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NONABLATIVE RESURFACING

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TYPES OF LASERS AND THEIR DIFFERENCES

Pulsed char-free CO_2 laser skin resurfacing has provided a method of removing thin layers of skin with minimal thermal damage. These lasers improve mild, moderate and severe rhytids, as well as photoaged skin. Laser energy is delivered at the ablation threshold of skin, without the side effects seen with older nonpulsed, continuous wave CO_2 lasers. The presumed mechanisms of char-free pulsed CO_2 laser rhytid improvement are 1) epidermal ablation, 2) dermal damage with collagen remodeling, and 3) thermal contraction.[5]

Despite the clinical improvement seen after CO_2 laser treatment, the enthusiasm for this system has been tempered by the prolonged healing and significant erythema that is commonly seen following laser treatment. Although this erythema can resolve in 1 month, it commonly lasts up to 6 months. Experienced laser physicians performing $C0_2$ laser surgery achieve excellent results; however, novice laser physicians have not found CO_2 systems to be as user friendly. With this significant learning curve, some physicians have shied away from laser resurfacing.

The erbium:yttrium-aluminum-garnet (Er:YAG) laser, with its 2940-nm wavelength, emits laser energy in the mid-infrared invisible light spectrum. This wavelength has 10, to 15 times the affinity for water absorption, compared with the $C0_2$ (10,600 nm) wavelength. It is this fact that leads to the difference in clinical response seen after treatment with these two lasers. The Er:YAG laser wavelength is at the peak of water absorption. Er:YAG laser treatment leads to epidermal ablation and dermal remodeling. Unlike $C0_2$ lasers, these systems produce little thermal effect.[2,8] The Er:YAG laser is a true ablation laser, unlike CO_2 lasers, which cause both vaporization and desiccation. Both the Er:YAG and pulsed char-free CO_2 lasers have water as the absorbing chromophore. The Er:YAG laser produces only about 5 R to 20 μ of thermal damage per impact, as opposed to the 50 p. to 125 p. of additional thermal damage seen with each CO_2 laser pass. CO_2 lasers produce a significant thermal effect; this residual thermal damage becomes a "heat sink" for the next CO_2 laser pass. This leads to desiccated collagen, with a resultant increase in new collagen production. Such an effect is not expected after Er:YAG laser treatment.

WOUND HEALING

Because Er:YAG laser treatment often involves more superficial ablation and leaves minimal thermal damage, the duration of erythema after resurfacing usually is less than that seen with CO_2 laser treatment. Wound healing and recovery time following Er:YAG laser treatment is generally shorter. Er:YAG laser resurfacing is ideal for resurfacing rela

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tively young people who lack deep wrinkles or extensive photodamage; however, a draining wound is still created with Er:YAG laser technology.

Both CO_z and Er:YAG laser technology, although promising in their benefits, are sometimes accompanied by untoward side effects and complications. The commonest of these, as mentioned earlier, is postoperative erythema, a side effect experienced by virtually all patients treated with these modalities. Other potential risks induced by ablative, dermal wounding modalities are delayed healing, postoperative pigmentary changes, and scarring.

If a dermal wound and new collagen formation are the primary mechanisms behind the improvement seen after laser resurfacing, then techniques that induce a dermal wound without epidermal ablation theoretically should lead to cosmetic improvement of dermal photodamage. This arena of *nonablative resurfacing,* or, as it is more appropriately called *subsurface remodeling,* is a new area of laser technology. There is therefore a dearth of published studies discussing subsurface remodeling. This article reviews what is currently known about these treatment modalities. In addition, the author reviews his own experience with these varied new approaches.

SUBSURFACE REMODELING

Clinical Experience

In one of the first studies evaluating a nonablative approach to dermal remodeling, a 1064-nm Q-switched neodymium Nd:YAG laser was used in an attempt to improve rhytids.[4] Eleven subjects with perioral or periorbital rhytids were evaluated using a Q-switched Nd:YAG laser at 5.5 J/cmz and a 3-mm spot size. All subjects were of skin phenotypes I and II; all had class I or II rhytids. The authors sought a nonspecific clinical endpoint of pinpoint bleeding. Subjects were treated only once and were evaluated 7, 30, 60, and 90 days after treatment. At follow-up, each subject was evaluated for improvement of rhytids, healing, pigmentary changes, and erythema. In three patients (two perioral / one periorbital), the authors noted improvement that was thought to be comparable to that following ablative resurfacing (Fig. 1). In six patients (three perioral/three periorbital), clinical improvement was noted but was not thought to be as significant as that seen with an ablative laser system. In two patients (one perioral/one periorbital), no clinical improvement was noted. In those subjects in whom clinical improvement was noted, the clinical changes were consistent the full 90 days of the study. No pigmentary changes or scarring was noted in any of the treated subjects. At 1 month, 3 of 11 subjects showed persistent erythema at the treated sites. At 3 months, all erythema was resolved.

Dermal remodeling is thought to occur through increased collagen I deposition, with collagen reorganization into parallel arrays of compact fibrils. Such an effect, the authors suggested, could occur with nonablative as well as ablative laser systems. Of note, the greatest improvement occurred in those patients who had the most persistent erythema. This suggested that the degree of improvement following any dermal wounding approach could be directly related to the degree of induced wounding.

This study was then expanded when the nonablative dermal remodeling effects of a Q-switched Nd:YAG laser were potentiated by the use of a topical carbon-assisted solution .[3] Two hundred forty-two solar damaged anatomic sites on sixty one human subjects were treated with three 1064-nm Q-switched Nd:YAG laser treatments. Parameters of treatment included a fluence of 2.5 J /cmz, pulse duration of 6 to 20 nanoseconds, and a spot size of 7 mm. The treatment sites were evaluated at baseline, and at 4, 8, 14, 20, and 32 weeks for skin texture, skin elasticity, and rhytid reduction. All sites were treated at a baseline visit, and later at 4 and 8 weeks. Adverse events were recorded throughout the study.

In this study, a low-fluence Q-switched Nd:YAG laser was used for treating mildly solar-damaged skin. Unlike the previous study, there was no epidermal disruption when the lower fluences were used. The Q-switched Nd:YAG laser energy is not well absorbed by tissue water; it is nonselectively placed within the dermis. The 1064-nm wavelength results in relatively deep penetration into the skin, which is indicative of minimal laser/ tissue interaction. As a result, 1) cellular damage is localized to the tissue immediately adjacent to the carbon; 2) nontargeted tissue is minimally affected; and 3) less than 10% of the typical energy output from CO_z lasers is required for the treatment.

At 8 months, the investigators reported im-

Figure 1. A, Periorbital rhytids prior to high fluence Q-switched Nd:YAG laser treatment. *B,* Improvement after nonablative Q-switched Nd:YAG laser treatment.

provement in skin texture and skin elasticity, as well as rhytid reduction compared with baseline (Fig. 2). Most adverse events were limited to mild, brief erythema.

Other nonablative lasers, such as the pulsed-dye laser, have been shown to improve dermal collagen. Histopathologic examination of 585-nm pulsed-dye laser-treated scars revealed improvement in dermal collagen. There is also an increase in the number of regional mast cells in pulsed-dye laser-irradiated scars. Because mast cells elaborate a variety of cytokines, their presence following irradiation and accompanying tissue revascularization can provide an explanation for therapeutic improvement following laser treatment. Using this concept, Kilmer et al evaluated the use of a pulsed-dye laser in the treatment of rhytids.[6] In a small pilot study, the authors noted improvement; however, the study results were tempered by the cosmetically unacceptable purpura that usually is seen after treatment with this laser.

In a recent study, the use of intense pulsed light also was evaluated in the treatment of rhytids.[1] Thirty female subjects, aged 35 to

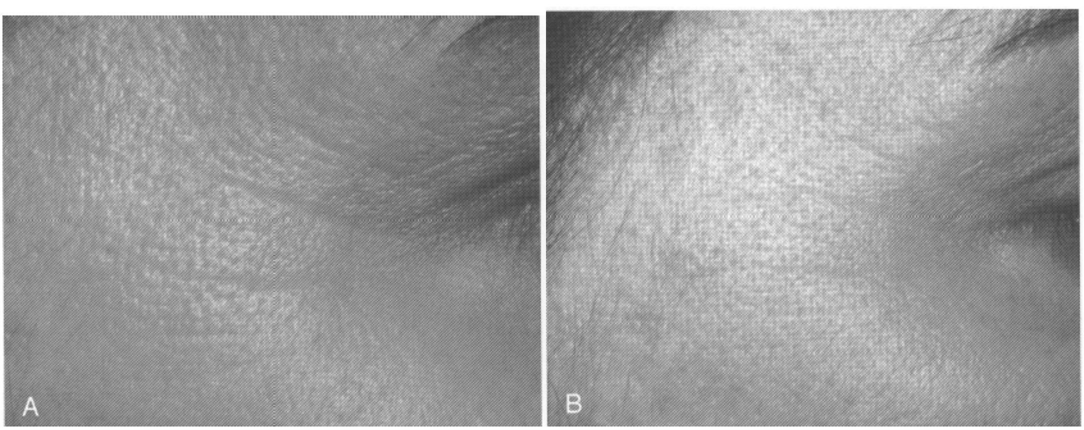

Figure 2. A, Periorbital rhytids prior to treatment with carbon-assisted low fluence Q-switched Nd:YAG laser treatment. *B,* Improvement after treatment with carbon-assisted low fluence Q-switched Nd:YAG laser treatment.

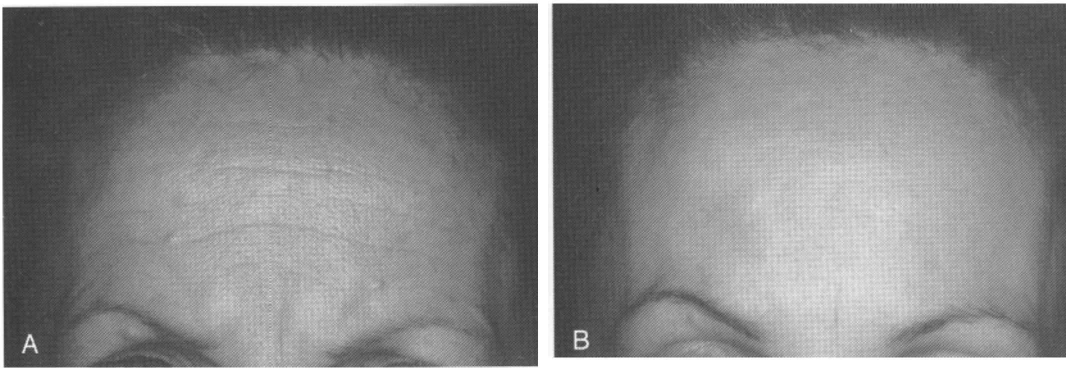

Figure 3. A, Forehead rhytids prior to treatment with nonablative intense pulse light. *B,* Improvement after treatment with nonablative intense pulse light.

years and Fitzpatrick type I to II and class I to II skin phenotypes, were treated. Treatment areas included the periorbital, perioral, and forehead regions. One to four treatments were provided over 10 weeks. Noncoherent intense pulsed light was delivered to the skin, using a 645-nm cutoff filter. This leads to emission of light with wavelengths between 645 nm and 1100 nm. Light was delivered through a bracketed cooling device, in triple 7-msec pulses, with a 50-msec interpulse delay. Delivered fluences were between 40 and 50 J/cm ^{2}. The author evaluated the degree of improvement 6 months after the last treatment, and complications also were evaluated at this time. Clinical improvement was divided into four quartiles:

1. No improvement
2. Some improvement
3. Substantial improvement
4. Total improvement'

Six months after the final treatment, five subjects were noted to have no improvement. Similarly, no subjects were noted to have total improvement. Sixteen subjects showed some improvement, whereas nine subjects showed substantial improvement' (Fig. 3). All subjects were evaluated for pigmentary changes, post-treatment blistering, erythema, and scarring. Of the 30 subjects, 3 were noted to have blistering immediately after treatment. All 30 subjects had post-treatment erythema. Six months after treatment, no pigmentary changes, erythema, or scarring were noted. The author concluded that intense pulsed light could improve some rhytids; however, the changes appeared to be subtler than those seen with ablative techniques.

The first specifically nonablative laser to be solely marketed to the physician community is a 1320-nm Nd:YAG laser. Nelson et al presented the first study evaluating the subsur

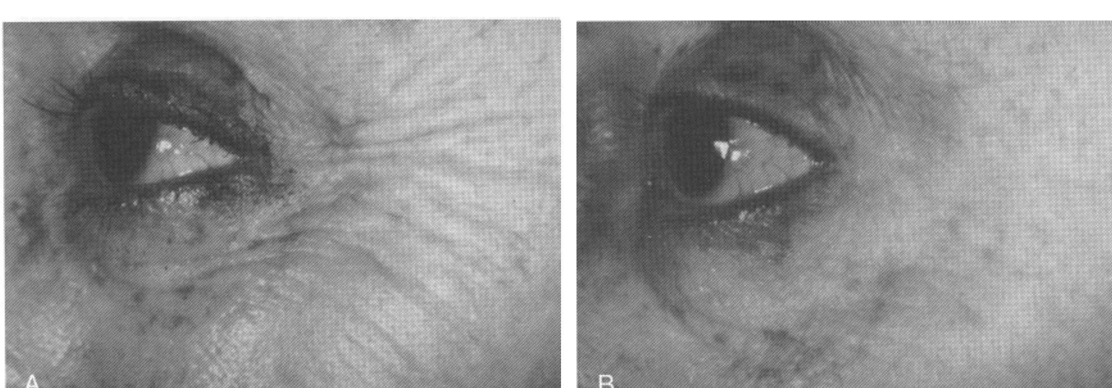

Figure 4. A, Periorbital rhytids prior to treatment with a 1320-nm Nd:YAG laser treatment. *B,* Improvement after treatment with a 1320-nm Nd:YAG laser treatment.

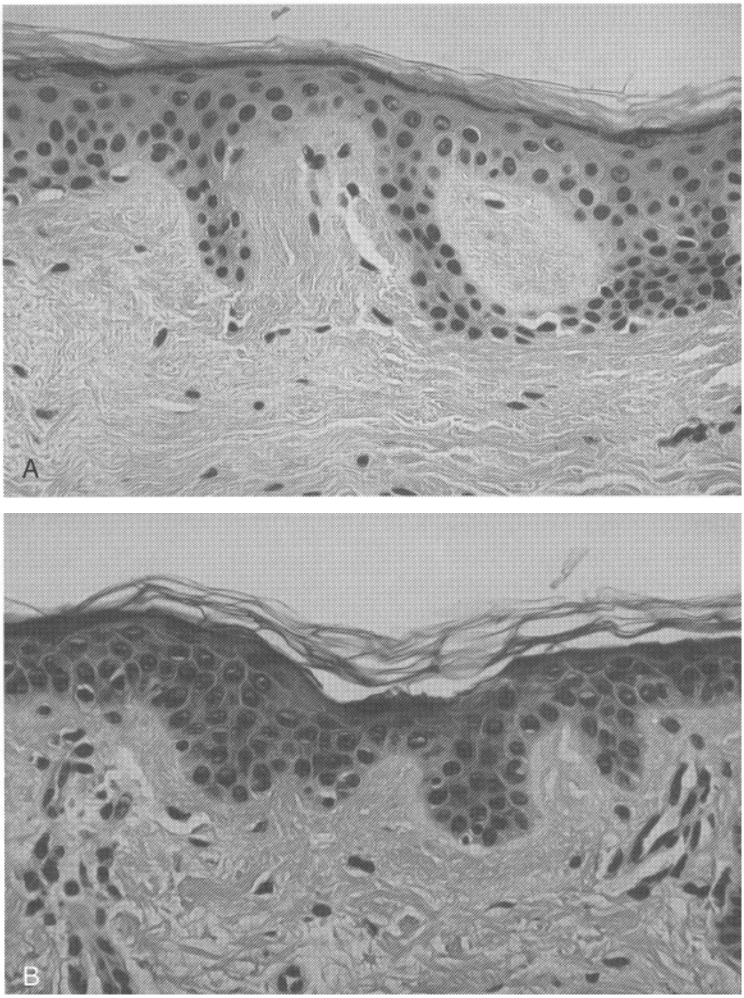

Figure 5. A, Loose irregular dermal collagen fibrils consistent with solar damaged dermis. B, Increased collagen thickness in papillary dermis 6 months after treatment with a 1320-nm Nd:YAG laser.

face remodeling efficacy of this system .[7] The goal of this system, similar to that of the previously described systems, is improvement of rhytids without the creation of a wound. The 1320-nm wavelength is advantageous in its high scattering coefficient. The laser irradiation scatters throughout the treated dermis after nonspecific absorption by dermal water.

In Nelson's study,' one or more passes of a 1320-nm Nd:YAG laser were used on photoaged skin. The waveform consisted of 3200μsec laser pulses at a 100-Hz repetition rate. Laser energy was delivered through a 5-mm spot size, with fluences up to 10 J/cm^2. A dynamic cryogen cooling technique was applied immediately before laser treatment to produce selective subsurface skin heating without epidermal damage. Immediately after treatment, mild edema and erythema appeared in the treated skin. These side effects were resolved within 2 days. Two months after treatment, facial rhytids were noted to be improved. No persistent erythema or pigmentary changes were noted. The currently available model of this 1320-nm Nd:YAG laser is accompanied by a unique handpiece with three portals. One portal contains the cryogen spray that cools the epidermis before and during treatment, one portal emits the 1320-nm Nd:YAG laser irradiation, and one portal contains a thermal sensor. Utilized fluences with the currently available models vary between 30 and 40 J / cm^2. Such fluences lead to peak measured temperatures of 42° to 48°C. Patients are usually treated at 2- to 4-week intervals and can be expected to show the degree of improvement expected from a nonablative approach (Fig. 4). Consistent with the noted clinical improvement is the histologic replacement of the irregular collagen bands with organized new collagen fibrils (Fig. 5).

Nonablative or subsurface remodeling represents the newest approach to improve photodamaged skin. Because the degree of collagen remodeling is not expected to be as great as that seen with other, more destructive ablative approaches, the nonablative technique is meant for those patients who do not wish to take time away from their daily activities to improve the quality of their sun-damaged skin with a laser. The technique is also not meant for those with extensive solar-induced epidermal pigmentary changes. Those subjects are best treated with either an ablative laser or a specific pigmented lesion laser. In the future, lasers might be created that can cause the same degree of improvement as that seen with ablative systems, without the potential complications and downtime from such systems.

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