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REVIEW

Carbon Dioxide Laser Resurfacing of Rhytides and Photodamaged Skin

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Abstract. Carbon dioxide (CO_2) laser resurfacing has been used as a method to treat rhytides and photodamaged skin. This laser offers several advantages over previously utilised modalities but its use has several inherent risks. This article will review important aspects of CO_2 laser resurfacing including laser-skin interactions, patient selection, effective pre- and post-operative regimens and potential complications.

Keywords: CO_2 laser, Laser treatment; Rhytides

INTRODUCTION

During the last century, the science of dermatology has changed dramatically. New modalities have been invented and explored which offer the clinician exciting treatment options. Lasers have offered a quick, safe and effective means of treating a diverse group of lesions including vascular birthmarks, benign pigmented lesions and tattoos. Approximately four years ago [1], laser skin resurfacing was introduced for the treatment of rhytides and photodamaged human skin and since that time it has received a great deal of attention from the media, patients and physicians of many specialties. The carbon dioxide (CO_2) laser offers several advantages over previously utilised modalities including concomitant haemostasis and a decreased risk of scarring or dyspigmentation.

CO_2 laser resurfacing can achieve excellent results but success is dependent on a variety of factors. The best results are obtained when the clinician understands the interaction of laser light with human skin, chooses patients carefully, uses effective pre- and postoperative regimens and is prepared to handle potential complications.

CO_2 LASERS

The CO_2 laser utilises a mixture of carbon dioxide, nitrogen and helium gas for the lasing medium and emits light at 10 600 nm. High voltage electric current is used to achieve excitation of the lasing medium. The infrared wavelength emitted by this laser is highly absorbed by tissue water. However, the surrounding tissue may also be affected by heat conduction and non-specific thermal injury can occur adjacent to the treatment site. For controlled tissue removal, CO_2 lasers were developed which have high peak powers capable of maximal tissue ablation and short pulse durations that will limit the thermal damage.

During the past few years, two approaches have been taken to achieve the desired selective tissue removal [2]. The first utilises high power lasers which deliver up to 500 mJ of energy in discrete 1 ms pulses and is exemplified by the Coherent Ultrapulse 5000® (Palo Alto, CA). Tissue Technologies TruPulse® (Albuquerque, NM) is engineered similarly and can produce a pulse of 6 W with a pulse duration of close to 60 µs. This reduced pulse duration results in a more superficial tissue vaporisation and limits the zone of thermal injury. Sharplan's SurgiPulse XJ-150® (Allendale, NJ) is also a high-peak power-pulsed laser that can achieve up to 400 mJ by the close coupling of two 200 mJ laser pulses.

The second approach for achieving controlled tissue vaporisation utilises a continuous mode low power CO_2 laser in conjunction with a scanner. Higher powers can be reached by focusing the laser beam onto a small spot size diameter. To limit thermal injury,

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individual sites are exposed for less than 1 ms by rapidly scanning the beam over a designated geometric pattern. Sharplan's Feathertouch® (Allendale, NJ) is an example of this type of laser. A collimated lens delivers laser pulses with the same energy regardless of the distance from the handpiece to the skin surface.

The computerised pattern generator® (CPG) developed by Coherent (Palo Alto, CA) is an automatic scanning device which is integrated into the laser and provides a rapid, precise, non-overlapping series of pulses in a pre-designated pattern. The CPG greatly increases the speed and uniformity of CO_2 resurfacing and offers the clinician the ability to vary the pattern, size and density of pulses [3].

The beam is moved across the skin in a series of passes until the desired depth of vaporisation is achieved. The various laser systems differ in the depth of vaporisation achieved with each pass. However, in general, the depth of tissue removal increases with pulse energy and number of passes [4].

The mechanism of the laser-induced improvement in photodamaged human skin remains incompletely understood. Actinically damaged skin is characterised by epidermal irregularity and atrophy [4]. Keratinocytes are atypical and vary in shape, size and staining properties. Melanocytes are generally increased in number and size and melanin is unevenly distributed to the keratinocytes resulting in irregular pigmentation of the skin. In the dermis, glycosaminoglycans are significantly increased and replace collagen which has been destroyed. Elastic fibres are abundant, abnormally thickened and tortuous.

The following histological improvements were seen after CO_2 laser skin resurfacing [4]. (1) Epidermal atypia and atrophy were eliminated and replaced by normal epithelium with new uniform keratinocytes. (2) Melanocyte hypertrophy was eliminated and melanin was evenly distributed to the keratinocytes. (3) Glycosaminoglycans were decreased and new collagen and elastic fibre formation was noted in the superficial and mid-dermis.

Studies will be required to elucidate the mechanisms of the above described changes but Fitzpatrick [5] has suggested several hypotheses. Single pulse vaporisation will eliminate superficial wrinkles and photodamage up to 150–200 μm deep in the skin. Post-operative healing leaves a smooth skin surface with the improved histology described above. Further, tissue shrinkage which can be observed during the procedure, especially during the second and third passes, may correlate with a reversible zone of thermal injury [6] which has been theorised to provide a 'scaffold' for new collagen formation and rejuvenation.

CO_2 laser skin resurfacing offers several advantages over chemical peels and dermabrasion. In comparison to chemical peels, the CO_2 laser offers a more predictable depth of injury. Using chemical peels, penetration may vary depending on anatomic area, amount of pre-treatment skin degreasing, quantity and concentration of acid, pressure exerted during application, and degree of photodamage [7]. Many clinicians find CO_2 laser resurfacing to be less difficult technically than dermabrasion. Further, because concomitant haemostasis occurs during CO_2 laser procedures, there is the added benefit of decreased exposure to blood-borne pathogens. Finally, because laser resurfacing results in a controlled depth of injury, the risks of scarring and dyspigmentation are significantly decreased.

PATIENT CONSULTATION

Patient selection is crucial to successful CO_2 laser resurfacing (Table 1). Because this procedure involves close follow-up and patient participation in wound care, unreliable or unstable patients are poor candidates. Additional relevant patient information can be obtained through a detailed clinical history and limited physical exam.

Most important in the clinical history is information on previous skin procedures. Dermabrasion or chemical peels may have

Table 1. Considerations for patient selection for CO_2 laser resurfacing

- History of reconstructive surgery or radiation therapy in the area to be treated
- History of keloids or hypertrophic scars
- History of Accutane® use
- History of HSV or HIV infection
- Patient skin type
- Presence of acne, dyschromias or koebnerising skin disorders
- Expected clinical improvement with CO_2 laser resurfacing
- Realistic patient expectations

resulted in scarring or dyspigmentation that should be noted by both the patient and physician. Patients with a history of rhytidectomy or reconstructive surgery via a flap or graft where neck skin has been moved to the mandible or face, may heal poorly. In general, the neck heals less well than the face because the former is thinner and has fewer adnexal structures such as hair follicles and sebaceous glands which are important sources for re-epithelialisation. In addition, a history of radiation treatments for acne, skin cancer or hirsutism may result in poor healing [8]. Again, a decreased number of adnexae, this time secondary to radiation damage, has been hypothesised as the cause of impaired healing in such patients.

Patients should also be asked about, and examined for, keloids or hypertrophic scars. Individuals with such a history may be at increased risk of similar sequelae after CO_2 laser resurfacing. A family history of keloidal scarring is of questionable importance. Further, it is prudent to determine whether resurfacing candidates have a history of isotretinoin (Accutane®, Hoffman-La Roche, Inc., Nutley, NJ) use. Such a history is likely in patients with severe scarring from cystic acne. Re-epithelialisation is known to be compromised, and keloidal and hypertrophic scarring have been reported after dermabrasion in patients with recent use of this medication. It is recommended that patients be off isotretinoin for at least one year before laser resurfacing.

Collagen vascular disorders such as systemic lupus erythematosus or scleroderma may be a contraindication to laser resurfacing as there is an increased risk of poor healing and scarring. Certainly a test spot should be performed on these patients.

Patients should be asked about a history of herpes simplex virus (HSV) infection. It should be noted however, that many people are unaware of herpetic infections because they do not have symptomatic recurrences. Thus, all patients undergoing laser resurfacing should be given prophylaxis for HSV infection. Patients with a history of frequent or severe recurrences may require higher drug dosing, prolonged prophylaxis and closer post-operative monitoring. Patients with a history of immunosuppression of any aetiology are poor candidates as they are at increased risk of infection. Human immunodeficiency virus (HIV)-positive patients may present a risk to the physician and other paramedical personnel. HIV proviral DNA has been found in laser plume but it is unclear whether the isolated particles are capable of producing infection [9]. Human papilloma virus has also been documented in the CO_2 laser plume [10,11].

Patient skin type must be considered in the selection of suitable candidates. The ideal candidate is a young patient with skin type I or II. Patients with type III or IV skin have been successfully treated but there is an increased risk of post-inflammatory hyperpigmentation [12]. A spot test, as well as pre- and post-operative treatment with hydroquinone and topical tretinoin, are suggested.

Skin disorders such as acne, rosacea or dyschromias should be treated prior to resurfacing. Disorders which are known to koebnerise (the appearance of skin disease in previously normal skin as a result of trauma) should also be considered in patient selection for laser resurfacing. Extension of disorders such as psoriasis or lichen planus to the areas of newly resurfaced skin can occur. Any lesions suspicious for skin malignancy should be biopsied and removed before the laser procedure.

One of the most important considerations is whether the laser can achieve the desired goals of the patient and physician. A variety of skin lesions have been found amenable to treatment by the CO_2 laser (Table 2) [13–25]. Skin irregularities previously responsive to dermabrasion or medium to deep chemical peels are adequately treated. Laser vaporisation does not reach the depth of a Baker–Gordon Phenol peel [26] and it will not achieve the lifting results of cosmetic surgery. Mild to moderate facial lines can be treated with success but deep wrinkles which result from muscle movement are not adequately improved. Patients with mild or moderate 'cobblestone' acne or shallow varicella scars are good candidates for laser resurfacing and can expect significant improvement [27]. However, those with deep 'ice pick' scars or severe atrophic acne are not likely to be satisfied with the degree of cosmetic improvement [28].

Patients must have a realistic expectation of treatment results and understand that for appropriately selected surface irregularities, improvement is expected, but that complete removal is unlikely. One study documented 45%–60% improvement in wrinkles [29]. The glabellar area appears to respond least whereas peri-orbital and -oral responses are much better and similar [30].

Table 2. CO_2 laser applications

1.	**Epidermal disorders**	4.	**Miscellaneous disorders**
	Epidermal naevus		Adenoma sebaceum
	Bowen's disease		Angiokeratomas
	Actinic keratoses		Venous lakes
	Actinic cheilitis		Lichen sclerosus and atrophicus
	Oral florid papillomatosis		Zoon's balanitis
	Seborrheic keratoses		Hailey–Hailey disease
			Granuloma faciale
2.	**Adnexal neoplasms**		Neurofibromas
	Syringomas		Myxoid cysts
	Trichoepitheliomas		Angiolymphoid hyperplasia
	Trichilemmomas		Pearly penile papules
	Xanthelasma		Chondrodermatitis nodularis helices
	Apocrine hidrocystoma		Rhinophyma
3.	**Warts**		Mycosis fungoides
	Verruca vulgaris	5.	**Cosmetic uses**
	Verruca plantaris		Rhytid ablation – laser resurfacing
	Periungual warts		Slit production for hair transplants
	Condyloma acuminatum		'Cobblestone' acne scars

Table 3. Preoperative treatment regimen

Medication	Dosage	Treatment period
4% Hydroquinone plus sunscreen	bid	Start 6 weeks before treatment Re-start approximately 4 weeks after treatment
Tretinoin 0.025%–0.1%	qhs	Start 6 weeks before treatment Re-start approximately 4 weeks after treatment
Ciprofloxacin	500 mg p.o. bid	Start 1 day before procedure Continue through the 5th postoperative day (a total of 7 days)
Acyclovir	400 mg p.o. tid	Start 1 day before procedure Continue through the 12th postoperative day (a total of 14 days)
Fluconazole	150 mg p.o. × 1	Day of surgery

PREOPERATIVE PREPARATION

For six weeks before laser skin resurfacing, we recommend that patients be placed on a daily regimen of 4% hydroquinone plus sunscreen twice a day and topical tretinoin 0.025–0.1% at bedtime (Table 3). Others use Kojic acid in place of hydroquinone or add glycolic acid. This regimen will help to reduce postoperative hyperpigmentation as well as milia formation and is especially important in patients with skin type III or IV.

One day before surgery, all patients should start a regimen of ciprofloxacin 500 mg p.o. bid for 7 days to prevent bacterial infection. Some physicians use dicloxacillin, cephalexin, or azithromycin but these antibiotics have limited or no effect against *Pseudomonas*. Antiherpetic prophylaxis is also required and traditionally has been provided by acyclovir 400 mg p.o. tid for 7 days starting one day before the procedure. We have now extended the antiherpetic prophylaxis to 14 days because of several patients who developed HSV infections following seven day therapy. Famciclovir (Smith Kline Beecham Pharmaceuticals, Philadelphia, PA) 250 mg p.o. bid for 7 days is an alternative and, because higher blood levels are achieved, may offer improved protection [5]. On the day of surgery, some practitioners prescribe fluconazole 150 mg p.o. × 1 as antifungal prophylaxis and, unless

contraindicated, a mild analgesic for post-operative discomfort.

TREATMENT

Before the administration of local or general anaesthesia, rhytides of concern should be identified with a skin marker. This allows patient participation in determining areas of particular focus during the procedure and avoids problems associated with the distortion of facial lines seen with local anaesthesia. For partial face procedures, local anaesthesia is generally adequate. Care should be taken to avoid lidocaine toxicity. Some clinicians have used topical anaesthesia such as EMLA® (Eutectic Mixture of Lidocaine Anesthesia, Astra, Westborough, MA) cream but we find that most patients are more comfortable with a combination of nerve blocks and local infiltration. It has been suggested that when local anaesthesia is used, an adrenaline solution no stronger than 1:200 000 be injected to avoid obliteration of the important colour indicators of vaporisation depth [28]. We utilise general anaesthesia with a laryngeal mask airway for full face resurfacing although some physicians have recently described the use of tumescent anaesthesia.

Phisoderm® (Chattem Inc., Chattanooga, TN) is used to prepare the skin. Alcohol should not be used because of its flammable potential and chlorhexidine has potential ocular toxicity. Stainless steel shields or gauze coverings are routinely used for eye protection of patients. Wet towels are placed over the patient's hair and around the treatment field to decrease the risk of combustion. The physician and all attendants must also wear laser safety glasses.

We use the Ultrapulse 5000® (Coherent Inc. Medical Group, Palo Alto, CA) for almost all of our procedures and thus will focus on this laser in the following discussion of treatment parameters. The laser beam is passed over all planned treatment areas except the eyelids utilising an initial setting of 300 mJ and a density of 5 or 6. Individual pulses should be overlapped less than 10%. Because eyelid skin is thinner, we recommend that the initial pass for this area be done at 200 mJ with a density of 5. As previously noted, the neck should not be treated because of poor healing capacity. In order to avoid apparent and unattractive transition zones between treated and non-treated areas, anatomic units, for example the peri-orbital or peri-oral area, should be treated in their entirety. The edges of the resurfaced areas should be 'feathered out' with slightly lower energies to avoid a discrete transition zone.

After the first pass, the char should be wiped clean with sterile moist gauze. The surface is then dried to prevent light absorption by any excess water. The entire treatment area can then receive an additional one or two passes as desired. Settings for the second pass are generally 300 mJ with a density of 5, and 200 mJ and a density of 5 are used for the third pass. For the eyelids, 200 mJ and a density of 4 are utilised for a second pass. Areas of particular irregularity such as the edges of deeper rhytides or scars may require additional passes. Fitzpatrick has described three endpoint indicators: (1) elimination of the wrinkle or scar; (2) a chamois yellow colour which indicates that the reticular dermis has been reached; and (3) no further shrinkage of the collagen [5]. Continued treatment after any of these signs are manifest, risks scarring.

POSTOPERATIVE CARE

Immediately after resurfacing (Table 4), a thick layer of Aquaphor Healing Ointment® (Beiersdorf Inc., Norwalk, CT) is applied to the skin followed by N-Terface® (Winfield Laboratories, Inc., Dallas, TX) which is precut to fit around the patient's facial features. Absorbent gauze is then layered followed by tubing net to hold all dressings in place.

The dressing is removed the day after treatment and patients are instructed to begin vinegar soaks. One teaspoon of white vinegar is added to one cup of cool water producing a solution which will act as an astringent and is soothing to the healing skin. This solution is applied to a clean gauze or wash cloth and the treated area is gently soaked for 10–15 min. The skin is then patted dry and a thin coat of Aquaphor Healing Ointment® is applied. The soaks are repeated at least four times a day but may be performed more frequently to increase comfort. If stinging or burning occurs, the solution may be diluted with additional water. It is important that a fresh vinegar solution be prepared for each soak to prevent contamination and infection.

Table 4. Postoperative treatment regimen

Wound dressing	Aquaphor Healing Ointment® N-Terface Absorbent gauze Tubing net	Immediately postoperatively
Vinegar soak	One teaspoon of white vinegar added to 1 cup of cool water: apply to wash cloth and soak at least four times a day	Start 1 day post-procedure Continue until skin re-epithelialised (approximately 7–10 days)
Antibiotics	Ciprofloxacin 500 mg p.o. bid	Start 1 day preopertively Continue through the 5th postoperative day
Antivirals	Acyclovir 400 mg p.o. tid	Start 1 day preoperatively Continue through the 12th postoperative day
Steroids	Celestone® 6 mg i.m. × 1 Decadron® 8 mg i.v. × 1 (add for full face procedures)	Given at the time of the procedure
Sunscreen	Daily	Start 3-4 weeks post-treatment
Retin-A® and/or glycolic acid		Start 4 weeks post-treatment

The antibiotic regimen started the day before surgery should be continued through at least the fifth postoperative day (a total treatment period of 7 days). We now continue the antiviral prophylaxis through the twelfth postoperative day. The use of steroids is controversial because of concerns about potential side effects or impaired healing. We have found that 6 mg of Celestone® (Schering Corp., Kenilworth, NJ) i.m. × 1 significantly decreased postprocedure swelling and did not result in increased complications. For full-face procedures we add 8 mg of Decadron® i.v. × 1 (Merck & Co., West Point, PA) intraoperatively. Postoperative pain is generally not significant due to the sealing of nerve endings as the treatment is performed. Patients describe a warm sensation similar to a sunburn which usually is noted immediately after the procedure and lasts 2–5 days [31].

Epidermal healing occurs in 5–10 days and patients are asked not to wear make-up until at least 14 days after their procedure. The re-epithelialisation is followed in all patients by a dry erythema that generally clears in 2–16 weeks [6,30] with an average of 3.5 months [31]. The persistence of erythema is related to the number of passes and the energy and density settings chosen. More persistent erythema has rarely been reported [30]. The clinical perception of erythema may persist for longer periods in those with partial-face resurfacing [31]. This rosy coloration can be concealed with a variety of cosmetics designed for the purpose including Physician's Formula® (Physicians Formula Cosmetics, Inc., Azusa, CA) or Dermablend® (Corrective Cosmetics Dist., Chicago, IL).

The treated area must be protected from the sun for at least 3–6 months and the patient should begin daily use of sunscreen to prevent hyperpigmentation. Lifelong application of sunscreen and limited sun exposure are recommended to maintain the benefits achieved by resurfacing. Tretinoin and/or glycolic acid products are generally re-started weeks after the treatment to diminish hyperpigmentation and to help maintain the new collagen. One author advocates the use of a topical vitamin C preparation which may have protective antioxidant properties [5].

During the first 3 months after the procedure, patients describe pruritus and a sensation of facial tightness which usually begin during the first week of healing and lasts for 3–21 days with an average of 5 days [31]. These may be adequately controlled with emollients, a low potency topical steroid [30] such as Desowen® (Galderma, Fort Worth, TX) and antihistamines.

Figures 1–4 illustrate some of the results that can be achieved using CO_2 laser surgery.

SIDE EFFECTS AND COMPLICATIONS

The most commonly reported side effect is dyspigmentation (Table 5). The incidence of postinflammatory hyperpigmentation is dependent on the coloration of the treated patient. Patients with skin type III or IV are most likely to develop this complication and

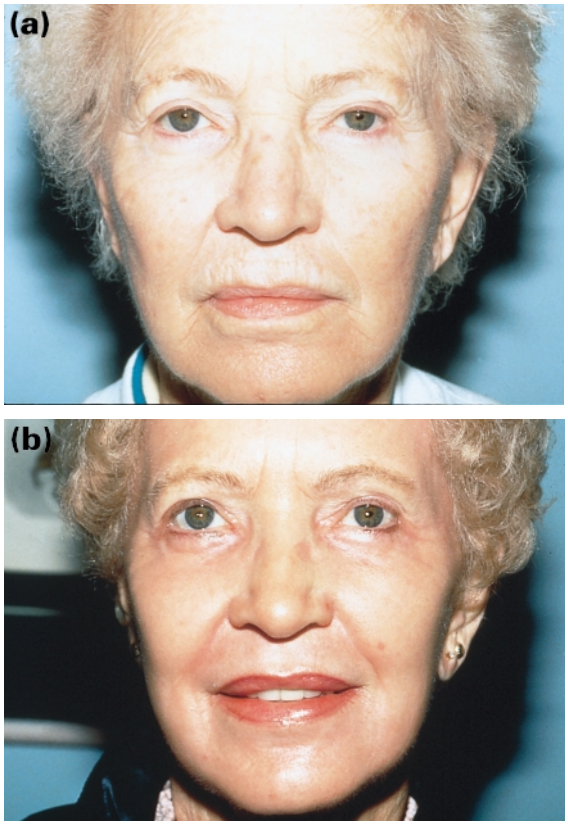

Fig. 1. 72-year-old Caucasian female patient (**a**) before and (**b**) 6 months after full-face CO_2 laser resurfacing.

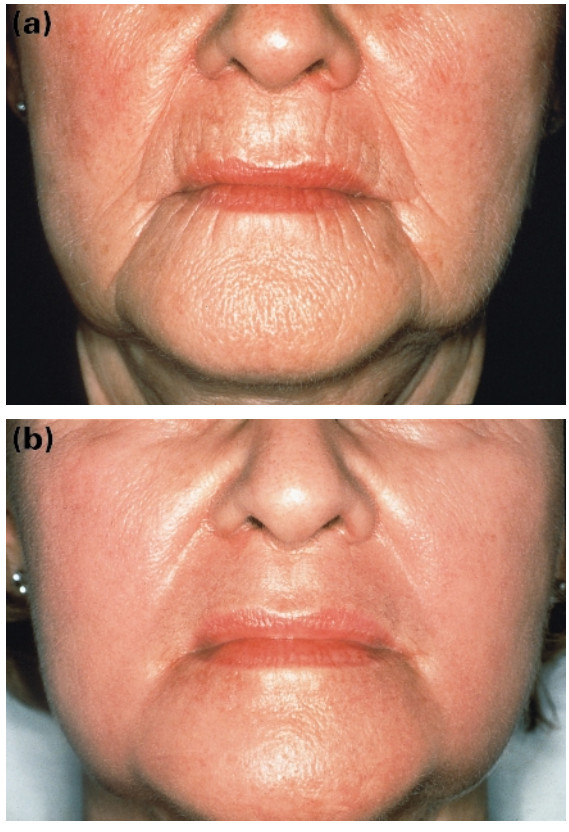

Fig. 2. 70-year-old Caucasian female (**a**) before and (**b**) 6 months after full-face CO_2 laser resurfacing.

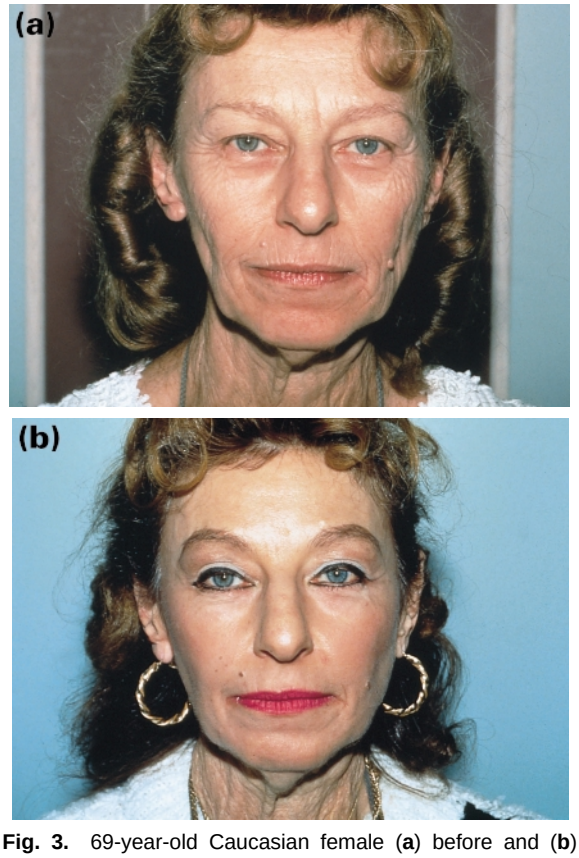

Fig. 3. 69-year-old Caucasian female (**a**) before and (**b**) 6 months after full-face CO_2 laser resurfacing.

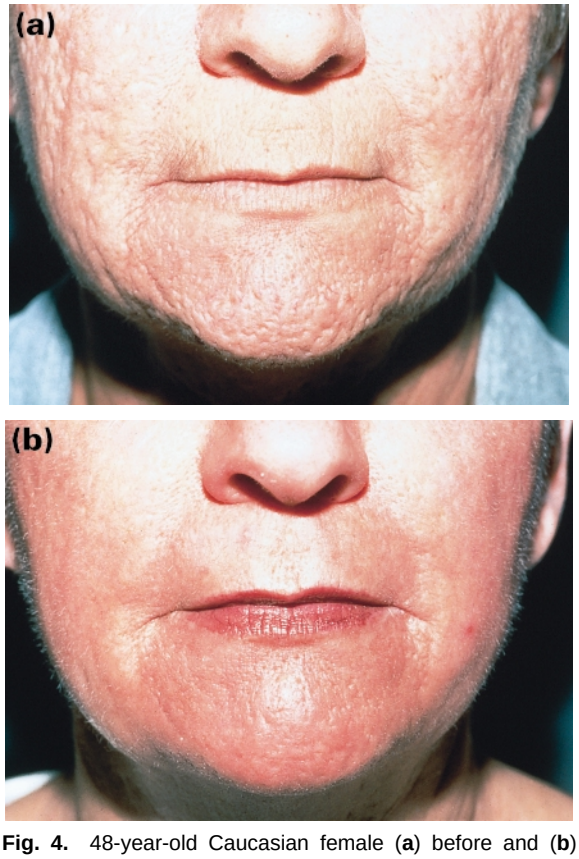

Fig. 4. 48-year-old Caucasian female (**a**) before and (**b**) 6 months after CO_2 laser resurfacing for acne scars.

Table 5. Complications of CO_2 resurfacing

Complication	Presentation/duration
Infections	Day 2–10/variable
Skin hypersensitivity	Day 7–10/several weeks
Milia formation and acneiform lesions	Week 3–6/variable
Scarring	Week 4–8/variable
Post-inflammatory hyperpigmentation	Month 1.5–3/1.5–3 months
Delayed hypopigmentation	Month 3–10/permanent

some facial areas are especially susceptible. Studies have documented hyperpigmentation in up to 80% of skin type IV individuals with resurfacing in the perioral area [6]. This pigment change is generally noted at 1.5–3 months and clears by postoperative month 3–4 with application of tretinoin and hydroquinone in combination with sunscreen use and sun avoidance. Resolution, in general, occurs more rapidly in lighter skin types [32].

Recently, practitioners have reported delayed hypopigmentation appearing 3–10 months after resurfacing with an average of 6.7 months [31]. The skin may appear normal after the resolution of erythema and before the onset of hypopigmentation. This dyschromia has been reported in patients of all skin types and there may be an increased risk in those with advanced sun damage [31].

Previously, infectious and allergic complications were not uncommon including Kaposi's varicelliform eruption, impetigo, candida and allergic contact dermatitis. The incidence of these events has been significantly decreased with adequate pre- and postoperative care [33]. When infections do occur, they are generally noted between days 2 and 10 after laser resurfacing [34]. We have noticed an increased incidence of *Candida* infections since we began using ciprofloxacin for antibiotic prophylaxis. However, such fungal infections respond well to topical nystatin cream or oral fluconazole.

Milia formation and acneiform lesions may occur in up to 83% [31] of patients during the third to sixth week after the procedure [7] and are easily treated with tretinoin or extraction. Oral antibiotics are rarely required.

Bernstein et al. [31] reported skin hypersensitivity, which was noted immediately after re-epithelialisation and resolved after several weeks, in 4.8% of patients. This complication may be more common in those with a history of atopy.

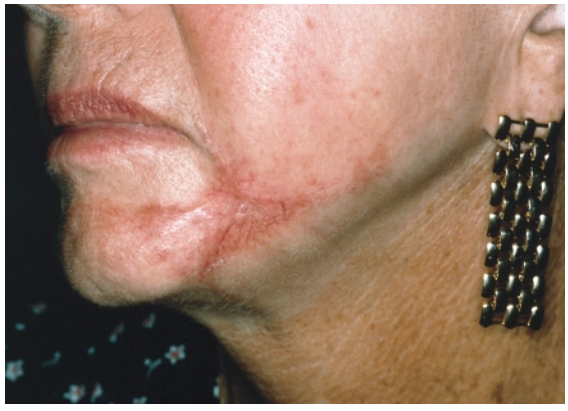

Fig. 5. 65-year-old Caucasian female with hypertrophic scarring approximately 1 year after CO_2 laser resurfacing.

The risk of scarring varies depending on the aggressiveness and skill of the clinician, the number of laser passes and the energy and density settings used during the resurfacing. As previously noted, some patients may be more susceptible to hypertrophic scarring (Fig. 5). When scarring does occur it appears by week 4–8 and can be treated with intralesional triamcinolone acetonide suspension and/or the pulsed dye laser [31].

NOVEL USES FOR CO_2 LASERS

The literature of the last 10 years has included some innovative ways to use CO_2 lasers in the clinical management of patients with selected dermatoses. Kartamaa and Reitamo [22] treated 10 patients with lichen sclerosus. The five men treated had penile lesions whereas three women had non-genital lesions and two had lichen sclerosus of the perineal skin. The Sharplan CO_2 laser was used in a defocused mode with an output of 5–6 W and a spot size of 2 mm. The diseased areas were treated with three to four passes until clinically healthy tissue was visible. Healing

required two to three weeks. All the penile lesions were clinically cured but one patient reported recurrences despite three treatments. The non-genital lesions improved but did not completely resolve. The perineal lesions improved but subsequently recurred.

Goldberg et al. [25] treated one patient with mycosis fungoides palmaris et plantaris with a CO_2 laser, utilising a 2 mm spot size and 4–8 W of power in defocused mode. They reported successful treatment with excellent cosmesis and no recurrence after 5 years of follow-up.

CO_2 lasers have been used in hair transplantation to produce slits in the scalp for grafts. Advantages of laser use include decreased exposure to blood-borne pathogens due to concomitant haemostasis and less handling of the grafts. Disadvantages include thermal damage at the recipient site and increased postprocedure crusting [7].

Some authors have reported improved resurfacing results by combining a variety of modalities. Scarborough and Bisaccia [35] reported success by using fat transfer or botulism toxin injection prior to CO_2 resurfacing. They injected the fat tissue suspension under the rhytides or scars or injected botulism toxin into the forehead or periorbital area to improve the wrinkles. At a later visit, CO_2 laser resurfacing was performed in the usual manner. Patients were reported to have better overall improvement and the authors hypothesised that their combined procedure may prolong the duration of the results. These authors have also combined transconjunctival blepharoplasty, CO_2 resurfacing and botulinum toxin injection [36].

THE FUTURE

Other lasers have been investigated for use in resurfacing procedures. The erbium-yttrium aluminium garnet (Erb-YAG) laser produces 2940 nm near infrared light which is well absorbed by tissue water. A new high-power Erb-YAG laser can generate energies of up to 1.5 J/pulse with pulse durations which can be varied between 150 and 600 μs and a repetition rate of 1–15 Hz. Vaporisation of superficial lesions such as fine wrinkles, epidermal naevi, sebaceous hyperplasia and adenoma sebaceum has been successful but the treatment of deeper entities is impeded by bleeding, and scarring has been noted [37]. The Erb-YAG laser is also capable of removing hard substances such as enamel and bone and can be used to treat osteoma cutis.

Other researchers are developing lasers which stimulate dermal collagen regeneration without epidermal injury [38,39]. The epidermis is cooled with a cryogen spurt milliseconds before the laser is activated producing spatially selective photocoagulation in the upper dermis without damaging the epidermis. It is hoped that the resultant dermal injury will induce sufficient collagen stimulation to achieve wrinkle reduction. Preliminary studies in animals demonstrate that the laser is able to stimulate fibroblast proliferation and new collagen formation. Studies are in progress to test the use of this laser on human subjects. If successful, this technology could revolutionalise laser resurfacing, providing similar benefits and significantly decreasing the cosmetic morbidity and risks of the procedure.

In summary, CO_2 laser resurfacing can be a safe and effective method for removal of surface irregularities and wrinkle ablation. However, inherent risks exist and the clinician must be prepared for these possibilities. Future research may provide insights into the mechanism of the laser-induced improvement in photodamaged skin and other information which will improve the safety and efficacy of this popular procedure.

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