Aesthetic CO₂ Laser Surgery: Evaluation of 907 Patients

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Resurfacing the skin to improve skin quality is an important concept in aesthetic plastic surgery. Although time-honored methods (e.g., dermabrasion and chemical peel) are available for this purpose, they have several disadvantages. A newer method with a high-energy pulsed carbon dioxide laser provides a more controllable and more predictable method of resurfacing facial skin.

In our study of 907 patients, monitored up to 2 years, 868 laser resurfacing procedures were done for facial wrinkles. Eight hundred two of 868 (92.4%) achieved very good to excellent results (>75% removal of wrinkles in 92.4% of cases). Forty-six of 61 (75.4%) patients with acne scars also obtained very good to excellent results. Most patients with selected skin lesions (rhinophyma, actinic cheilitis, epidermal nevi, seborrheic keratoses, syringomas, xanthelasmas, and postsurgical scars) achieved good to excellent results, although these are admittedly more difficult to quantify.

Major complications were uncommon. One hundred one of 907 (11.1%) patients had development of temporary hyperpigmentation, which resolved in an average of 2.6 weeks. Thirty-four of 907 (3.8%) patients had development of mild permanent hypopigmentation. Eight of 908 (0.9%) patients had development of some induration that resolved with use of intrallesional steroids. Most of these (5 of 8) were in the perioral area. Three of 907 (0.3%) patients had development of a small persistent scar. Seven of 316 (2%) patients undergoing periorbital resurfacing had development of some mild scleral show. Early in our experience one patient developed ectropion that required surgical correction.

We conclude that the new generation high-energy pulsed carbon dioxide laser is safe and effective for resurfacing facial skin. However, this procedure is very technique dependent and requires a combination of didactic and hands-on training, conservative surgical judgment, and diligent patient follow-up to obtain optimal results with minimal complications.

Introduction

Rejuvenation of the skin is an important aspect of aesthetic facial surgery. Many patients...
Table 1

Breakdown of laser procedures

| Procedure                                         | Numbers of each aesthetic unit |
|--------------------------------------------------|-------------------------------|
| Resurfacing for facial wrinkles                  | 868                           |
| Perioral                                          | 482                           |
| Periorbital                                       | 316                           |
| Total face                                        | 62                            |
| Forehead                                         | 35                            |
| Cheeks                                           | 15                            |
| Resurfacing with other facial aesthetic surgery   |                               |
| Blepharoplasty and periorbital resurfacing       | 271                           |
| Face lift and regional resurfacing (not cheeks)   | 27                            |
| Endoscopic brow lift and forehead resurfacing    | 18                            |
| Resurfacing for acne scarring                    | 61                            |
| Other lesions & early surgical scars              | 51                            |

These numbers total more than 907 because some patients had more than one procedure.

Table 2

Rating system

| Rating    | Percent of improvement in wrinkles/lesions/acne/scars |
|-----------|--------------------------------------------------------|
| Excellent | ≥95%                                                   |
| Very good | 75% to 94%                                             |
| Fair      | 50% to 74%                                             |
| Poor      | <50%                                                   |

Carbon dioxide lasers, emitting light at 10,600 nm, have become an important tool in dermatology and, more recently, in aesthetic plastic surgery. Because the carbon dioxide laser beam is predominantly absorbed by water, it has become a useful tool in resurfacing the skin (90% of the epidermal content is water). Continuous-wave CO₂ lasers have been available for more than a decade but never gained wide acceptance for resurfacing the skin because of the long duration of exposure, allowing thermal diffusion of the laser energy into tissue, which causes an unacceptably wide zone of thermal damage. The time needed for reduction of temperature at any site by 50% is known as thermal relaxation time, and for the superficial layer of skin is estimated at 700 to 1000 μsec. A familiar example of this is that if one passes a finger through a candle flame fast enough, there is no burn, and in fact, no heat is felt. Thus if a CO₂ laser could develop enough energy to vaporize skin in less than 900 μsec, the target skin could be vaporized, causing only minimal thermal damage to the adjacent underlying skin. This concept led to the development of the new generation of high-energy pulsed lasers, with pulse widths of less than 900 μsec. The first laser to achieve this was the Ultrapulse® (Coherent, Inc., Palo Alto, CA), which is the laser used by the authors of this report. Other CO₂ lasers are available today, each having different operating systems and physical characteristics. Our experience is limited to the Ultrapulse® laser, and because of the differences among lasers, it is unknown at present whether our data and results can be applied to other devices.

One of the major advantages of facial skin resurfacing with the CO₂ laser is the immediate visible dermal tightening. This gives visual assessment of the degree of surface correction, adding an element of control and predictability not available with any chemical peel or dermabrasion.

Patients and Methods

Nine hundred seven patients underwent CO₂ laser resurfacing. The patients elected the procedures shown in Table 1.

There were 814 females and 93 males ranging in age from 3 to 86 years. The evaluation of all patients was carried out with predetermined criteria (Table 2) and included review of charts and preoperative and postoperative slides and/or an interview in person. Eighty percent of all patients in the American series were evaluated in person.

A random subgroup of the American patients who underwent operation by one of the authors (T. L. R.) was asked to rate their own satisfaction with their results. These responses were reported to one of the other authors (J. A.), who was not involved in the surgery or postoperative care.

Anesthesia

All patients undergoing CO₂ laser blepharoplasty associ-
Table 3
Results at 5 to 24 months

| Resurfacing for wrinkles | N  | Excellent (65.2%) | Very good (27.2%) | Fair (7.5%) | Poor |
|--------------------------|----|------------------|-------------------|-------------|------|
| All facial areas         | 868| 566              | 236               | 65          | 1    |
| Perioral                 | 482| 412 (85.5%)      | 66 (13.7%)        | 4 (0.8%)    | 0    |
| Periorbital + laser blepharoplasty | 271 | 181 (66.8%)      | 82 (30.3%)        | 8 (3%)     | 0    |
| Forehead                 | 17 | 5 (29.4%)        | 6 (35.3%)         | 6 (35.3%)  | 0    |
| Acne scarring            | 61 | 17 (27.9%)       | 29 (47.5%)        | 15 (24.6%) | 0    |
| Lesions/ surgical scars  | 51 | 39 (76.5%)       | 11 (21.5%)        | 1 (2%)     | 0    |

ated with periorbital resurfacing were given intravenous sedation with a combination of midazolam, fentanyl, and/or propofol. Direct local anesthetic infiltration of the upper and lower eyelids was performed with lidocaine (Xylocaine) or Xylocaine and bupivacaine (Marcaine), both with epinephrine. Tetracaine eyedrops were also used. Patients undergoing resurfacing required a combination of nerve blocks and local infiltration.

**Laser Safety**

During blepharoplasty, the globe was protected by use of a sandblasted David-Baker clamp (upper eyelid), or Jaeger stainless steel plate (lower eyelid), and a stainless steel shield for the contralateral eye. During resurfacing, the eyes were protected with either wet gauze (if resurfacing was not near the eyes) or sandblasted stainless steel eye shields. To minimize the risk of fire from an unplanned triggering of the laser, the patient’s head was surrounded with either crumpled sterile aluminum foil (to diffuse the beam) or wet sterile towels (to absorb the beam). Oxygen cannula or endotracheal tubes, if used, were wrapped with sterile aluminum foil.

**Preparation**

All patients were washed with aqueous chlorhexidine or benzalkonium chloride (Zephiran). Use of volatile solutions, such as acetone or alcohol, were avoided.

**Carbon Dioxide Laser Blepharoplasty**

For laser blepharoplasty, the laser was set in the continuous-wave mode at 5 to 8 W, except when making the upper lid skin incision, for which the laser was set in the pulsed mode at 15 mJ and 4 W. A 0.2 mm spot size was used in the focused mode for incision and defocused mode for hemostasis. In the early phase of this study, resurfacing of the skin was performed with the Coherent Ultrapulse® laser with a 3 mm collimated handpiece. At first, maximum energy available on the machine was 250 mJ per pulse. In the last year of the study, an upgrade to 500 mJ per pulse became available and was used routinely after this time. An effort was made to overlap the spots by approximately 20% to avoid gaps between spots. In the last 6 months of the study, the scanner (computerized pattern generator) became available, and it was used at similar fluence (300 mJ through its 2.25 mm spot size). This scanner delivers 81 pulses over 120 mm² in 0.3 seconds, increasing the uniformity and speed of the procedure. The scanner was set at a density of 5 to 7 (clinically apparent overlap of spots of 20% to 30%).

**Periorbital Region**

Early in the study, 250 mJ per pulse at 2 to 3 W was used. Later 500 mJ per pulse was used, and finally, with the scanner at 300 mJ, density 5 to 7. On the eyelid, one complete pass was made. If a second pass was necessary, it was always made at half the energy or half the density. On the crow’s feet, two or three complete passes were made depending on the depth of the wrinkles.

**All Other Facial Aesthetic Units**

In the early study, we used 250 mJ per pulse at 2 to 5 W, with the 3 mm spot size. Later 500 mJ per pulse was used at 3 to 10 W. The scanner was used at equivalent fluence during the last 6 months (300 mJ, density 5 to 7).

**Technique**

Patients with wrinkles or acne scarring underwent treat-
ment of a complete aesthetic unit. Spot resurfacing was only performed for small isolated skin lesions or scars.

In the early phase of the study, when the manual 3 mm handpiece was used, the complete cosmetic unit was treated by resurfacing perpendicular to the wrinkle lines or scar. On the first pass, 10% to 20% overlap was achieved. The vaporized epidermal debris was then removed with gauze soaked in saline solution. The skin was not allowed to desiccate during the procedure. After the first pass, only abnormal areas were treated on subsequent passes. The laser beam was again passed across wrinkle lines or acne scars with 20% to 30% overlap. Feathering at the edges of laser-treated areas was performed on each pass by decreasing the fluence with the manual handpiece. After the introduction of the scanner, it was rarely necessary to work the individual wrinkle shoulders and valleys. Instead, additional passes were made with the larger patterns in the areas where wrinkles remained.

**Postoperative Dressing**

All laser-treated areas were dressed with a semipermeable dressing with nonconfluent adhesive (Flexzan®, Dow-Hickman, Sugarland, TX). Dressings were changed when necessary, usually after the first 24 hours. Subsequently, the dressing adhered to the treated area and lifted when reepithelialization was complete (approximately 7 to 10 days, depending on the depth of the resurfacing). No antibiotic ointments were used because of the high incidence of contact dermatitis when applied to the healing skin.

**Postoperative Medication**

All patients were given oral cephalosporin for 5 days. After the initial phase of our study revealed a 3% incidence of acute herpes simplex, even in patients with no prior history, we began requiring a 10-day course of acyclovir 400 mg three times daily administered by mouth for all patients, beginning 2 days before operation. Patients who had full facial resurfacing were given dexamethasone (Decadron®) 8 mg intravenously during and after operation followed by an oral Decadron® taper. A mild analgesic was used, if necessary, for pain.

When reepithelialization was complete, topical steroid cream (clobetasol propionate [Temovate-E®]) twice daily was used intermittently (10 days on and 4 days off) for two or three cycles to reduce erythema. If hyperpigmentation occurred after operation, 4% hydroquinone and glycolic acid or 0.1% retinoic acid was used twice daily until cleared. A sunscreen was used by all patients for 3 months after operation to decrease the risk of hyperpigmentation.

**Results**

Table 3 shows the results for all patients. Very good to excellent results, that is >74% improvement, were obtained in 92.4% of all patients treated for facial wrinkles (Figures 1 and 2). Perioral and periorbital areas responded best (99.2% and 97.1%, respectively) (Figures 3 and 4). Only 67.4% of patients with forehead wrinkles achieved this degree of improvement. Because all forehead wrinkles are dynamic (produced by muscle activity)
and tend to be deeper, it is not surprising that the results in this region were not as good.

Patients with acne scarring obtained very good to excellent results in 75.4% of cases (Figure 5). As expected, superficial acne scars responded better than deeper scars, although all of the cases showed significant improvement.

With selected facial skin lesions (rhinophyma, actinic cheilitis, syringomas, xanthelasma, epidermal nevus, actinic keratoses, hemangioma, seborrheic keratoses, and dermatosis papulosa nigra), all patients but one achieved very good to excellent results (Figure 6). Patients with actinic cheilitis obtained excellent results with quicker healing (average 3 to 4 weeks) than with the older continuous-wave or superpulsed CO₂ laser. Patients with rhinophyma responded better after treatment with the continuous-wave mode. All patients with postsurgical scars obtained very good to excellent results when CO₂ laser resurfacing was used 6 to 8 weeks after the initial surgical procedure. This was visible as blurring of the surgical scar and blending with surrounding skin.

Complications

Erythema
All patients had some degree of erythema. The scale ranged from a pink color ("mild" erythema) to a very intense red color ("severe" erythema). None of the patients had "severe" erythema. Erythema was "moderate" in 16% (145/907) of patients and "mild" in 83.8% (760/907). No erythema was noticeable in 0.2% (2/907) of patients. The mean duration of the erythema was 11 weeks.

Pain/Discomfort
Mild discomfort was more commonly reported than true "pain." None of the patients required strong analgesia,
97.5% (886/907) of patients required no analgesia, 2.3% (21/907) of patients required mild analgesia, and 0.2% (2/907) of patients required moderate analgesia.

Hypermegmentation
A significant number of patients (11%, 100/907) had development of transient (defined as less than 120 days after operation) hyperpigmentation. Only 0.1% (1/907) of patients had persistent (greater than 120 days) hyperpigmentation. Hyperpigmentation was treated with topical hydroquinone and/or retinoic acid.

Hypopigmentation
Transient (less than 120 days after operation) hypopigmentation occurred in 2% (18/907) of patients, whereas persistent (greater than 120 days) hypopigmentation was observed in 3.7% (34/907) of patients. All cases of hypopigmentation were less severe than the “porcelain” white hypopigmentation that has been observed after phenol peels.*

Pruritus
Seventeen percent of patients reported mild pruritus, which generally resolved within 2 weeks after operation. Antihistamines or ice compresses were used in some patients.

Synechia
These small epithelial bridges were observed in 0.8% (7/907) of patients and occurred 3 to 11 days after operation, during reepithelialization.

Induration
Most cases of induration occurred on the upper lip. This problem was noted in 0.9% (8/907) of patients.

Scar
Three patients had development of small scars. These

*After completion of this study, longer-term follow-up suggests that the incidence of hypopigmentation is approximately 10%.
occurred on the lower eyelid, lip (Figure 7), and cheek. The latter patient underwent a cheek laser resurfacing combined with a face lift with wide subcutaneous undermining.

**Acute Herpes Simplex**
Before the administration of prophylactic acyclovir (Zovirax®), the incidence was 3%, but with the prophylaxis the incidence was reduced to less than 1%.

**Scleral Show**
Transient (less than 120 days after operation) scleral show was observed in 2.5% (8/316) of patients. Persistent (greater than 120 days after operation) scleral show, less than 1 mm, was observed in 1.9% (7/316) of patients. Persistent scleral show, greater than 1 mm, was observed in 0.3% (1/316) of patients.

**Ectropion**
Ectropion was observed in one patient (0.3%, 1/316) in whom preoperative lid laxity was overlooked. Ectropion resolved after a lateral canthal suspension procedure was performed.

**Acne**
One patient (0.1%, 1/907) had development of active acne under the dressing.

**Milia**
Milia was observed in 7.2% (68/907) of patients and was treated by unroofing the lesions.

**Patient Satisfaction**
Patients were asked to judge their results 5 to 24 months after operation, using the same criteria we used (Figure 8). Ninety-three percent of patients with resurfacing of various facial units and 91% of patients with periorbital resurfacing believed that more than 74% improvement was achieved with this laser procedure. Ten of the patients had a previous chemical peel (trichloroacetic acid or phenol). All 10 of these patients preferred the laser treatment over chemical peel because of better results, less hypopigmentation, and/or less discomfort.

**Discussion**
Although time-honored methods are currently available for resurfacing skin, these have some disadvantages. Dermabrasion is a bloody procedure, making it difficult to visualize end points. The greatest disadvantage of dermabrasion is the potential for the blood aerosol to remain in the air for as long as 48 hours after the procedure.20 This places the operating room personnel and other patients at risk of contracting human immunodeficiency virus, hepatitis B, and hepatitis C.21 Moreover, dermabrasion is technically difficult to learn and teach, and few surgeons would risk dermabrasion on the eyelids.22

Chemical peeling with phenol and trichloroacetic acid is essentially a blind technique. The end result depends on multiple variables, and, consequently, can be inconsistent. Factors such as pretreatment with retinoic acid, acetone, or glycolic acid, number of applications, heaviness of application, and postoperative taping may influence the final result.23-25

Phenol may cause systemic toxicity and commonly produces postoperative pain and hypopigmentation.23 Trichloroacetic acid in higher concentrations, that is,
>40%, has a poor safety margin and can cause scarring.\textsuperscript{26} In addition to this, trichloroacetic acid is not very effective against deep perioral wrinkles.

\textsuperscript{26} CO\textsubscript{2} lasers have been used for more than three decades and have more recently been of value in some incisional cosmetic surgery, especially blepharoplasty.\textsuperscript{13-19,27} However, the continuous-wave and superpulse CO\textsubscript{2} laser were limited by their thermal effects. Improvements in laser technology by use of the theory of selective photothermolysis have enabled the use of pulsed laser systems which minimize thermal damage to noninvolved tissue.\textsuperscript{28,29}

The Ultrapulse\textsuperscript{\textregistered} CO\textsubscript{2} laser produces extremely short (600 to 1000 \textmu sec) high-energy pulses, which ablate target tissue more rapidly than heat and can be conducted to surrounding skin.\textsuperscript{28-30} Clean ablation is possible because the pulse duration is shorter than the target tissue thermal relaxation time. Because the laser procedure is accurate and relatively bloodless, the operator can readily visualize the desired end point.\textsuperscript{31-33}

To achieve this clean tissue ablation, a critical power density for skin must be exceeded. The critical power density for CO\textsubscript{2} laser surgery in skin is 4 to 5 Joule/cm\textsuperscript{2}, vaporizing to a depth of approximately 100 \mu m, and producing only a 20 to 50 \mu m zone of thermal damage. When ablation is attempted at less than optimal power density, overheating and significant charring and/or scarring result. This can be avoided by use of the CO\textsubscript{2} laser at power densities greater than the critical value (250 mJ for the 3 mm spot manual handpiece and 150 mJ for the scanner’s 2.25 mm spot). This is the opposite to what one may initially believe, but use of too low an energy results in an “on” time of the laser beam of greater than the thermal relaxation time, allowing irreversible thermal damage to adjacent tissue. Superpulse CO\textsubscript{2} lasers produced high peak power but rapid decay and a longer tail of lower energy.\textsuperscript{8} The newer radio frequency–stimulated CO\textsubscript{2} lasers, such as the Ultrapulse\textsuperscript{\textregistered} CO\textsubscript{2} laser used in this study, produce sustained high peak power, resulting in significantly greater energy per pulse.

Use of a 3 mm spot size, clean charless ablation requires a single laser impact energy with a minimum of 150 mJ to vaporize the targeted skin before significant heat is conducted to surrounding structures. Normal tissue is able to adequately cool down between pulses so heat buildup will not occur.

With a focused handpiece, the CO\textsubscript{2} laser can cut tissues with a marked reduction in bleeding, making it especially useful for surgeries on highly vascular areas such as the eyelids and scalp. Laser-assisted blepharoplasties have consequently become increasingly popular as a result of reduction in bleeding, bruising, and a decrease in operative time.\textsuperscript{34-37}

When evaluating a patient for lower lid resurfacing, we recommend careful evaluation of lower lid margin laxity, by strong downward traction on the lid for 5 seconds. If

\textbf{Figure 8.} Patient satisfaction at 5 to 24 months postoperatively.
more than 3 to 4 seconds is required for the lid margin to contact the globe, lateral canthal tendon suspension or other lid tightening procedure should be performed prophylactically at the time of the eyelid resurfacing and/or blepharoplasty. In the defocused mode, CO₂ lasers are used to vaporize tissue so that the skin can be contoured, for example, rhinophyma.38,39

Optimal results with the high-energy pulsed CO₂ laser are achieved with static wrinkles of the face, actinic damaged skin, pitted (but not ice pick) acne scars, exophytic skin lesions, actinic cheilitis, and some posttraumatic scars. Resurfacing can be used alone or in combination with a brow lift (endoscopic or coronal), laser blepharoplasty, and face lift. However, we do not recommend scars. Resurfacing can be used alone or in combination with static wrinkles of the face, actinic damage, pitted acne scars, exophytic skin lesions, actinic cheilitis, and some posttraumatic scars. Resurfacing may be done on the forehead when a subperiosteal brow lift is performed at the same time, because this is an extremely vascular and thick flap. When there is much redundant skin, the combination of the laser and an incisional procedure can give good, mutually complimentary results.

One end point, the relative flattening of the abnormal contour of wrinkles, can be readily visualized. Entry from papillary dermis to reticular dermis can be seen by change in the surface collagen pattern from smooth to coarse and irregular collagen bundles and a characteristic yellow color. The number of passes with the laser was determined by whichever end point appears first; the disappearance of the wrinkles/acne scars or the appearance of a yellow color that persists after wiping with a wet gauze. Although the authors frequently went to a deeper level, indicated by the appearance of a chamois yellow color, it is strongly recommended that surgeons in their first 6 to 12 months of laser experience stop at the first appearance of a pale yellow color that persists after wiping with a wet gauze. Although the authors frequently went to a deeper level, indicated by the appearance of a chamois yellow color, it is strongly recommended that surgeons in their first 6 to 12 months of laser experience stop at the first appearance of a pale yellow color that persists after wiping with a wet gauze. The chamois-yellow color mandatory end point is difficult to judge, and continuing deeply will virtually guarantee an unacceptably high risk of hypertrophic scarring. It is safer to be conservative on the first treatment and reevaluate the patient in the future for a second session of CO₂ laser resurfacing, if necessary.

By resurfacing down to the level of the upper reticular dermis, new collagen formation will occur evenly throughout the dermis, producing long-lasting tightening of the skin. In addition to this, dermis contains structural proteins including elastin and collagen. Although elastin is extremely heat stable, collagen (type 1) microfibrils will change their structure arrangement at temperatures of 50° to 60° C, shortening by as much as one third of their length.40-43 This collagen shortening is believed to be responsible for the immediate tightening seen clinically with the CO₂ laser.

Acne scarring, on the other hand, is caused by focal collagen abnormalities and so requires a different treatment. The shoulder of acne scars needs to be resurfaced more deeply than the surrounding normal skin to achieve maximum benefit. Because acne scars often extend deeply into the dermis, 100% improvement is rarely achieved in these extremely deep scars without destruction of appendages.44 Additional complimentary procedures, such as dermal grafting, punch grafting, or filling agents, may need to be used.

Early posttraumatic and surgical scars may be rendered less noticeable by laser resurfacing to blend them into the surrounding tissues, especially when performed 6 to 8 weeks after the injury. Although there is no clearly defined scientific reason for resurfacing during this period, it is believed that one can optimize collagen remodeling during this time. Syringomas and xanthelasmas that are situated in the upper dermis can be suitably removed with the resurfacing techniques. They are replaced with new collagen. Recurrences, however, may occur at the edges of the treated area.

Induration must be carefully looked for, both visually and by feeling the skin with the fingertips, as it heralds the potential for hypertrophic scarring. It may appear as early as 3 weeks, most commonly in the upper lip. When discovered, it is treated immediately and biweekly with intralesional injection of a dilute solution of Kenalog 5 mg/ml until softening begins. Early treatment with the 585 nm pulsed-dye laser may also be used.

Synechia or adhesions are most common in the lower eyelids and rarely the nasolabial fold or labiomental crease. Care must be taken to pull the skin taut to eliminate any creases or folds when the adhesive dressing is being applied to minimize this problem. Synechia appear as linear white lines or creases. Inspection under magnification reveals an epithelial tunnel. If identified early (1 to 2 weeks), the adhesion can be simply pulled apart by traction between two cotton-tipped applicators. If overlooked, it may present as an inflamed area with retention of epidermal debris. Treatment is to lyse the epithelial bridge with fine pointed scissors under magnification. The subsequent natural tightening will generally smooth out the crease.
Hyperpigmentation was more commonly seen in the darker skin types (Fitzpatrick types IV to VI) rather than those with fair skin. One black-skinned patient (Fitzpatrick type VI) underwent laser blepharoplasty and periorbital resurfacing after 8 weeks preparation with retinoic acid and hydroquinone and healed normally without any hyperpigmentation or hypopigmentation.

From our clinical results, we conclude that the new generation high-output CO₂ lasers used in this study are ideal for resurfacing fine to moderate facial wrinkles, tightening the facial skin, and improving acne scars, exophytic skin lesions, rhinophyma, actinic cheilitis, and postsurgical scars because of their ability to remove abnormal tissue with minimal thermal damage to surrounding normal skin. This is in accordance with the results of other authors. This cannot be extrapolated to the continuous-wave or superpulse CO₂ lasers because the power density is not equivalent. When compared with older resurfacing methods such as dermabrasion and chemical peel, CO₂ laser resurfacing is a good alternative because of the following:

1. Laser resurfacing is relatively bloodless, therefore direct visualization of the desired end point is possible.
2. Precise depth can be controlled by laser energy, power, density, and number of laser passes.
3. The small spot size and precision facilitates treatment of finer details.
4. Use of the CO₂ lasers in the periorcular regions is successful in removing wrinkles right up to the eyelashes. Both upper and lower eyelids may be resurfaced.
5. With adequate smoke evacuation, the risk of spreading unwanted viruses in the plume is minimal. As mentioned previously, the aerosolized blood from dermabrasion may persist for up to 48 hours after the procedure.
6. The laser has no systemic toxicity, whereas chemical phenol peels are absorbed and may cause cardiac or renal toxicity or allergic reactions.
7. When the laser is turned off, there is no ongoing tissue injury. At the conclusion of a chemical peel, a toxic chemical remains in the skin, penetrating into the subcutaneous, muscular, and lymphatic tissues, causing massive swelling.
8. Medium deep and deep chemical peels often damage melanocytes, resulting in skin that may be porcelain white. Hypopigmentation occurs infrequently with conservative laser resurfacing, but when it does, it is mild and rarely sharply demarcated. This is probably due to the fact that the melanocytes below the level of resurfacing are undamaged, whereas the deep chemical peel penetrates the entire thickness of the skin.
9. The heat produced by the CO₂ laser on surrounding and underlying dermis may be responsible for the immediate tightening of the skin permitting immediate assessment of the degree of improvement. This gives more control to the surgeon, a benefit not available with chemical peel or dermabrasion.
10. The risk of hypertrophic scarring with the laser is less than for comparably deep trichloroacetic acid peels.
11. When laser resurfacing is combined with incisional plastic surgery, especially endoscopic brow lift, both the cause of the wrinkles and the wrinkles themselves can be simultaneously treated, yielding a result that is better and longer lasting than either method by itself.

We believe that the new generation high-energy pulsed CO₂ laser is a safe and effective tool for aesthetic plastic surgery. However, this procedure is very technique dependent and requires a combination of didactic and hands-on training, conservative surgical judgment, and diligent patient follow-up to obtain optimal results with minimal complications.

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