Ablative Laser Resurfacing: Is It Still the Gold Standard for Facial Rejuvenation?

Daška Štulhofer Buzina, Jasna Lipozenčić, Zrinka Bukvić Mokos, Romana Čeović, Krešimir Kostović

University Hospital Center Zagreb, Department of Dermatology and Venereology, School of Medicine University of Zagreb, Zagreb, Croatia

Corresponding author:
Daška Štulhofer Buzina, MD, MS
University Hospital Center Zagreb
Department of Dermatology and Venereology
School of Medicine University of Zagreb
Šalata 4
HR-10000 Zagreb
daska.stulhofer-buzina@zg.htnet.hr

Received: July 7, 2010
Accepted: July 30, 2010

SUMMARY A new era in dermatological cosmetology, especially in the field of nonsurgical skin rejuvenation, started with ablative resurfacings, at first by carbon dioxide laser and later by Er:YAG or their combination. Although ablative lasers result in major improvements in photodamaged skin, the related postoperative recovery time and side effects are currently unacceptable for most patients. During the last forty years, skin resurfacing has changed dramatically. After ablative laser systems, nonablative and now fractional laser systems have been developed, fulfilling the new demands for a lesser risk of side effects and minimal or no downtime.

KEY WORDS: ablative lasers, nonablative lasers, resurfacing, rejuvenation

INTRODUCTION

In the last thirty years, the young and good-shape appearance has become more important than ever. Skin aging caused by intrinsic but also extrinsic factors due to excessive photoexposure, very popular in the 1970s and 1980s, has forced many patients to seek for medical advice and help. Scarring from severe acne, trauma or surgery, or other abnormalities cause stress and grave concerns in some patients, up to the point of needing psychological treatment. A number of different treatments have been used for rejuvenation of sun-damaged skin, including topical retinoids, bleaching agents, chemical peeling, dermabrasion, and excisions. A new era in dermatological cosmetology, especially in the field of nonsurgical skin rejuvenation, started in the 1980s, when the first carbon dioxide (CO_2) laser resurfacing was introduced. New generations of resurfacing ablative lasers have followed but in recent times, a new demand has arisen. Although ablative lasers did

Acta Dermatovenerol Croat
2010;18(3):190-194

help to improve skin irregularities significantly, the new demand has focused on the treatment with minimal side effects and minimal or no downtime. In response, a spectrum of nonablative and fractional lasers for skin resurfacing have been developed.

ABLATIVE LASER RESURFACING

The first CO_2 lasers with continuous wave (cw) mode were excellent for tissue cutting and coagulation simultaneously, but their further utility was limited by their significant thermal damage to the surrounding tissue. This unpredictable degree of thermal necrosis, even in pulsed mode, resulted in significant postoperative morbidity and a number of unwanted side effects. Although highly effective with most dramatic clinical and histologic improvements in the appearance of photodamaged skin, long and demanding postoperative recovery, and possible serious side effects sidelined CO_2 lasers. In 1996, the Er:YAG laser was introduced, characterized by thinner zone of ablation and thermal necrosis. This resulted in shorter healing time and less postoperative side effects (1,2).

CARBON DIOXIDE LASER RESURFACING

Development of high-energy pulsed CO_2 and scanned cw CO_2 lasers has made possible laser skin resurfacing of photodamaged skin with reliable vaporization and controlled thermal damage. Carbon dioxide lasers emit light at 10600 nm in far infrared spectrum. Energy is preferentially absorbed by intracellular and extracellular water creating rapid heating and vaporization of tissue. New high energy short pulsed CO_2 lasers and scanned cw CO_2 produce relatively superficial tissue vaporization and minimize deeper thermal injury that is associated with undesirable side effects like scarring and hypopigmentations. The pulsed CO_2 resurfacing allows for precise depth of ablation and controlled thermal damage. Although the exact mechanism is not fully understood, impressive outcomes after CO_2 resurfacing seem to be the result of long-term collagen remodeling and neocollagenesis (3). It appears that thermal injury below the vaporization zone induces desiccation and collagen shrinkage, which serves as a scaffold for the formation and deposition of new collagen. Immunohistochemistry evaluations demonstrated up-regulation of procollagens I and II, interleukin 1-β, TNF-α, TGF-β1, and matrix metalloproteinases. Due to excellent results in the improvement of photodamaged skin, photoinduced rhytids, dyschromias, and atrophic scars in experienced hands and in optimally chosen candidates, CO_2 lasers are still considered the gold standard for facial rejuvenation (4). One of the crucial parts of these treatments is patient selection. An ideal candidate for CO_2 laser resurfacing is the patient in good health with fair skin type (I to II skin type according to Fitzpatrick's classification) who has photodamaged skin and moderate postoperative expectations. The patient's age is irrelevant (5). Absolute contraindications to the procedure include a history of keloids and connective tissue disease and history of radiation therapy or scleroderma due to reduction of adnexal structures that serve as a pool of stem cells for reepithelialization. Another contraindication is a recent (within one year) isotretinoin therapy that can result in atypical scarring. Resurfacing performed soon after a face-lift procedure or blepharoplasty increases the risk of skin necrosis, ectropion, and scarring due to undermined vascularization. Patients with unrealistic expectations represent absolute contraindication for this treatment. Furthermore, patients with epilepsy are not candidates for this treatment, as well as patients with diseases that include koebnerizing features. To improve the outcome of laser resurfacing preoperative regimens, local hydroquinone (patients with Fitzpatrick's skin type III) and topical tretinoin (to speed reepithelialization) are used. In all patients, prophylactic oral antiviral therapy (acyclovir 200 mg q.i.d.) should be administered starting one day prior to resurfacing and continued for 10 days or until reepithelialization is completed. In addition, all patients are routinely prescribed antibiotics (doxycycline 100 mg b.i.d. azithromycin) (1,3,6). The CO_2 laser resurfacing is a painful method due to its tissue heating effect. For treatment of individual cosmetic units (periorbital, perioral), topical anesthetic agents such as the EMLA cream (Astra Pharmaceuticals), eutectic mixture of lidocaine 2.5% and prilocaine 2.5% in an oil-in-water emulsion applied under occlusion for 90 minutes are usually used. It can also be combined with local or regional anesthesia. For full face CO_2 resurfacing, a combination of topical and systemic agents (regional nerve blockade, tumescent anesthesia, and general anesthesia) is usually needed. During the first few days, edema and exudation occur. They will become most severe on the second and third postoperative days. For most patients, the postoperative period poses a big problem. It is a long and demanding period, which is unacceptable for some patients. Head elevation, ice packs, and in severe cases oral corticosteroids are administered. The application of bio-occlusive dressings during the first 72 hours will speed up reepithelialization and minimize pain. After complete reepithelialization (10-14 days), marked erythema persists for a variable period ranging from 4 months to up to 1 year, but can be camouflaged by make-up. Sun avoidance is crucial before any laser treatment and during the entire period of post-laser erythema to reduce the risk of post-inflammatory hypopigmentations (1,4). Another major problem with CO_2 resurfacing are the complications. Although the results with this laser system are excellent, they are associated with some side effects due to significant thermal damage to the surrounding tissue. These include long-lasting swelling and erythema, skin dyspigmentations, an increased risk of skin infections, eczema and scarring. Apart from post-treatment erythema, which is accepted as part of normal healing process, dyspigmentations are the most common adverse effects. Post-inflammatory hyperpigmentations occur in dark-skinned patients and during the summer months. The most serious are late hypopigmentations that occur 6-12 months after treatment and represent unexplained delayed loss of pigmentation although normal repigmentation has occurred after resurfacing. Milia and acneiform eruptions due to follicular reepithelialization and occlusive moisturizers are frequent events, especially in the first few weeks, but they quickly respond to standard treatment. Contact allergic dermatitis is usually caused by the use of local antibiotics, topical anesthetics, corticosteroids, and other irritants. The main danger are infections that are minimized by prophylactic therapy. Scarring can also be minimized by proper patient selection and by a conservative number of laser passes (5,7).

ERBIUM:YTTRIUM-ALUMINUM-GARNET (Er:YAG) LASER RESURFACING

The Er:YAG laser emits light at a wavelength of 2940 nm, closely to absorption peak of water (3000 nm), so all energy is absorbed superficially, in the epidermis and papillary dermis. During Er:YAG laser ablation, delivered energy is transformed into heat but escapes as steam decreasing thermal injury to the surrounding tissue. Hence, no visible contraction of dermal collagen fibers is observed (3). This may be a reason for moderate results after Er:YAG resurfacing in comparison with CO_2 treatment (9). On the other hand, superficial ablation with Er:YAG is a more safe method for resurfacing, especially for regions with thin skin (periorbital). It minimizes scarring due to limited thermal damage. Such laser resurfacing is thus suitable for mild to moderate rhytids and photodamaged skin (9). Patient selection is similar as in the case of CO_2 laser resurfacing, except that Er:YAG laser resurfacing reduces the risk of pigmentary changes and is safer in darker skin types (skin types III and IV) (1). In a split-face study, Khatri *et al*. compared Er:YAG laser and CO_2 laser for resurfacing periorbital and perioral rhytids. They found that Er:YAG laser at similar fluence and pass number had a more superficial ablation and faster healing rate, but was less efficient. It seems that the depth of thermal injury rather than the depth of ablation has a major role in the degree of dermal remodeling (10). To avoid some serious complications, preoperative regime (antiviral and antibacterial prophylaxis) is similar to the one characteristic of CO_2 laser resurfacing. Preoperative counseling should ensure that the patient's expectations are reasonable and that the possible risks are understood (11). For Er:YAG resurfacing, topical anesthesia in combination with infiltrative or other types of systemic anesthesia is required. After laser treatment, topical semi-occlusive dressings ('closed' technique) or topical moisturizers ('open' technique) are applied (12). Post-treatment swelling may persist for 10-14 days, but post-inflammatory erythema resolves in 6 weeks to 6 months, depending on the depth of resurfacing. Rapid reepithelialization and faster resolution of post-treatment erythema are the major benefits for patients treated with Er:YAG lasers. In addition, post-treatment complications are less serious then with CO_2 resurfacing. In comparative studies, healing time of both laser systems for identical depth of ablation was similar. In general, Er:YAG laser causes lower morbidity and less erythema than CO_2 laser The most frequent complications following the former treatment are hyperpigmentations (13,14).

NONABLATIVE LASERS

Nonablative skin rejuvenation provides an alternative to traditional, ablative, laser resurfacing. Newer rejuvenation laser systems stimulate collagen production and remodeling in dermis, resulting in mild to moderate improvement of facial rhytids and atrophic scars. They address new clients' demands for short healing time and reduced discomfort. There are three main groups of new laser systems: mid infrared (IR) lasers, visible light lasers (pulsed dye laser (PDL) and pulsed 532 nm potassium titanyl phosphate lasers (KTP)), and broadband light sources (intense pulsed light (IPL)) (15). The prototype of nonablative laser systems is infrared Nd:YAG laser that emits light within the infrared portion (1320 nm). It is weakly absorbed by superficial water-containing epidermis, but penetrates into deeper structures. In addition, the cooling device of Nd:YAG laser protects the epidermis and deposits heat in upper papillary dermis where collagen production is induced. A number of published studies have demonstrated the effectiveness of the 1320 nm laser. Patients who are concerned with the risks and are willing to accept minimal efficacy in exchange for minimizing risks are the ideal candidates for nonablative approaches (1). Dark-skinned patients are at a high risk of post-treatment hyperpigmentations and should avoid sun exposure after treatment. Patients who are scheduled to undergo systemic isotretinoin therapy within one year from the treatment should postpone it due to the possible impairment of wound healing. Herpes or bacterial prophylaxis are not routinely prescribed, unless the patient has a history of recurrent herpes or staphylococcal infections of facial skin. Topical anesthesia is sufficient for pain control during nonablative resurfacing. After the treatment, ice packs may be applied. The main advantage is the absence of the need for postoperative care. Minimal edema and erythema resolve over a couple of hours. The patient can return to normal life immediately after treatment (4).

The long pulsed PDL show modest results in photorejuvenation, mainly because of their vascular targeting and superficial penetration. IPL systems, targeting both melanin and hemoglobin, result in improvement of dyschromias and vascular changes, but have minimal clinical effects on rhytids. The main advantages are the large spot size, ability to improve a variety of photoaged imperfections, and ease of use (6,16-19).

FRACTIONAL RESURFACING

Fractional resurfacing is the newest technology that uses a completely new approach. The method consists of fractions of thermally denatured skin of controlled width and depth. The small wounds heal rapidly from the untreated surrounding skin. Currently, there are several devices approved for fractional ablative and nonablative resurfacing. One of them is 1550 nm erbium-doped mid-infrared fiber laser that performs cylindrical areas of thermal damage to the epidermis and upper dermis inducing the so-called ‘micro thermal zones’. These zones represent 15%-25% of the treated skin surface. Although neocollagenesis occurs in these zones, similarly to ablative resurfacing, it is characterized by faster recovery and fewer side effects. Erythema and edema resolve within a few days but improvements in rhytids and photoaged skin are modest. Consequently, more treatments are needed (5-6, at 4-week intervals). There is no doubt that fractional laser skin resurfacing has established itself, especially due to a better standard of safety than previous ablative technologies. Although clinical improvement is the most important issue, due attention should also be paid to minimizing side effects and complications. Patients undergoing isotretinoin therapy should wait for 12 months before starting with fractional resurfacing. All patients should receive prophylactic antiviral therapy and those with a history of bacterial infections of the facial skin should take bacterial prophylaxis. Before the procedure, topical anesthesia with EMLA cream under occlusion for 90 minutes is required. Post-treatment, topical emollients should be applied (4,20-22).

CONCLUSION

The field of laser skin resurfacing has evolved rapidly in the past twenty years. From ablative laser systems (CO_2 and Er:YAG) to nonablative (near IR, IPL, RF systems) and now fractional laser systems, skin resurfacing has changed dramatically. Although ablative lasers result in major improvements in the skin tone, rhytid severity, and hypertrophic scar depth, the related postoperative recovery time and side effects are unacceptable for most patients (23). The popularity of ablative laser resurfacings with CO_2 and Er:YAG lasers has declined with the introduction of new nonablative rejuvenation procedures characterized by minimal or no downtime. Nonablative laser resurfacing is ideal for patients with mild skin changes, as well as for those who are unwilling to undergo expensive and demanding ablative procedures. The latest resurfacing modalities, fractional resurfacing, bridges the differences between the two earlier types. It produces more visible clinical and histologic changes that are comparable to ablative lasers, but spares most of the skin and is characterized by rapid reepithelialization and mild side effects just like nonablative resurfacing. There is a consensus that in the absence of studies directly comparing the efficacy of ablative, nonablative, and fractional laser resurfacing, the ablative technologies that produce superficial vaporization and dermal heating should remain the gold standard for treating photodamaged skin, rhytids, dyschromias, and textural disturbances of greater and moderate extent (1,4,24). Future studies are needed to determine relative efficacy of the three laser modalities.

References

1. Riggs K, Keller M, Humphreys TR. Ablative laser resurfacing: high-energy pulsed carbon dioxide and erbium:yttrium-aluminium-garnet. Clin Dermatol 2007;25:462-73.
2. Alister TS, Lupton JR. Lasers in dermatology: an overview of types and indications. Am J Clin Dermatol 2001;2:291-303.
3. Tanzi EL, Lupton JR, Alaster TS. Lasers in dermatology: four decades of progress. J Am Acad Dermatol 2003;49:1-31.
4. Alexiades-Armenakas MR, Dover JS, Arndt KA. The spectrum of laser skin resurfacing: nonablative, fractional, and ablative laser resurfacing. J Am Acad Dermatol 2008;58:519-37.
5. Alister TS. Cutaneous resurfacing with CO_2 and Er:YAG: preoperative, intraoperative, and postoperative considerations. Plast Reconstr Surg 1999;103:619-31.
6. Papadavid E, Katsambas A. Lasers for facial rejuvenation: a review. Int J Dermatol 2003;42:680-7.
7. Utley DS, Koch RJ, Egbert BM. Histologic analysis of the thermal effect on epidermal and dermal structures following treatment with the superpulsed CO_2 laser and the erbium: YAG laser: an *in vivo* study. Laser Surg Med 1999;24:93-102.
8. Alister TS. Clinical and histologic evaluation of six erbium:YAG lasers for cutaneous resurfacing. Laser Surg Med 1999;24:87-92.
9. Tenzel EL, Alister TS. Single-pass carbon dioxide *versus* multiple-pass Er:YAG lasers skin resurfacing: a comparison of postoperative wound healing and side effect rates. Dermatol Surg 2003;29:80-4.
10. Khatri KA, Ross V, Grevelnik JM, Magro CM, Anderson RR. Comparison of erbium:YAG and carbon dioxide lasers in resurfacing of facial rhytides. Arch Dermatol 1999;135:391-7.
11. Alister TS. Cutaneous resurfacing with Er:YAG lasers. Dermatol Surg 2000;26:73-5.
12. Alister TS, Lupton JR. Erbium:YAG cutaneous laser resurfacing. Dermatol Clin 2001;19:453-66.
13. Zachary CB. Modulating the Er:YAG Laser. Lasers Surg Med 2000;26:223-6.
14. Kaufmann R, Hibst R. Pulsed erbium:YAG laser ablation in cutaneous surgery. Lasers Surg Med 1996;19:324-30.
15. DeHoratius D, Dover JS. Nonablative tissue remodeling and photorejuvenation. Clin Dermatol 2007;25:474-9.
16. Manuskiatti W, Fitzpatrick RE, Goldman MP. Energy density and numbers of treatment affect response of keloidal and hypertrophic sternotomy scars to the 585-nm flashlamp-pumped pulsed-dye laser. J Am Acad Dermatol 2001;45:557-65.
17. Manuskiatti W, Fitzpatrick RE, Goldman MP. Treatment of facial skin using combinations of CO_2, Q-switched alexandrite, flashlamp-pumped pulsed dye, and Er:YAG lasers in the same treatment session. Dermatol Surg 2000;26:114-20.
18. Stangl S, Kimming W. Nebenwirkungen in der Therapie mit hochenergetischen Blitzlampen und Lasern. Hautarzt 2008;59:108-15.
19. Stangl S, Hadshiew I, Kimmig W. Side effects and complications using intense pulsed light (IPL) sources. Med Laser Applic 2008;23:15-20.
20. Metelitsa AI, Alister TS. Fractionated laser skin resurfacing treatment complications: a review. Dermatol Surg 2010;36:299-306.
21. Brightman LA, Brauer JA, Anolik R, Weiss E, Karen J, Chapas A, *et al.* Ablative and fractional ablative lasers. Dermatol Clin 2009;27:479-89.
22. Narurkar VA. Nonablative fractional laser resurfacing. Dermatol Clin 2009;27:473-8.
23. Fitzpatrick RE, Smith SR, Sriprachya-Anunt S. Depth of vaporization and the effect of pulse stracking with a high-energy, pulsed carbon dioxide laser. J Am Acad Dermatol 1999;40:615-22.
24. Goldman MP, Manuskiatti W. Combined laser resurfacing with the 950-μsec pulsed CO_2 + Er:YAG lasers. Dermatol Surg 1999;25:160-3.