
1,450 nm Long-Pulsed Diode Laser for Nonablative Skin Rejuvenation

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BACKGROUND. There has been growing patient demand for laser technology to treat rhytids and to refine skin texture without the associated lifestyle hindrance common to ablative cutaneous procedures. Nonablative laser systems have been developed to meet this need and, in many instances, have replaced ablative lasers as the preferred treatment modality.

OBJECTIVE. To review long-pulsed diode laser technology in the treatment of a variety of cutaneous disorders.

MATERIALS AND METHODS. All publications involving 1,450 nm

long-pulsed diode laser technology were reviewed and discussed. **RESULTS.** The latest generation of nonablative lasers, in the mid-infrared electromagnetic spectrum, selectively targets and heats dermal tissue to stimulate collagen remodeling while sparing the epidermis.

CONCLUSIONS. Demonstrating efficacy in the treatment of a wide range of cutaneous disorders, including facial rhytids, acne vulgaris, and atrophic scars, the 1,450 nm diode laser is a useful addition to the nonablative laser armamentarium.

SEEMA N. DOSHI, MD, AND TINA S. ALSTER, MD, HAVE INDICATED NO SIGNIFICANT INTEREST WITH COMMERCIAL SUPPORTERS.

IN RECENT years, the focus in skin rejuvenation techniques has shifted from ablative laser skin resurfacing to nonablative dermal remodeling. Although the efficacy of the carbon dioxide and erbium (Er):yttrium-aluminum-garnet (YAG) lasers for amelioration of severely photo-damaged skin, rhytids, acne scars, and dyschromias is unequivocal, untoward side effects of prolonged erythema, pigmentary alterations, and infections are not uncommon.¹⁻³ Offering a low incidence of adverse effects and a virtually nonexistent recovery period, nonablative lasers and light sources are drawing increasing interest from patients and medical practitioners alike.⁴ Despite inconsistent results and frequently only modest clinical improvement, nonablative laser skin resurfacing has emerged as a favored treatment modality for certain patients.

Nonablative Laser Technology

Rapid expansion of nonablative laser technology has yielded a myriad of systems with subsurfacing capability. Included in this growing list are the pulsed dye (585 and 595 nm), intense pulsed light (500–1,200 nm), neodymium (Nd):YAG (1,064 and 1,320 nm), diode (980 and 1,450 nm), and Er:glass (1,540 nm) lasers.⁵⁻¹² All operate on the well-established principles of selective photothermolysis¹³ and can be divided into essentially two groups: those that target a discrete dermal chromophore and those that target

dermal water.^{14,15} Despite distinctly different targets, these lasers effect similar histologic changes. Thermal injury, whether directed at dermal microvasculature or tissue water, most likely induces an inflammatory response with cytokine up-regulation and fibroblast proliferation.¹⁶ Subsequent deposition of papillary dermal collagen in a parallel configuration accounts for the clinical improvement noted months after treatment.^{16,17}

Midinfrared Lasers

In the infrared portion of the electromagnetic spectrum (> 700 nm), the water absorption coefficient is relatively low, thereby effecting deeper laser tissue penetration.¹⁴ As the majority of solar damage occurs at dermal depths ranging from 100 to 400 μm , midinfrared lasers possess optimal wavelengths for water-based nonablative skin remodeling.^{16,18} Bulk heating of tissue is induced by the relatively non-specific nature of a water chromophore, rendering surface skin cooling a requisite.¹⁸ The level of dermal injury relates to a careful balance between surface cooling and heating.¹⁶ Cooling prevents integumental injury while maximizing fluence for greater dermal heating.¹⁸ Of the midinfrared laser systems available, the 1,450 nm diode laser produces lower peak powers (10–15 W), necessitating longer pulse durations to achieve optimal fluences. Thus, tissue cooling is applied at brief intervals before, during, and after laser exposure.¹⁵

Clinical Applications

The most popular long-pulsed diode resurfacing laser (Smoothbeam, Candela Corp., Wayland, MA, USA) is a

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1,450 nm nonablative system with an integrated dynamic cooling device (tetrafluoroethane -26°C). In recent clinical trials, this diode laser has demonstrated efficacy in the diminution of rhytids, treatment of active acne, and improvement of atrophic scars.^{9,10,19-21} Goldberg and colleagues demonstrated clinical improvement of class I and II facial rhytids after two to four monthly treatments.⁹ The study, in which the contralateral face was treated with cryogen cooling alone, established that the improvement observed was a direct result of tissue injury from laser irradiation rather than from physical injury induced by the cryogen spray. Ten patients noted mild improvement, and three patients with periocular rhytids noted moderate improvements.

A larger study by Tanzi and Alster involved 25 patients with skin phototypes I to III and mild to moderate facial rhytids.¹⁰ Four Smoothbeam laser treatments were delivered at monthly intervals (4 mm spot size, fluence 15–20 J/cm², pulse duration 210 milliseconds). Clinical and histologic evaluations of treated skin were made at regular intervals during the 12-month follow-up study period. Statistically significant improvement in mean clinical scores was noted in all treatment areas, most notably in the periocular region (Figure 1). It was speculated that the thin nature of the periocular skin either augmented the degree of thermal injury or simply enhanced the perception of neocollagenesis. Peak improvement, both histologically and clinically, was noted 6 months after the final laser procedure, without any further new collagen formation occurring at the 12-month follow-up period.

Transverse neck rhytids, which characteristically present a treatment challenge, have also responded favorably to 1,450 nm laser irradiation.¹⁹ Twenty patients with skin phototypes I to V received three monthly treatments at a fluence range of 10 to 13 J/cm². Evaluations were performed at each treatment session and at the 1-, 3-, and 6-month follow-up visits. Both sequential digital photographs and *in vivo* three-dimensional skin surface

microtopography measurements revealed statistically significant improvement in the appearance and texture of the treated areas compared with nontreated controls. The greatest improvement was observed at the last (6 month) follow-up (Figure 2). Scores from both patient satisfaction surveys and two independent observers paralleled the objective improvements demonstrated by topography.

In another study by Tanzi and Alster, the long-pulsed diode system was even shown to improve atrophic acne scars. The 1,320 nm Nd:YAG (CoolTouch, CoolTouch Corp., Auburn, CA, USA) and 1,450 nm diode (Smoothbeam) lasers were directly compared on randomly assigned facial halves. Greater clinical improvement was seen with the 1,450 nm diode system at each of several follow-up visits in the post-treatment study period, although positive changes from baseline were noted with both lasers (Figure 3).²⁰ Skin surface texture (measured with *in vivo* microtopography) also improved after treatment with each of the two systems, but the 1,450 nm diode laser induced more significant change, peaking 6 months post-treatment.

Lastly, active acne vulgaris has been successfully treated with the 1,450 nm diode laser (Figure 4).²¹ Given the fact that sebaceous glands reside 200 to 1,000 μm below the stratum corneum, the diode laser, with its ability to penetrate tissue to a depth of 435 μm , can easily reach the intended target. In phase I studies by Hardaway and colleagues, post-diode laser treatment histology revealed thermal damage from 50 to 800 μm below the stratum corneum, particularly around adnexae, suggesting a lower injury threshold for these structures.¹⁸ This same group treated upper back halves of 27 acne patients at 3-week time intervals, for a total of four diode laser treatments at fluences ranging from 14 to 22 J/cm².²¹ Contralateral back halves were treated with cryogen spray alone. A statistically significant decrease in acne lesion counts was noted



Figure 1. Periocular rhytids before (*left*) and 6 months after the third long-pulsed 1,450 nm diode laser treatment (*right*).



Figure 2. Transverse lateral neck lines before (*left*) and 6 months after the third consecutive monthly treatment with a 1,450 nm diode laser (*right*). The anterior portion of neck lines was not treated.



Figure 3. Atrophic scars before (*left*) and 6 months after the third treatment with a 1,450 nm diode laser (*right*).



Figure 4. Facial acne before (*left*) and 1 month after 1,450 nm diode laser irradiation (*right*).

on the laser-treated back halves. Ruptured pilosebaceous units were seen in post-treatment biopsies, but this finding did not persist in repeat biopsies 6 to 12 months later. It was hypothesized that a temporary reduction in sebum secretion and the *Propionibacterium acnes* population was responsible for the clinical improvement seen.

Safety Profile and Side Effects

Keeping with the trend of other nonablative lasers, the side effects of long-pulsed diode laser irradiation are nominal

and transient. Immediate erythema and edema are typically seen in treated sites, lasting less than 24 hours. Hyperpigmentation occurred in 3 of 27 patients in the acne study and was graded as severe by 1 patient.²¹ Although only one subject noted hyperpigmentation in the study by Goldberg and Silapunt,⁸ it occurred in 18% of total treatments performed in the initial study by Tanzi and Alster.¹⁰ These latter authors speculated that the short intervals (3 weeks) between laser treatments and the long tissue cooling time (60 milliseconds) were responsible for the increased frequency of this side effect. Subsequent studies using shorter cryogen spurts (total 50 milliseconds) and longer intertreatment intervals (4–6 weeks) produced lower rates of hyperpigmentation (5–7%).^{19,20}

Conclusions

Initial studies with the long-pulsed diode laser have established this system as a valuable and diverse tool. The deeply penetrating wavelength imparts thermal injury to dermal collagen and to the pilosebaceous unit, thereby accounting for the various clinical effects observed. Studies have established this laser as a good choice for patients with minimal epidermal damage who desire improvement of mild to moderate rhytids without the postoperative morbidity common to the ablative laser systems. Additionally, the results in the treatment of active acne and atrophic scars are promising. Further study will elucidate optimal treatment parameters and protocols to attain the best clinical results.

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Commentary

This article succinctly describes the utility of the 1,450 nm diode laser for treatment of rhytids, acne scars, and active acne. The depth of penetration of this wavelength seems to be very well suited to the midsebaceous gland level. The mechanism of action is similar to other infrared water targeting lasers in which surrounding water molecules are heated and thermal diffusion occurs into neighboring tissue.

Comparative studies show similar effects of 1,450 to 1,320 and 1,540 nm. As described in this article, cooling durations greater than 40 milliseconds appear to be associated with increased risks of pigmentation changes in ethnic skin types. Therefore, this device should be used with cooling durations of less than 40 milliseconds for maximum safety.

In terms of efficacy and safety, epidermal cooling mechanisms reduce the risks associated with this wavelength and allow the beneficial effects of collagen remodeling in the dermis with induction of controlled thermal elevation of collagen. This leads not only to improvement in superficial rhytids but also improvement in active acne and acne scars. This article summarizes the efficacy in a wide range of cutaneous disorders, including facial rhytids, acne vulgaris, and atrophic scars. The 1,450 nm diode laser is useful in the nonablative laser armamentarium similar to wavelengths of 1,320 and 1,540 nm.

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