

LASER RESURFACING OF ATROPHIC SCARS

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Lasers have taken on an increasingly important role for a large variety of cosmetic applications. The rapid development and refinement of an array of new laser systems have led to the tremendous popularity of lasers as a treatment modality for a variety of skin conditions. In many cases, physicians are able to achieve better cosmetic results with the use of lasers when compared with other surgical modalities. The high-energy, pulsed CO₂ laser is one of several currently available laser systems that safely provides highly reproducible and predictable results with low morbidity when proper techniques are employed. This laser system has proven to be a useful modality in the treatment of atrophic scarring resulting from acne, trauma, and surgery.

ATROPHIC SCARS

Any surgical procedure may result in a scar. Scars secondary to trauma or surgery may be either atrophic or hypertrophic depending on age, race, anatomic location, and type of procedure or injury. Scarring is a common sequela of conditions that affect a significant number of people, including acne vulgaris and varicella. Many patients seek treatment for the disfigurement caused by obvious variations in skin texture secondary to scarring.

Many different procedures, alone and in combination, have been used in an attempt to correct atrophic scarring. Chemical peels have been used to treat superficial scars. Excision, punch grafting, and tissue augmentation with a variety of filling materials have been implemented for atrophic and ice pick scars.* Dermabrasion has long been considered to be the most definitive treatment for atrophic and pitted scars secondary to acne.^{14, 28, 33, 36, 43, 45} Each of these treatment modalities is limited by various factors including poor visualization during surgery, transmission of infectious particles, incomplete lesion removal, fibrosis and scarring, permanent pigmentary alteration, and the necessity for repeated treatments.^{1, 41}

HIGH-ENERGY, SHORT PULSED CO₂ LASERS

The recent development of CO₂ lasers using high peak powers and short pulse durations allows for diminished thermal conduction to normal cutaneous structures by limiting the pulse duration to a period of time shorter than the thermal relaxation time of water-containing tissue.^{6, 9, 10, 13, 17, 22, 40} A multitude of cutaneous lesions can be eliminated by skin resurfacing with these pulsed laser systems that minimize damage to normal skin struc-

*References 6, 8, 18, 23, 27, 29, 30, 32, 34, 35, 37, and 38.

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tures by vaporizing lesional tissue faster than heat can be conducted to the surrounding area.^{4, 11, 12, 26, 39} The advantage of the newest, high-energy pulsed or scanned CO₂ lasers in comparison with more conventional treatment modalities lies in their ability to precisely vaporize predictable and reproducible amounts of tissue with each progressive laser pass. The vaporization is accomplished in a bloodless and char-free field until the endpoint of a smooth, even skin surface is achieved. With proper surgical technique and diligent postoperative care, postoperative pain and edema can be minimized following the resurfacing treatment. Similar to dermabrasion, the mechanism of CO₂ laser resurfacing involves regeneration of epidermis and dermis as well as collagen remodeling. Treatment with the CO₂ laser also exerts a thermal effect on collagen that results in collagen shrinkage and may be responsible for improvement attained even following relatively superficial ablation.¹⁸ Atrophic scars resulting from acne, surgery, or trauma respond more favorably to laser resurfacing than to other more conventional forms of treatment.^{1, 5, 15, 16}

TREATMENT INDICATIONS AND PATIENT SELECTION

Atrophic or pitted facial scars secondary to acne, trauma, or surgery are amenable to high-energy, pulsed or scanned CO₂ laser resurfacing with a high likelihood of significant improvement and minimal risk of scarring, permanent pigmentary change, or other adverse sequelae (Table 1).^{2, 3, 5, 8} Hypertrophic or keloid scars do not respond well to laser resurfacing owing to the high risk of recurrence and are thus best treated with the 585-

nm pulsed dye laser (see the article by Dr. Alster elsewhere in this issue). Acne patients seeking treatment for atrophic scars should be treated with standard topical and oral acne medications, including antibiotics, retinoic or azelaic acid, and benzoyl peroxide, to induce remission of any active inflammatory lesions prior to resurfacing. It is important to ensure that patients have a clear understanding of the expected treatment result. Patients who expect to have perfectly smooth facial skin following treatment are poor candidates for any resurfacing procedure. It is highly advisable to show patients photographs representative of typical preoperative and postoperative clinical appearances in order to educate them on the limitations of the procedure.^{2, 42}

Although fair-skinned (Fitzpatrick phototypes I and II) patients represent ideal candidates for cutaneous laser resurfacing, individuals with darker skin tones are also suitable.^{5, 16, 42} In the largest published series of CO₂ laser resurfacing to date, Alster and Garg reported persistent erythema lasting 2 to 3 months following UltraPulse (Coherent Laser Corp, Palo Alto, CA) laser resurfacing of facial rhytides in 259 patients. Thirty percent of treated patients, representing all skin types, experienced transient hyperpigmentation that cleared in 3 to 4 months with the application of hydroquinone-containing creams.³ Ho et al treated 30 Asian and Hispanic patients for facial rhytides and acne scars with the UltraPulse or SilkTouch CO₂ laser (Sharplan Laser Corp, Allendale, NJ). They reported persistent erythema lasting an average of 6 weeks as the most common undesired sequela of laser treatment. The frequency of hyperpigmentation following laser resurfacing was reduced with the adjunctive use of preoperative and postoperative tretinoin, hydroquinone, and desonide creams as well as a broad-spectrum sunscreen following treatment. The authors concluded that the risk of dyspigmentation can be reduced when proper preoperative and postoperative management is implemented. It is important to note, however, that they treated a small test spot in each resurfacing candidate prior to treating large areas in order to evaluate each patient's tendency for scarring and dyspigmentation. They excluded from their series those patients who showed prolonged erythema, hyperpigmentation, or hypopigmentation in the test area.¹⁶ It is incumbent on the treating physician, therefore, to ensure that patients with darker skin tones fully under-

Table 1. LASER RESURFACING OF ATROPHIC SCARS: INDICATIONS AND CONTRAINDICATIONS FOR TREATMENT

Indications	Absolute Contraindications	Relative Contraindications
Acne scars	Oral retinoid use	Dark skin tone
Surgical scars	Keloid former	Ultraviolet light exposure
Traumatic scars	Concurrent bacterial or viral infection	Fibrosis from prior treatment
	Unrealistic patient expectations	Immunologic or other deficiency
		Active acneiform lesions

stand the high likelihood of postinflammatory hyperpigmentation that may persist for up to 6 months postoperatively. Treatment and observation of a small test area of the face may be prudent prior to treating an entire cosmetic unit in order for both patient and physician to develop realistic expectations.

There is evidence that poor wound healing and unpredictable scarring may occur when any resurfacing procedure is performed within 2 years of treatment with oral retinoids.^{31, 44} Some authors suggest that 6 months to 1 year may be an adequate interval between oral retinoid therapy and cutaneous laser resurfacing.² Patients who have received other forms of treatment such as dermabrasion, chemical peel, or silicone injections that have resulted in tissue fibrosis may have less predictable improvement following laser resurfacing.^{2, 42}

Assessment of the suitability of a candidate for laser resurfacing should include consideration of the patient's lifestyle. Patients who work outside or spend a large proportion of their recreational time involved in outdoor sports may find it difficult to avoid sun exposure for the required 2 to 3 months following laser resurfacing. Although these patients need not necessarily be excluded from treatment, it is important to insist that they apply sunscreens routinely.

INFORMED CONSENT AND PREOPERATIVE INSTRUCTIONS

Once the physician has determined that the patient is a suitable candidate for laser resurfacing, complete verbal and written explanations are given regarding the laser procedure, expected length of surgery, method of anesthesia delivery, and postoperative activity and wound care. Possible complications of treatment are discussed and outlined on the consent form (Table 2). The consent form should include a release for preoperative and postoperative photography. Patients are encouraged to view an educational video outlining the procedure and postoperative course, in addition to representative preoperative and postoperative photographs of patients who have undergone the procedure.

The patient is given a comprehensive list of instructions regarding the pre-laser and post-laser resurfacing treatment program. When full-face resurfacing is performed, all patients are treated with a prophylactic

Table 2. POSSIBLE COMPLICATIONS FOLLOWING HIGH-ENERGY PULSED CO₂ LASER RESURFACING

Tissue fibrosis or hypertrophic scar formation
Pigmentary alteration (hyperpigmentation or hypopigmentation)
Infection (bacterial, viral, or fungal)
Persistent erythema and skin sensitivity
Demarcation lines or patches
Ectropion formation
Milia development
Exacerbation of acne
Koebnerization of pre-existing condition (ie, vitiligo, psoriasis, eczema, verrucae)
Allergy to topical ointments or oral medications

course of acyclovir or famciclovir. For more limited treatment areas, antiviral agents are given only to those patients with a prior history of facial herpes simplex virus infection. The antiviral medication is started 24 hours prior to the procedure and is continued for a total of 7 to 10 days, until complete re-epithelialization occurs. Sun exposure and tanning are contraindicated prior to treatment and during the first few months following laser surgery. The patient is advised to arrange time off from work and social obligations during the 7 to 10 days following treatment. Medications are phoned in to the patient's pharmacy 24 to 48 hours prior to the procedure so that they can be picked up before surgery. Patients are instructed to have a responsible adult accompany them on the day of laser surgery in order to ensure that they get home safely following the procedure. In addition, they are encouraged to arrange for capable help during the first 24 to 48 hours following the procedure to assist with ambulation, local postoperative skin care, and medications.

ANESTHESIA

Topical, local (including tumescent and regional nerve blocks), or intravenous anesthesia, or a combination thereof, may be used to achieve an adequate level of comfort during the laser procedure. For full-face resurfacing procedures, a combination of trigeminal nerve blocks and intravenous anesthesia decreases the total amount of intravenous sedation required, thereby reducing the risk of adverse effects secondary to the intravenous anesthetic. For resurfacing of limited areas, local anesthesia is administered either intralesionally or as a nerve block. Because the

tumescent effect of local anesthesia may obscure subtle variations in skin topography, areas on which treatment is to be focused should be outlined with a marking pen prior to infiltration of anesthesia. When intravenous anesthesia is administered, it is highly advisable to employ an anesthesiologist or certified nurse anesthetist for its delivery. Adequate anesthesia is typically achieved with the use of propofol, fentanyl, midazolam, or ketamine. Appropriate monitoring equipment, including an electrocardiogram, oxygen saturation, and blood pressure monitor, should be used. In addition, an emergency cart, complete with Ambu bag, resuscitation medications, and functioning electrocardioversion device, should be available.

LASER RESURFACING TECHNIQUE

Even when atrophic scars are localized to a small area of the face, it is always preferable to lase the entire cosmetic unit or the face in its entirety, because the treated area will appear distinctly different from the surrounding skin in texture and, transiently, in color. Treating the cosmetic unit as a whole thus minimizes the perception of these differences. Skin preparation immediately prior to the procedure includes a total facial scrub to remove makeup and debris. Alcohol-containing preparations are contraindicated owing to their flammability. Hair-bearing areas are protected with wet towels or gauze. The patient is provided with either protective eyeshields or goggles, depending on whether the periocular areas are treated. Nonreflective metal eyeshields are mandatory when the periorbital regions are lasered in order to prevent ocular injury.

Using either the 3-mm collimated handpiece or a computerized pattern generator (CPG) (Coherent Laser Corp, Palo Alto, CA) or scanning device (Sharplan Laser Corp, Allendale, NJ), one to three complete laser passes are performed over the cosmetic unit or full face without overlapping treatment spots. The coagulated skin is manually removed after each laser pass with saline-soaked gauze. Scars become more clearly defined following the first laser pass, appearing as white, slightly depressed areas. Further passes are made around and across the scars in a "sculpting" fashion, allowing the dermis to visibly contract around each scar. The treatment endpoint of relative scar effacement can be determined readily owing to the absence

of bleeding or char formation. It is important not to overtreat individual scars, because this may actually make them appear more prominent. The treated scars will continue to show improvement in texture for up to 12 to 18 months following the procedure because of the continued remodeling of collagen.

With the Coherent UltraPulse laser system, the physician may elect to use either the 3-mm collimated handpiece or CPG handpiece, or both, during the procedure. The 3-mm collimated beam is best used at energies of 350 to 500 mJ and powers of 3 to 7 W, with a total of one to three passes generally required to efface atrophic scars. When using the CPG, the device should be set at a density of 4 to 6 and a pattern of the physician's choice at a diameter of 6 to 8 mm. One to two laser passes are usually required at settings of 300 mJ of energy and 60 W of power. Treating the full face or cosmetic unit first with the scanning device (CPG) and then tracing over individual scar borders with the smaller, more easily manipulated collimated handpiece is an efficient treatment method. When the SilkTouch laser is used for resurfacing, the parameters producing the desired tissue response include a power of 5 to 7 W with a 0.2-second pulse duration for spot sizes 2 to 4 mm and power of 15 W with a 0.2-second pulse duration for a 6-mm spot size. Other CO₂ resurfacing laser systems that are currently available include the TruPulse (Tissue Technologies, Albuquerque, NM) and NovaPulse (Luxar Corporation, Bothell, WA) laser systems. Little has been reported regarding the use of the latter two systems in the treatment of scars. It is expected that with proper use they could also effectively improve these lesions.

Immediately following treatment, a topical ointment, such as Catrx 10, Aquaphor, Theraplex, or light petrolatum should be liberally applied. The use of antibiotic ointment on newly laser-resurfaced skin has been associated with a high degree of sensitivity.^{2, 20} Some surgeons prefer to use a semioclusive biosynthetic dressing such as Second Skin (Spenco Medical Corp, Waco, TX) or Flexzan (Dow Hickman Pharmaceuticals, Sugarland, TX); however, the use of these dressings may increase the risk of secondary infection. In either case, hydration with occlusion optimizes healing and re-epithelialization and minimizes postoperative pain.^{1, 25, 42}

POSTOPERATIVE CARE

When full-face laser resurfacing is performed or when large areas of the face are

treated, the patient is given an intravenous dose of a broad-spectrum antibiotic (cefazolin) at the completion of the laser procedure. Oral antibiotic prophylaxis with gram-positive coverage (ie, azithromycin) is initiated on the day of treatment and continued for 5 to 7 days. Acyclovir or famciclovir is started 24 hours prior to the resurfacing procedure in patients with a history of herpes simplex infection and in all patients undergoing full-face resurfacing regardless of their history. The medication is continued at a dosage of 400 mg three times daily (acyclovir) or 125 mg twice daily (famciclovir) until complete epithelialization has occurred (7–10 days). In order to minimize postoperative edema, patients receiving treatment to the full face or to large areas are given a dose of intravenous methylprednisolone at the time of completion of laser treatment. The patient is prescribed a tapering methylprednisolone dose pack beginning with six 10-mg tablets following the procedure and tapering by 10 mg daily for a total of 6 days. For all patients, regardless of the extent of laser resurfacing, postoperative pain control is achieved by administration of oral analgesics and nighttime sedatives.

Patients are instructed to keep their head elevated for the first few nights and while resting in order to reduce swelling. Immediate post-laser resurfacing skin care includes the continuous use of ice, cool gel packs, or cold compresses at least every 1 to 2 hours while awake for the first 3 days following surgery. Packages of frozen peas or corn contour well to the face and are easy for the patient to use. On the fourth postoperative day, the patient is instructed to begin gently washing the treated area with a mild, non-abrasive cleanser and cool water. An office visit is scheduled on day 4 and generally at 1, 2, 4, and 8 weeks postoperatively depending on individual patient response. Telephone triage by a competent nurse may improve office efficiency by providing the patient with reassurance and reviewing postoperative skin care and comfort measures. In addition, a physician experienced in laser treatment should be available at all times to reassure patients and to answer questions.

Experienced estheticians in the office provide post-laser skin care, including gentle debridement with dilute hydrogen peroxide or saline compresses and mild steam hydration beginning on postoperative day 4. Once re-epithelialization has occurred, the patient is provided with a makeup application session

in order to learn the technique of applying appropriate camouflage makeup. Residual erythema can be covered with camouflage makeup only when there is no longer evidence of oozing or crusting.^{2, 21} Using this postoperative regimen, most patients feel comfortable returning to their usual activities, including work, by the second postoperative week.

CLINICAL RESULTS

In a report of 13 patients with skin types III and IV who underwent CO₂ laser resurfacing for acne scars, 10 patients were treated with the UltraPulse laser and 3 were treated with the Sharplan SilkTouch flashscanner.¹⁶ The authors treated the "shoulders" of scars first with one to four laser passes, followed by one laser pass to the whole cosmetic unit, or vice versa. A 25% average improvement following one laser treatment was reported, with saucer-shaped scars responding better than ice-pick scars. These authors postulated that deeper scars would possibly show greater response to punch excision or punch grafting prior to laser resurfacing.

In one recent study of 50 patients with skin phototypes I to V and moderate-to-severe atrophic facial acne scars treated with a high-energy, pulsed CO₂ laser, blinded assessor ratings found overall clinical improvement following laser scar treatment to average 81.4% (Figs. 1 and 2). Two to five laser passes over the scarred areas were delivered in this study using a 3-mm collimated handpiece. Skin texture analyses of the laser-irradiated scars showed a return of normal skin surface markings and were comparable with those analyses obtained in normal adjacent skin. All patients were followed for 6 months with no evidence of scar recurrence or worsening.⁵ To the contrary, a continued clinical improvement in atrophic scars is observed for at least 1 year following the resurfacing procedure (unpublished observation). This phenomenon is probably based on collagen remodeling, which begins during the final phase of wound healing and during which the dermis responds to injury with the production of collagen and matrix proteins.^{7, 19} Similar clinical results are achieved following laser resurfacing of traumatic scars (Figs. 3 and 4).



Figure 1. *A*, Atrophic acne scarring. *B*, Six months following full-face CO₂ laser resurfacing.

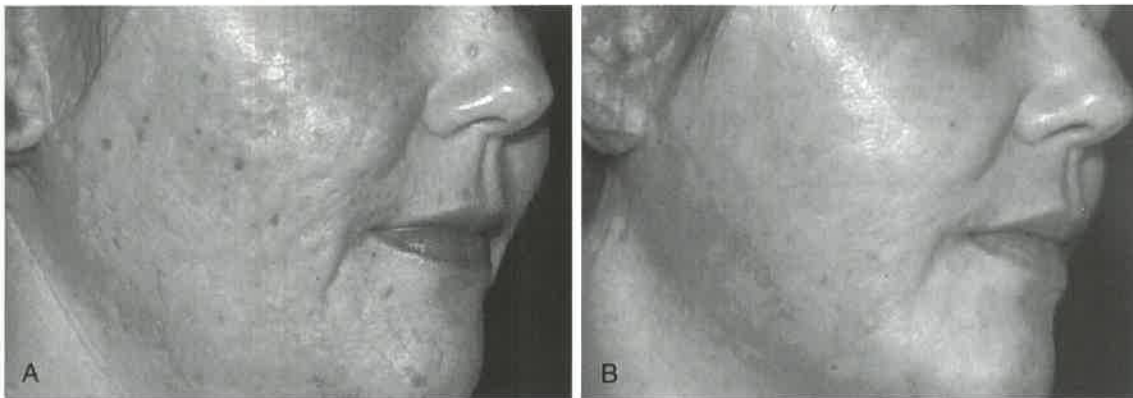


Figure 2. *A*, Atrophic acne scarring. *B*, Three months following full-face CO₂ laser resurfacing.

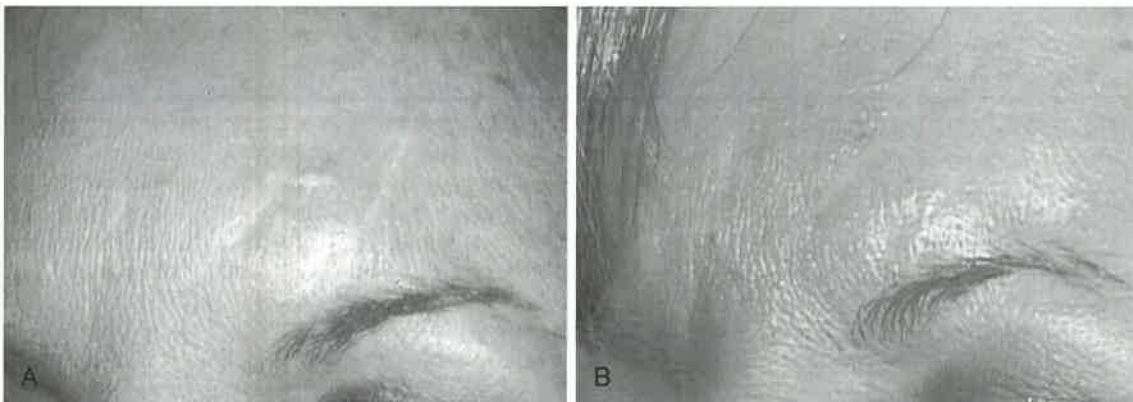


Figure 3. *A*, Traumatic forehead scar. *B*, Four months following laser resurfacing.

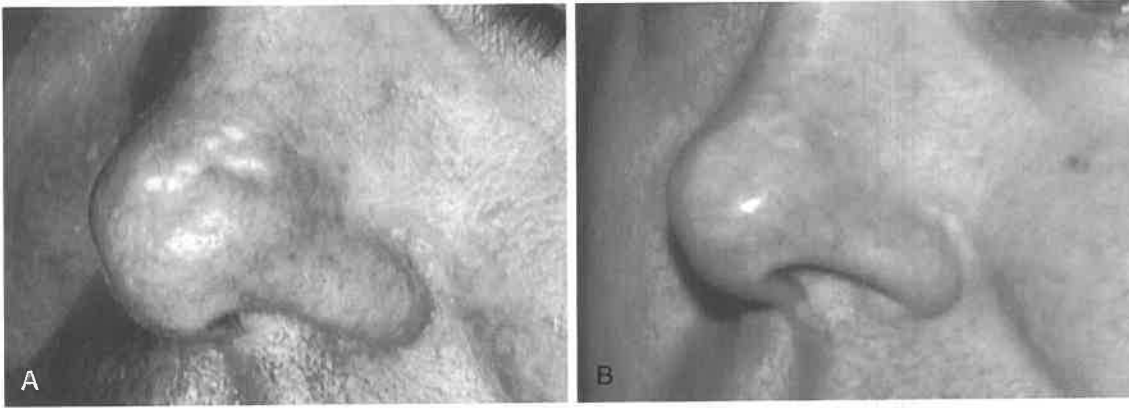


Figure 4. A, Atrophic scar secondary to herpes zoster. B, Six months following laser resurfacing.

SIDE EFFECTS

Fortunately, side effects are uncommon following high-energy pulsed or scanned CO₂ laser surgery. Erythema, typically lasting 4 weeks to 4 months and sometimes 6 to 9 months, is expected and should not be regarded as a complication of treatment. Prolonged erythema with tissue induration and tenderness usually is indicative of early hypertrophic scarring. Milia and acne may occur temporarily, especially if occlusive ointments are used postoperatively in acne-prone skin. The addition of retinoic or glycolic acid to the postoperative regimen may reduce milia formation.⁴² Standard oral antibiotics traditionally used for the treatment of acne may be instituted for postoperative exacerbations of acne lesions.

As with any surgical procedure, infection is a possible complication of laser resurfacing. The use of occlusive or semiocclusive dressings rather than ointments alone following laser resurfacing may predispose patients to infection. Culture and sensitivity testing is indicated when infection is suspected, and the patient should be placed on broad-spectrum oral antibiotics. Herpes simplex virus reactivation may occur despite oral antiviral prophylaxis, in which case the oral dosage should be increased and diligent local care instituted.

Hyperpigmentation is not uncommon, occurring in 30% or more of patients within 4 to 6 weeks postoperatively. Although patients with olive skin tones are more likely to hyperpigment, this side effect can occur in any patient undergoing cutaneous laser resurfacing.^{2, 5} Although most cases of hyperpigmentation will eventually resolve spontane-

ously, the fading process typically takes several months. Treatment with hydroquinone-containing preparations, compounded with glycolic, retinoic, or azelaic acid and hydrocortisone, in addition to diligent sunscreen use, will hasten resolution.^{2, 21, 24} A series of light (30% glycolic acid) chemical peels may also hasten the resolution of hyperpigmentation. Hypopigmentation, a common sequela of dermabrasion, has been reported infrequently as a delayed complication of laser resurfacing. It is usually not seen until several months following the laser procedure and seems to occur more commonly in areas treated with a greater number of laser passes. In addition, areas predisposed to hypopigmentation include the oral commissures and areas of skin that have been previously treated by other modalities, including dermabrasion and phenol peels. Hypopigmentation, which has been commonly associated with dermabrasion, may be attributed to deeper follicular melanocyte injury than that which routinely occurs during laser resurfacing alone.¹⁶ Although a series of superficial chemical peels may improve the overall appearance of the skin surrounding these areas of hypopigmentation, the pigment loss appears to be permanent.

In general, the controlled tissue ablative properties and visualization of treatment endpoints with the use of the high-energy, pulsed, or scanned CO₂ lasers greatly reduce the risk of scarring associated with resurfacing. As with all resurfacing techniques, however, scarring may occur if the procedure is performed without awareness of depth of dermal penetration or with excessive thermal damage of the remaining nonvaporized skin. When this complication occurs, distinct areas

of fibrosis with or without hypertrophy are usually evident within 3 to 4 weeks following laser treatment. As mentioned previously, the risk of scarring may be increased in patients who have been treated with oral retinoids within the preceding 2 years as well as in those patients who develop postoperative bacterial or herpetic infection.^{31, 42, 44}

CONCLUSION

Laser resurfacing of atrophic facial scarring is clinically significant and is of tremendous importance to patients who suffer from the sequelae of some earlier inflammatory condition or physical trauma. Although continuous wave CO₂ lasers have been used for tissue vaporization for many years, their use for cutaneous resurfacing was limited by heat conduction to surrounding tissues with resultant scarring. With the advent of high-energy pulsed and scanned CO₂ laser technology, precisely controlled, layer-by-layer tissue vaporization may be achieved with minimal thermal damage to adjacent normal skin when the correct laser parameters and techniques are employed. This advance in laser technology has simplified performance of cutaneous resurfacing while minimizing adverse sequelae to the patient.

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