

# Laser resurfacing today and the 'cook book' approach: a recipe for disaster?

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## Abstract

**Background** Laser ablative skin resurfacing achieves skin rejuvenation by precise ablation of photoaged skin and subsequent re-epithelialisation and dermal remodelling. Carbon dioxide (CO<sub>2</sub>) and Erbium:YAG (Er:YAG) lasers are the established choice. A wide range and many sets of parameters have been proposed as the gold standard for each system but results have varied.

**Aims** To show that this single system 'cook book' approach must be rejected in favour of a more comprehensive approach.

**Subjects and methods** The author has experience of ablative skin resurfacing in over 1200 patients and has used both systems. A more flexible approach, using a combined wavelength system, is presented. It comprises precise ablation of the epidermal with the Er:YAG (to create an epidermal window), followed instantaneously with subablative heating of the exposed dermis with the CO<sub>2</sub> laser.

**Results** Since adopting the dual wavelength/dual modality approach, more than 600 patients have been treated, with excellent results and a very high patient satisfaction index, currently around 90%, obtained from the sum of the very satisfied and satisfied patients using a five-grade scale. Possible resurfacing-related complications have included prolonged erythema, hyper or hypopigmentation, scarring and viral infections, which were more common with single system resurfacing. The author's complication rate remains under 1%, without any prophylactic use of antiviral agents.

**Conclusions** The cook book approach, whereby a particular set of fixed laser resurfacing parameters for a specific single laser system are adopted and rigidly applied in all patients, will not achieve the best treatment effects and may even produce a bad result and dissatisfied patients. The dual modality approach allows a combination of the favourable elements of each of the two wavelengths with excellent and consistent results.

**Keywords:** CO<sub>2</sub> laser, Er:YAG laser, laser parameters, laser skin resurfacing

## Introduction

Since its inception just over 15 years ago,<sup>1</sup> ablative laser resurfacing has rapidly advanced in tandem with the

development of dedicated systems, supplanting the previous traditional methods of mechanical dermabrasion, skin shaving and chemical peeling.<sup>2,3</sup> At first, manufacturers hastened to reprogram existing systems delivering a variety of wavelengths with varying degrees of success, but two wavelengths quickly evolved as the main ones used in ablative laser resurfacing for the removal of rhytides in the rejuvenation of photoaged skin, namely 10 600 nm from the carbon dioxide (CO<sub>2</sub>)

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laser and 2940 nm from the erbium yttrium aluminium garnet (Er: YAG) laser. Systems were then developed with resurfacing as their primary indication, which further helped to advance the use of lasers in ablative resurfacing compared with the conventional approaches.

As experience with the available systems increased, both wavelengths, and therefore both types of laser, developed their own opponents and proponents. The CO<sub>2</sub> supporters claimed deeper effects with a comparatively bloodless field, and were further subdivided between the pulsed<sup>4–8</sup> and continuous wave (C/W)<sup>9,10</sup> versions. Although pulsed CO<sub>2</sub> resurfacing produced less oedema and erythema and had apparently better short-term results, the final clinical effect in the long term was better for the C/W system, both macroscopically and as assessed with transmission and scanning electron microscopy.<sup>11–13</sup> On the other hand, the Er:YAG proponents pointed to a less aggressive approach, with less oedema and erythema and thus less downtime for the patients,<sup>14–19</sup> although the results were not as good in severe photoageing, and did not last as long as with the CO<sub>2</sub> laser.

Each laser system offered advantages and disadvantages, based on their particular wavelength-dependent laser–tissue interactions, as will be discussed further below. The optimum approach was to combine the best elements of both laser systems in a single console offering both laser wavelengths delivered through the one handpiece.<sup>20,21</sup>

This study examines the relative merits and demerits of both wavelengths, looks at the advantages of the dual-wavelength approach, and most importantly, suggests that irregardless of the system used, a rigidly applied cook book approach to laser ablative resurfacing is counterproductive to achieving consistently good results in a variety of skin types and degrees of photoageing-related sequelae.

## The CO<sub>2</sub> laser

The CO<sub>2</sub> laser ablated the epidermis and papillary dermis quite well and left thermal damage in the dermis, which decreased in reverse proportion to the depth of damage from the tissue surface, extending into the upper to mid reticular dermis. This became known as residual thermal damage (RTD), and was quickly accepted as a necessary criterion for good results.<sup>22</sup> The reasonable haemostasis achieved through the good depth of dermal coagulation was also an advantage, resulting as it did in a comparatively dry operative field. The side-effects were, however, fairly severe, oozing and oedema seen immediately after the procedure followed by heavy crusting, and an extended period of erythema which result in a long

patient downtime. On the plus side, however, the results were very good in general, as far as long-term wrinkle removal is concerned. At first, the pulsed version of the CO<sub>2</sub> system was thought to be more effective than the C/W, as it tended to produce less erythema and thus shortened the patient downtime. The erythema, in fact a necessary part of the wound healing process initiated by the RTD, was first believed to be connected with inflammation, but was then shown to be the result of the neovascularisation of the healing dermis seen through a young and therefore more translucent epidermis.<sup>23</sup> This neovascularisation was reported to be an essential component of the proliferative and remodelling phases of wound healing, supplying both good nutrition to the healing dermis, and also creating a powerful oxygen gradient down which reparative cells could flow into the dermal wound area. The greater erythema associated with the CO<sub>2</sub> laser (and in particular the C/W CO<sub>2</sub>) was therefore an asset as far as the long-term effects were concerned, and this was demonstrated in the long-term with clinical photography, transmission and scanning electron microscopy.<sup>11–13</sup>

## The Er:YAG laser

When the Er:YAG laser was first introduced, it was reported to be a gentler system, giving a much more precise ablation of the epidermis and papillary dermis with minimal deposition of RTD. The side-effects were thus less severe and shorter in duration than the CO<sub>2</sub> laser. The results, however, were not as spectacular as the CO<sub>2</sub> laser and did not last as long, a direct consequence of the lack of RTD associated with the Er:YAG wavelength, which also led to the poor coagulative effect resulting in spotty bleeding in the operative field once the papillary dermis was reached.

A sound understanding of laser–tissue interactions and their consequences in clinical application not only enables an understanding of all the above factors, but can also bend the rules, somewhat, and allows lasers to do things they usually do not, or vice versa. In the case of the Er:YAG, for example, when the usual parameters are altered, it can be used in both ablative mode, to create an epidermal window, through which much lower incident radiant fluencies, or energy densities, are delivered in a nonablative mode to produce RTD in a manner very similar to the CO<sub>2</sub>.<sup>24</sup>

## The dual wavelength approach

The best answer, however, was to combine both wavelengths in one system, which happened in the

late 1990s. The Er:YAG was applied in its normal mode to ablate the epidermis cleanly with a small amount of dermal RTD, and virtually simultaneously the CO<sub>2</sub> energy was delivered in subablative mode via the same handpiece, through the epidermal window created by the Er:YAG pulse, to deliver an appropriate amount of RTD but without removing any more tissue. This way, the advantages of both systems were combined, giving excellent results. Moreover, the side-effects, although still not at the low level associated with the Er:YAG laser, were significantly less than the CO<sub>2</sub> on its own.

Apart from updates to the design of this combined Er:YAG/CO<sub>2</sub> system (the Derma K® from Lumenis, Yokneam, Israel), nothing has been introduced in ablative resurfacing to improve the results given by this dual wavelength system, and the author believes that it represents the correct approach to laser resurfacing today.

#### Optimal treatment and wound care

Notwithstanding the above, any clinician performing ablative resurfacing with the laser must try to obtain the best result possible in his or her patients, and this is achieved by using the best possible laser: if CO<sub>2</sub> must be used, it should be a C/W CO<sub>2</sub>. If a clinic does not have a C/W CO<sub>2</sub> laser, but does have an Er:YAG, then the use of the Er:YAG in the ablative mode followed by the subablative mode is acceptable. In neither of these cases, however, is the effect as good as the dual-wavelength system.

Postsurgical care techniques are also an extremely important measure, almost as important as the laser procedure itself, and can make the difference between an excellent and a poor result.<sup>25,26</sup> These techniques must be carefully studied and understood: it is not enough simply to adopt a recipe that works well for another clinician without being fully aware of both the pharmacodynamics and the philosophy behind the regimen.

#### Surgical expertise

There is, however, one more extremely important element which needs to be considered as far as use of the laser is concerned, and that is the level of expertise of the surgeon: this does not mean only how long the surgeon has been using the laser, but also, and mainly, if he or she is using it correctly, with a full understanding of all facets of laser–tissue interaction. At laser conferences, participants may constantly be heard from the floor asking speakers for their parameters (another recipe) for certain procedures, which they then assiduously copy down and go away to try them out for themselves. The knowledge of these parameters on their own will

certainly not make a bad laser surgeon good (a little knowledge can be a dangerous thing in laser resurfacing), although they may well make a good laser surgeon better. Having said that, however, it is one of the author's personal goals to introduce some standardization of the sometimes confusing and even contradictory ranges of reported parameters which will enable consistent results for certain procedures in patients of any skin type. Nevertheless, seeing these parameters and understanding them are two separate issues, and successful treatment depends on the understanding rather than on the parameters themselves.

The extremely low level of knowledge found in a surprisingly large number of laser clinicians of the most basic theories on which laser physics and laser–tissue interactions are based is a source of constant surprise. Those who are neophytes have an excuse, but must immediately make plans to attend courses, and learn. There is, however, no excuse for this low level of knowledge in surgeons of several years' experience. In fact they are putting their patients at risk by continuing to practice, and moreover it is a real danger that through their incompetence they will give laser surgery a bad name, as 'the laser is to blame' tends to be their favourite excuse. This is why attending laser resurfacing-related meetings remains extremely important, even for the experienced and laser-cognizant surgeon, to reinforce the basics, and evaluate new approaches.

#### Nonablative skin rejuvenation

Finally, the laser–tissue and light–tissue interaction waters are becoming even muddier with the popular increase in the use of what is termed nonablative skin rejuvenation as an alternative, in favourable cases, to ablative resurfacing. Nonablative skin rejuvenation, or photorejuvenation as first described by Bitter,<sup>27</sup> aims at creating a controlled wound healing response in the dermis under an intact epidermis to achieve the rejuvenation of photoaged skin, and has none of the severe symptoms and patient downtime associated with laser resurfacing. The large range of wavelengths and light sources available demand that the clinician should possess even more basic knowledge, and not simply follow a cookbook approach to treatment without considering each patient as an individual case. Just as with the ablative lasers, however, once this knowledge is acquired, the principles behind treatment with particular lasers or light sources can be much more easily grasped through a thorough understanding of light–tissue interaction, as even with ablative lasers, the 'L' in the acronym 'laser' stands for 'light'.

Nonablative skin rejuvenation has its limitations, however, and these are one of the first things that clinicians considering its use must always consider. Nonablative skin rejuvenation with the correct parameters will help remove many of the sequelae of photoageing, including mild wrinkles, but it must be used in combination with post-treatment adjunctive skin care programmes, just as with laser ablative procedures. Patients must be given a comprehensive education programme to ensure realistic expectations, and some degree of patient selection must be exercised. However, and most importantly, nonablative skin rejuvenation is not a substitute for laser ablative resurfacing when wrinkles are deep and extensive.

## Discussion

The range of parameters and techniques proposed for the CO<sub>2</sub> or Er:YAG lasers for use in ablative resurfacing is staggeringly wide. Even for the experienced laser surgeon, a confusing choice exists of advocated settings in watts, joules, joules per square centimetre, or any combination of these. In addition to the parameters, the treatment techniques also vary with the use of particular scanners and set patterns, the pulse repetition rate, the end point and the number of passes required. For the novice laser resurfer the state of confusion is of course even worse. When faced with this extensive range of options, the clinician who is not too certain of the laser–tissue interaction basics is thus encouraged to take the easy way out and adopt the cookbook approach involving the use of a particular set of parameters presented at a meeting, published in the literature by a leader in the field, or (perhaps even worse) provided by the manufacturer. This set of parameters is then used rigidly despite the age or skin type of the patient, or the location and severity of the sequelae being treated. This is the cookbook approach at its worst, and of course the potential for bad treatment results is very high.

On the other hand, the combination of the Er:YAG followed by the subablative CO<sub>2</sub> wavelengths offers the optimal characteristics of each laser, and minimizes the disadvantages. The Er:YAG laser does what it does best, namely precisely erasing the epidermis, and the CO<sub>2</sub> laser does one of the things it can do best, i.e. warms up the target tissue. In other words, the synergistic use of these lasers together in laser ablative resurfacing produces an overall result better than the sum of the individual components, and which allows the whole resurfacing process to be achieved in a single pass, eliminating the confusion over the number of passes in almost all patients, with a very narrow range of parameters which change depending on the skin thickness of the area being treated. This

permits standardization of the procedure leading to ease of indication. In addition, using the optimal characteristics of the two component wavelengths also minimises and reduces side-effects for the patient, thus representing the best approach to laser ablative resurfacing. The narrow range of parameters evolved by the author for the dual wavelength system might well be criticised as another cookbook approach, the very thing the author is arguing against, but the major difference is that these parameters are based on sound photobiological principles of laser–tissue and light–tissue interaction with a combination of specific wavelengths, and have moreover been employed in more than 604 patients with skin types ranging from II to V, and ages from 27 to 82, with a patient satisfaction index of around 90% and a complications rate of less than 1%.<sup>28</sup>

## Conclusions

The current state-of-the-art technology in skin rejuvenation for severely chronologically and photodamaged skin is firmly based on laser resurfacing with the ablative laser systems and in, the author's opinion, with the dual-wavelength method in particular. However, laser clinicians must look far beyond the actual tool, the system itself, and adopt an encompassing, comprehensive approach in order to achieve good results and happy patients. Successfully practising laser resurfacing absolutely demands extensive knowledge of all aspects of light-tissue interaction and post-treatment wound care. All of these facets should be applied on a patient-by-patient basis rather than relying on an indiscriminate cook book methodology. A comprehensive care strategy is the only valid way to avoid an approach that might otherwise be a recipe for disaster.

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## References

- 1 Spadoni D, Cain CL. Facial resurfacing. Using the carbon dioxide laser. *AORN J* 1989; **50**: 1009–13.
- 2 Alt TH, Goodman GJ, Coleman WP, Hamke CW, Yarbrough JM. Dermabrasion. In: WP Coleman, ed. *Cosmetic Surgery of the Skin*. St Louis, MO, USA: Mosby; 1997: pp. 112–52.
- 3 Stuzin JM, Baker TJ, Gordon HL. Treatment of photoaging. Facial chemical peeling (phenol and trichloroacetic acid) and dermabrasion. *Clin Plast Surg* 1993; **20**: 9.

- 4 Trelles MA, Coates J, Trelles OR, Trelles K, Curto M, Clarke A. Histological correlation in laser skin resurfacing. *Lasers Med Sci* 1995; **10**: 279–82.
- 5 David LM, Sarne AJ, Unger WP. Rapid laser scanning for facial resurfacing. *Dermatol Surg* 1995; **21**: 1031–3.
- 6 Apfelberg DB. The UltraPulse carbon dioxide laser with computer pattern generator automatic scanner for facial cosmetic surgery and resurfacing. *Ann Plast Surg* 1996; **36**: 522–9.
- 7 Alster TS. Comparison of two high-energy, pulsed carbon dioxide lasers in the treatment of periorbital rhytides. *Dermatol Surg* 1996; **22**: 541–5.
- 8 Rubach BW, Schoenrock LD. Histological and clinical evaluation of facial resurfacing using a carbon dioxide laser with the computer pattern generator. *Arch Otolaryngol Head Neck Surg* 1997; **123**: 929–34.
- 9 Chernoff G, Slatkine M, Zair E, Mead D. Silk Touch: a new technology for skin resurfacing in aesthetic surgery. *J Clin Laser Med Surg* 1995; **13**: 97–100.
- 10 Lask G, Keller G, Lowe N, Gormley D. Laser skin resurfacing with the SilkTouch flashscanner for facial rhytides. *Dermatol Surg* 1995; **21**: 1021–4.
- 11 Trelles MA, Rigau J, Mellor TK, García L. A clinical and histological comparison of flashscanning versus pulsed technology in carbon dioxide laser facial skin resurfacing. *Dermatol Surg* 1998; **24**: 43–9.
- 12 Trelles MA, Rigau J, Mellor TK, García L. A clinical and histological comparison of flashscanning versus pulsed technology in carbon dioxide laser facial skin resurfacing. *Dermatol Surg* 1998; **24**: 43–9.
- 13 Trelles MA, Garcia L, Rigau J, Allones I, Velez M. Pulsed and scanned CO<sub>2</sub> laser resurfacing compared at two years postoperatively with scanning electron microscopy. *Plast Recon Surg* 2003, vol III; **6**: 2069–78.
- 14 Kaufmann R, Hibst R. Pulsed 2.94-microns erbium-YAG laser skin ablation – experimental results and first clinical application. *Clin Exp Dermatol* 1990; **15**: 389–93.
- 15 Kaufmann R, Hibst R. Pulsed Erbium: YAG laser ablation in cutaneous surgery. *Lasers Surg Med* 1996; **19**: 324–30.
- 16 Teikemeier G, Goldberg DJ. Skin resurfacing with the erbium: YAG Laser. *Dermatol Surg* 1997; **23**: 685–7.
- 17 Miller LD. The erbium laser gains a role in cosmetic surgery. *Biophoton International* 1997 (May/June): 38–42.
- 18 Hohenleutner U, Hohenleutner S, Baumler W, Landthaler M. Fast and effective skin ablation with an Er: YAG laser: determination of ablation rates and thermal damage zones. *Lasers Surg Med* 1997; **20**: 242–7.
- 19 Bass LS. Erbium: YAG laser skin resurfacing: preliminary clinical evaluation. *Ann Plast Surg* 1998; **40**: 328–34.
- 20 Hobart JA, Negus DK, Andersen DE. Dual mode laser delivery system providing tissue ablation and coagulation. 1999, Patent WO 9938752.
- 21 Trelles MA, García-Solana L, Calderhead RG. Skin resurfacing improved with a new dual wavelength Er: YAG / CO<sub>2</sub> laser system: a comparative study. *J Clin Laser Med Surg* 1999; **17**: 99–104.
- 22 Ross EV, Naseef GS, McKinlay JR, Barnette DJ, Skrobal M, Grevelink J, Anderson RR. Comparison of carbon dioxide laser, erbium: YAG laser, dermabrasion, and dermatome: a study of thermal damage, wound contraction, and wound healing in a live pig model: implications for skin resurfacing. *J Am Acad Dermatol* 2000; **42**: 92–105.
- 23 Trelles MA, Mordon S, Svaasand LO, Mellor TK, Rigau J, García L. The origin and role of erythema after carbon dioxide laser resurfacing. A clinical case and histological study. *Dermatol Surg* 1998; **24**: 25–9.
- 24 Trelles MA, Mordon S, Benitez V, Levy JL. Er: YAG laser resurfacing using combined ablation and coagulation modes. *Dermatol Surg* 2001; **27**: 727–34.
- 25 Trelles MA, Allones I, Luna R. One-pass resurfacing with a combined-mode erbium: YAG/CO<sub>2</sub> laser system: a study in 102 patients. *Br J Dermatol* 2002; **146**: 473–80.
- 26 Trelles MA, Velez M, Allones I. Easy dressing: an economic, transparent nonporous film for wound care after laser resurfacing. *Arch Dermatol* 2001; **137**: 674–5.
- 27 Bitter PH. Noninvasive rejuvenation of photoaged skin using serial, full-face intense pulsed light treatments. *Dermatol Surg* 2000; **26**: 835–43.
- 28 Trelles MA. Laser ablative resurfacing in photorejuvenation based on more than a decade's experience and 12 000 patients: personal observations. *J Cosmetic Derm* in press.