clinically warranted. Settings for a commonly used AFL (Fraxel re:pair) range from 20 to 100 mJ with treatment densities of 600 to 1600 MTZ/cm². The Lumenis system (Total Fx) has 2 heads with variable energies (Deep FX: 15–25 mJ, Active FX: 80–125 mJ) and densities (Deep FX: 10%–15%, Active RX: 1%–3%) depending on the severity of scarring.
- Optimal treatment settings vary depending on the laser used and the severity of each individual’s scarring. There is evidence that suggests patient satisfaction and clinical results improve with increasing fluences. Increased postoperative adverse events (pain, erythema, dyspigmentation) are more often observed when higher treatment densities are selected.
- Patients who receive NAFL treatment should use a mild cleanser and moisturizer several times daily for the first few days after each treatment session (or as long as bronzing/xerosis is apparent). Sun exposure should be avoided during this time.
- Postoperative erythema resolves spontaneously, but its intensity and duration may be reduced by immediate treatment with a 590-nm wavelength light-emitting diode (LED) array.
- Those who receive treatment with an AFL must undergo open-wound or closed-wound care as previously described for the first several postoperative days. Thereafter, patients can slowly resume the use of their regular skin-care products.
- Adverse events reported with fractional lasers:

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<td>Delayed purpura</td>
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<td>Superficial erosions</td>
<td>Eruptive keratoacanthomas</td>
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<td>Contact dermatitis</td>
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the first few days after each treatment session (or as long as bronzing/xerosis is apparent). Sun exposure should be avoided during this time. Postoperative erythema resolves spontaneously but its intensity and duration may be reduced by immediate treatment with a 590-nm wavelength LED array. On the other hand, those who receive treatment with an AFL must undergo open-wound or closed-wound care as previously described for the first several postoperative days. Thereafter, patients can slowly resume the use of their regular skin-care products.

Patients who undergo NAFL sessions on a monthly basis show progressive improvement with each successive treatment. Skin resurfacing with AFL does not require as many sessions to observe clinical improvement. Most patients require only 1 or 2 AFL treatments at 6- to 12-months intervals. It is has been theorized that the enhanced clinical effects of AFLs are related to their ability to penetrate more deeply into the skin compared with fully ablative lasers and NAFLs, and also to a prolonged wound remodeling response of several months’ duration.

Fractional skin resurfacing is associated with a relatively low complication rate. Most untoward events of NAFL treatment are mild and transient, including erythema, periorcular edema, xerosis, and slight darkening of the skin (bronzing) during desquamation of the microscopic epidermal necrotic debris. The most commonly encountered adverse events reported are acneiform and herpetic eruptions in fewer than 2% of patients. Postinflammatory hyperpigmentation may also occur, particularly in patients with darker skin phototypes. Intense erythema, serosanguinous drainage, and crust are typical for 5 to 7 days after AFL treatment (compared with 2 to 3 days with NAFL). Caution must be advised when treating skin in areas that are thin or devoid of pilosebaceous units. Although rare, hypertrophic scarring of the neck, chest, and periorcular regions has been reported with AFLs, so overly aggressive treatment settings should be avoided in these sensitive anatomic sites. To date, permanent pigmentary alteration has not been reported. Other exceedingly rare adverse events such as eruptive keratoacanthomas and recall phenomenon also have been reported. Table 1 presents fractional laser side effects and complications.

**SUMMARY**

Cutaneous injuries that result in scar tissue formation are a result of overly exuberant wound healing. Scars are relatively common and lead patients to seek treatment for cosmetic or functional improvement. At present, the many medical treatments that are available for these maladies often prove inadequate or inconvenient. It is precisely for these

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<td><strong>Side Effect/Complication</strong></td>
<td><strong>When to Look for It</strong></td>
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| Prolonged erythema | 1 month+ | • Avoid use of irritating topicals  
• Apply mild corticosteroid  
• LED photomodulation |
| Milia/acne exacerbation | 1 month+ | • Discontinue occlusive dressings/ointments  
• Physical extraction of milia  
• Oral antibiotics for acne |
| Contact/allergic dermatitis | Any time | • Discontinue allergen/irritant  
• Topical/oral corticosteroid  
• Oral antihistamine |
| Infection | 1–14 days | • Take appropriate cultures  
• Oral antibacterial/antiviral  
• Topical wound care |
| Hyperpigmentation | 1 month+ | • Topical lighteners  
• Mild chemical peels  
• Sunscreen |
| Hypopigmentation | 6 months+ | • Excimer laser  
• Topical photochemotherapy |
| Hypertrophic scar | 1 month+ | • Potent topical corticosteroid  
• Pulsed dye laser |
| Ectropion | 1 month+ | • Surgical correction |
Fig. 5. Clinical algorithm to facial scarring. AFL, ablative fractional laser; NAFL, nonablative fractional laser; PDL, pulsed dye laser.
reasons that laser therapy has been investigated for improvement of scars and ulcerations.

There are several laser systems available that permit successful treatment of various types of scars, and Fig. 5 displays the laser scar revision treatment algorithm. The 585-nm PDL remains the gold standard for laser treatment of hypertrophic scars and keloids. In addition, the PDL has been shown to lead to more rapid healing of pre-scars. Atrophic scars may best be treated with ablative and fractionally ablative and nonablative laser systems, depending on the specific circumstances of each patient. Nonablative systems, although less clinically efficacious, may be used in patients desiring a treatment with reduced post-operative recovery. Laser scar revision is optimized when individual patient and scar characteristics are thoroughly evaluated to determine the best course of treatment and, more importantly, to determine whether the patient and physician share realistic expectations and treatment goals.

REFERENCES