Dual Mode Er:YAG Laser Systems For Skin Resurfacing

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The history of laser resurfacing is relatively short. Even so, it continues to evolve at significant speed. First, the high-energy short-pulse (HESP) CO_2 lasers were demonstrated to provide effective skin rejuvenation when used appropriately. More recently, there has been considerable fanfare about the Erbium YAG lasers because of the impressive coefficient of absorption of the 2.94μm wavelength by water. These features have been used to induce very superficial 'laser peels'[1]. However, some disappointment has been generated about the problems with deeper vaporization by Er:YAG lasers[2]. This is related to the bleeding which occurs after penetration of the papillary dermis. Excessive bleeding at this stage prevents further tissue vaporization because the laser beam is completely absorbed by the wet blood field.

Recent developments in Er:YAG lasers have led to the combination of ablative and coagulative pulses (hence the term dual mode), which allow much deeper vaporization with significant control of hemostasis. To date, two dual mode systems are available in the US. A combined Er:YAG and CO_2 laser (DermaK™, by ESC), and sequential ablation/coagulation pulsed Er:YAG laser (Contour™, by Sciton). A third system (CO_3™, by Cynosure) employs a variable pulse Er:YAG laser which delivers single laser pulses from 500μsec to 10msec. The authors have had no clinical experience with the latter system, but believe it should have some of the beneficial features of the dual mode systems. The authors have utilized the dual mode Contour Er:YAG laser for up to 11 months, and their experiences are reflected herein.

The vaporization threshold of the Er:YAG laser has been calculated to be between 0.5 and

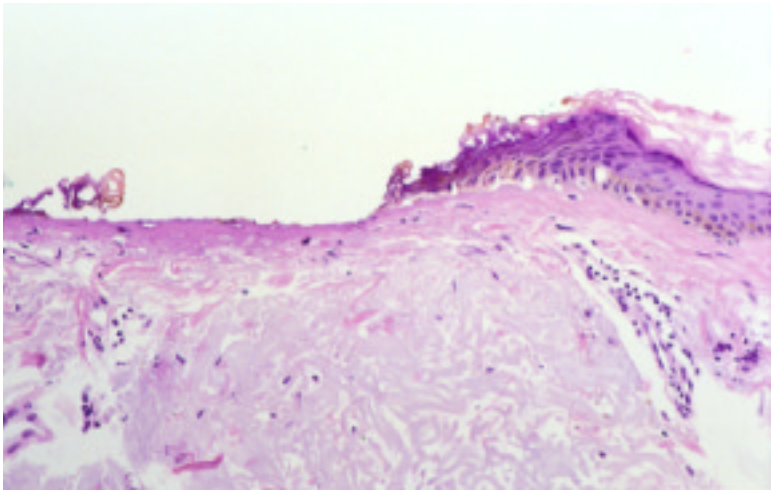

Fig 1a 50 microns ablation, 100 microns coagulation, 3 passes. (H&E x100) Approximately. 130 microns of ablation into the papillary dermis with 100 microns of thermal damage after three passes.

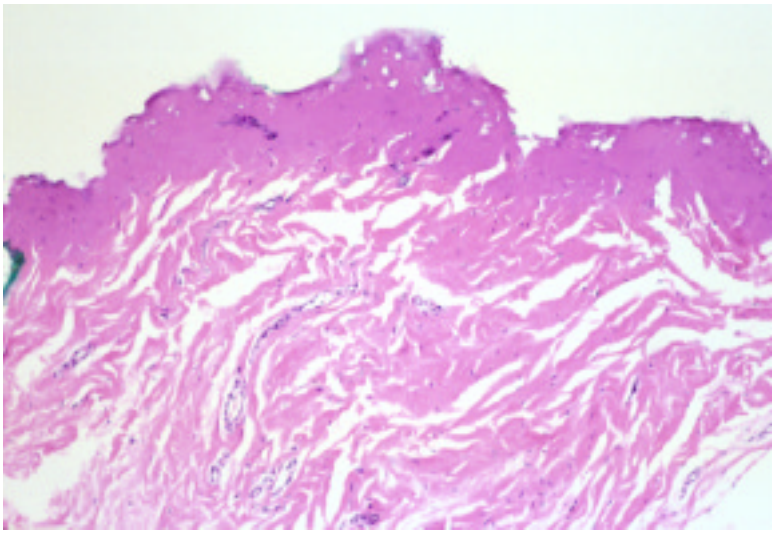

Fig 1b 50 microns ablation, 100 microns coagulation, 5 passes. (H&E x200) Approximately 200 microns of ablation into the dermis with 150 microns of thermal damage. This shows that the dual mode Er:YAG can indeed induce an impressive degree of thermal coagulation at these parameters.

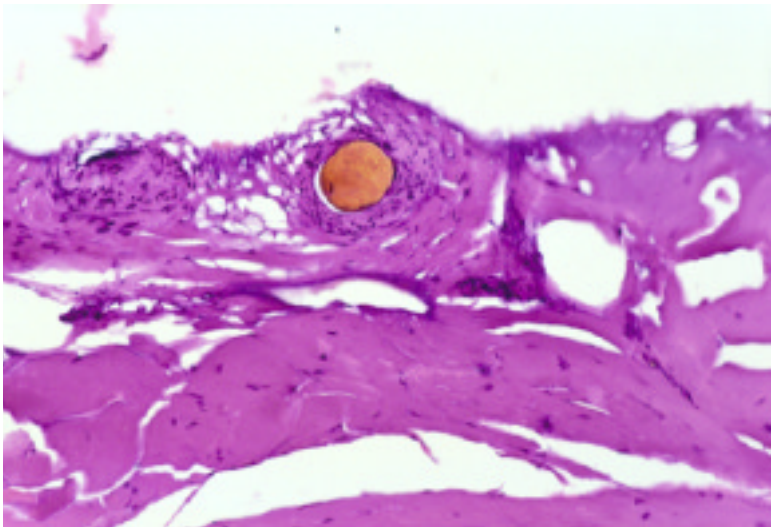

Fig 1c Thrombosed capillary. At these parameters good coagulation of small vessels can be obtained.

1.5J/cm^2. Each joule/cm^2 will instantly vaporize 2-4μm of tissue leaving minimal thermal injury. The Contour Er:YAG contains not one but two Er:YAG lasers providing 45 watts of power. The engineers use a technology called optical multiplexing to generate multiple variable length "macropulses" to generate high tissue fluence. At 50% overlap, fluences of up to 100J/cm^2 can be generated for aggressive vaporization. Sufficient energy can be delivered to remove the epidermis in one pass. The optical multiplexing also allows the laser to be used either in an ablative mode, a combined ablative/coagulative dual mode, or a pure coagulative mode. The ablative mode is characterized by a short 200μsec supra threshold pulse. The dual mode ablation/coagulation is achieved by an ablative pulse immediately followed by a relatively long sub-ablative pulse. The coagulative mode consists simply of a series of sub-ablative pulses. In our experience this latter mode is rarely used, but might have applications for blepharoplasty.

The Contour has a touch screen control panel. The operator punches in the microns of ablation to be achieved, and the microns of coagulative thermal damage to be induced. This is a departure from any other system, and makes the operator consider the tissue effects carefully and in clinically relevant units. Other features on the screen include the fluence, scan pattern and size, repetition rate and degree of overlap. Changing the latter is automatically associated with a change in the declared fluence delivered to the tissue. These are useful and intuitive additions that add to the safety of the laser particularly when one considers that Er:YAG laser tissue vaporization is almost linear with each pass, and has no 'chamois' color changes associated with thermal necrosis. This is in contrast to the CO_2 laser that has a plateau of ablation and characteristic 'colors of depth'. In desiccated tissue, the ablation rate is very low when using the CO_2 laser at 10.6μm and thus the ablation process typically ceases after 3 passes. At 2.94μm, (with the Er.YAG) the ablation rate of desiccated tissue is lower but still significant, and it appears to be roughly

Fig 2a Preoperative photograph. Significant photoaging including elastosis and wrinkling.

Fig 2b 9 weeks status post Er:YAG laser abrasion. This lady is still red, belying the myth that these patients have no prolonged erythema. However, the improvement is substantial, and comparable with a CO_2 laser.

2/3 the rate for hydrated tissue, that is approximately 2-2.5μm/J/cm^2.

Techniques

Standard preoperative resurfacing measures were employed in all patients. All procedures were performed under local anesthesia. Superficial anesthesia could be adequately achieved by EMLA™ , though ELA-Max™ gave significantly better topical anesthesia. Sub-lingual diazepam 5mg was given 30 mins prior to anesthesia. Meperidine 50-75mg and Hydroxyzine 25mg IM were also frequently used.

Each anatomic area of the face needs to be assessed separately with regard to depth of vaporization. The **eyelid** epidermal thickness is approximately 50-70μm. The normal parameters in this area would be a first pass using ablation only at 60μm (15J/cm^2) to remove the entire epidermis in one pass. A 20–30 % pulse overlap is used to reduce any irregularity associated with the gaussian beam. Although the residual laser debris need not be wiped away, removal does give the surgeon a better view of the tissue for subsequent irradiation. A second pass would normally include both ablative/coagulative modes at 60/25μm. When necessary, a third pass could be given at 30μm of ablation alone. By contrast the **upper lip** generally requires more aggressive resurfacing. The first pass might be at 90μm of ablation, second at 90/50μm ablation/coagulation, a third at 90/100μm and so forth depending on the degree of rhytids and elastosis (Fig1a-c). There is no obvious end point with this laser. Novice users need to be cautious about the depth of vaporization. Visible contraction is evident in second and subsequent passes when using the combined ablative and coagulative modes.

Those who are used to and expect a completely dry field in all their patients will be in for slight surprise. Some patients are just more vascular than others. Bleeding is a function of many factors including rosaceous change, anxi-

Fig 3a This Asian man with acne scarring is seen pre Er:YAG. We elected to perform a regional laser abrasion in the worst affected areas.

Fig 3b Immediately post Er:YAG laser procedure.

Fig 3c 4.5 month post Er:YAG. Well healed, significant improvement in

ety level, and venous pressure. There is a trade off between absolute hemostasis and reduced thermal injury when comparing the CO_2 lasers with the dual mode Contour Er:YAG laser. For this reason one should feel free to be relatively aggressive with the coagulating mode of the Contour, though this might delay healing and prolong erythema. In fact, the manufacturers might want to increase this component of their system. However, most patients do not need more than 50μm of coagulation to control hemostasis, and on the eyelids 25μm is sufficient.

Some experienced Er:YAG laser surgeons like to work free-hand because conventional Er:YAG lasers (15-20W) are relatively underpowered and the scanners can be rather pedestrian. This technique can lead to stacking of pulses and an irregular outcome in inexperienced hands. At 45W, the Contour Er:YAG is a very high powered system enabling the scanner to run at a usefully fast rate. There is a noticeable reduction in scanning speed when using the dual mode as opposed to the single ablation-only mode. There are times when a collimated spot is more useful than a scan pattern. The single spot is either 2 or 4mm in diameter. The 2mm diameter spot is capable of delivering extremely high fluences, and may be used for local sculpting of elevated lesions such as epidermal nevi, angiofibromas, other benign tumors, scars, rhinophyma, and superficial skin cancers. For general resurfacing purposes the 4mm spot is used. Feathering techniques are employed to blend the perimeter of any treated area. It should be remembered that the natural tendency of the 'collimated' Er:YAG beam is to be divergent at a distance of greater than approximately 5 inches. By pulling back the hand piece one can achieve very significant reduction in fluences for feathering purposes. As always, careful observation of tissue response is indicated to assess appropriateness of parameters.

Postoperatively, patients were dressed with a topical hydrogel dressing that was changed at two days and four days. Subsequently patients

Fig 4a Significant photodamage pre Er:YAG

Fig4b Good response at 5 weeks. Reduced rhytids and even color.

were maintained with an open dressing technique.

Results

The majority of patients had reepithelialized by 3-5 days. Deeper areas of vaporization took relatively longer to heal. Persistent erythema was noted in those who underwent any significant depth of vaporization. This was noted to last for up to three months in some cases (Fig 2a,b). In comparison to the CO_2 laser, erythema did clear somewhat faster, though as the authors became more aggressive, so too did the erythema persist longer. Scarring was not seen in any of our combined patients, though the authors would caution that this complication might certainly occur with injudicious technique.

Post inflammatory hyperpigmentation was seen in darker skin types, though was never persistent. Persistent hypopigmentation was seen in one patient. In this case, the loss of pigmentation was quite linear and appeared to be related to depth of vaporization. It is assumed that this relatively common sequel of CO_2 laser resurfacing will probably occur more frequently in the future, and patients should be warned of its occurrence.

One patient had a significant local bacterial infection, but responded without further complication to systemic antibiotics. No patients had herpes simplex infection. This was presumably related to obsessional use of antiviral agents.

The patients were followed for a maximum of 11 months. Significant improvements were noted in all patients. There was a definite learning curve; those patients who were treated latterly were probably treated more aggressively than those treated earlier. Patients with significant photodamage, thick wrinkles, and elastosis required deeper vaporization when compared with those with more superficial damage. Tissue 'contraction' was seen on second and subsequent passes, though it was less apparent than with the CO_2 laser. This is consistent with some other investigators experience[3]. This is presumably related to the increased desiccation induced by the latter.

Summary

There are many myths about the Er:YAG lasers the biggest of which are "No prolonged redness" and "less scarring". These are simply untrue. We believe that these complications are mainly depth related. Both authors have had patients who are still pink at three months.

In the series of patients treated, both superficial and deep laser abrasion were performed. Those patients who underwent superficial laser abrasion healed quickly with only minimal erythema. However, these results were very comparable with those patients undergoing very superficial laser abrasion with the HESP CO_2 laser systems.

The conventional Er:YAG lasers exhibit significantly different characteristics to the dual mode systems. The conventional systems provide efficient ablation but little coagulation. Removal of the epidermis can take multiple passes when using low powered single mode systems [4] . This results in excellent superficial cutaneous laser resurfacing, but deeper vaporization is often compromised by papillary and upper reticular bleeding. The dual mode systems are extremely versatile for both superficial and deep vaporization, even in highly vascular areas. They provide controlled coagulation.

There has been some concern about long term post laser hyperpigmentation in Asian patients. We are in agreement with other investigators in expressing cautious optimism about this when using the Er:YAG lasers[5]. Frankly, we have never observed permanent hyperpigmentation in any racial group (Fig 3a-c). Anecdotally, Er:YAG laser treated patients have a lower incidence of hypopigmentation than CO_2 treated patients. This may be related to more superficial treatments and less thermal injury with the Er:YAG laser [6,7].

The power of the laser system is important because it drives the speed at which the scanner can pulse. Lower powered systems have frustratingly slow scan patterns, and some operators therefore prefer to use the laser in a freehand painting fashion. Low power systems are also unable to remove the entire epidermis in one pass, and resurfacing can require multiple passes. The Contour contains not one but two laser heads, and allows the fast delivery of variable length macropulses of high fluence.

Perception and variation are the spice of life. Life would indeed be pretty boring if we all liked and believed the same things. Our take on laser resurfacing is that most of the systems out there work pretty well if used appropriately. However, not all Er:YAG lasers are made equally, either from an engineering or ease of use point of view. And that the Contour does offer certain advantages. Its high-power, dual-mode, optical-multiplexing, fast-scanning characteristics are real benefits to the operator when performing laser resurfacing. One of us (RCG) still likes to use the HESP CO_2 laser for those patients with deeper rhytids. The other uses only the dual mode Er:YAG. Both physicians obtain nice results (Fig 4a,b). There are no absolutes in this arena.

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Disclosure statement.
For the purposes of a clinical study, UCSF received the loan of an Er:YAG laser from Sciton, Inc. UCSF also received a discount on the purchase of laser equipment. CBZ received educational travel grants to attend meetings from both Sciton and Ferndale Labs.

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