Comparison of a 1450-nm Diode Laser and a 1320-nm Nd:YAG Laser in the Treatment of Atrophic Facial Scars: A Prospective Clinical and Histologic Study

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BACKGROUND. Atrophic scar revision techniques, although numerous, have been hampered by inadequate clinical responses and prolonged postoperative recovery periods. Nonablative laser treatment has been shown to effect significant dermal collagen remodeling with minimal posttreatment sequelae. Although many studies have been published regarding the effectiveness of these nonablative lasers on rhytides, there are limited data demonstrating their specific effects on atrophic scars.

OBJECTIVE. To evaluate and compare the efficacy and safety of long-pulsed 1320-nm Nd:YAG and 1450-nm diode lasers in the treatment of atrophic facial scarring.

METHODS. A series of 20 patients (skin phototypes I–V) with mild to moderate atrophic facial acne scars randomly received three successive monthly treatments with a long-pulsed 1320-nm Nd:YAG laser on one facial half and a long-pulsed 1450-nm diode laser on the contralateral facial half. Patients were evaluated using digital photography and three-dimensional in vivo microtopography measurements at each treatment visit and at 1, 3, 6, and 12 months postoperatively. Histologic evaluations of cutaneous biopsies obtained before treatment, immediately after the first treatment, and at 1, 3, 6, and 12 months after the third treatment were performed. Clinical assessment scores were determined at each treatment session and follow-up visit. Patient satisfaction surveys were obtained at the end of the study.

RESULTS. Mild to moderate clinical improvement was observed after the series of three treatments in the majority of patients studied. Patient satisfaction scores and in vivo microtopography measurements paralleled the photographic and histopathologic changes seen. Side effects of treatment were limited to mild transient erythema, edema, and hyperpigmentation. No scarring or adverse textural changes resulted from the use of either laser system.

CONCLUSIONS. Nonablative long-pulsed 1320-nm Nd:YAG and 1450-nm diode lasers each offer clinical improvement for patients with atrophic scarring without significant side effects or complications. The 1450-nm diode laser showed greater clinical scar response at the parameters studied. The use of nonablative laser systems is a good treatment alternative for patients with atrophic scarring who are unable or unwilling to endure the prolonged postoperative recovery process associated with ablative laser skin resurfacing procedures.

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protected using a surface coolant. Induction of dermal collagen remodeling without epidermal damage was first demonstrated using a 585-nm flashlamp-pumped pulsed dye laser for hypertrophic scars20–25 and, more recently, in the treatment of rhytides.26 Although good clinical results are observed after pulsed dye laser irradiation, postoperative purpura persisting for several days limits its usefulness for nonablative skin resurfacing. A Q-switched 1064-nm Nd:YAG laser has also been used to treat rhytides successfully; however, the procedure produces postoperative pinpoint bleeding, rendering it less desirable as a nonablative technique.27 Investigators have also shown successful photorejuvenation of facial skin after intense pulsed light treatment.28,29 Although substantial clinical improvement of dyspigmentation and telangiectasia associated with cutaneous photodamage has been documented, dermal collagen remodeling with subsequent improvement in rhytides after intense pulsed light treatment has been less impressive.29,30 The newest generation of nonablative modalities, including the long-pulsed 1320-nm Nd:YAG, 1450-nm diode, and 1540-nm Erbium:glass laser systems, uses deeply penetrating midinfrared wavelengths coupled with protective epidermal cooling devices that selectively target water-containing tissue to stimulate collagen production.31 Initial studies32–39 suggest that these latter systems can substantially improve facial rhytides by their presumed effects on dermal collagen; however, no studies have been published that have specifically evaluated their effects on atrophic scars. We report herein the long-term clinical and histologic results of two different nonablative, midinfrared laser systems on atrophic facial acne scars.

Methods

Twenty consecutive patients with mild to moderate atrophic facial scars (mean age of 36.7 years; skin phototypes V) were included in the study after institutional review board–approved informed consent was obtained. Patients with a history of isotretinoin use, dermabrasion, phenol peel, or temporary filler (e.g., collagen, fat) injections within 3 years of study initiation were excluded from the study. Any prior history of injectable silicone or other permanent fillers in the facial areas also served as exclusion criteria.

Facial halves were randomly assigned to receive treatment with a 1320-nm Nd:YAG laser (CoolTouch; CoolTouch Corp., Auburn, CA) on one side and a 1450-nm midinfrared diode (SmoothBeam; Candela Corp., Wayland, MA) on the contralateral side. Each patient received three laser treatments by a single operator (E.L.T.) using an identical laser technique at 4-week intervals. Topical anesthetic cream (ELA-Max 5 Ferndale Laboratories, Inc., Ferndale, MI) was applied to the treatment areas for 20 to 30 minutes and then completely removed from the skin with water-soaked gauze before each laser procedure. The 1450-nm diode laser was used at fluences ranging 9 to 14 J/cm² (average of 11.8 J/cm², 6-mm spot) in a single, nonoverlapping pass over the dried treatment area. Concomitant skin surface cooling was achieved with a dynamic cooling device that delivered cryogenic spray spurs totaling 50 ms (dynamic cooling device level 2: 10-Ms pre-cool, 30-ms intraoperative cool, 10-ms post-cool). The 1320-nm Nd:YAG laser applied fluences ranging 12 to 17 J/cm² (average of 14.8 J/cm²) through a 10-mm spot size to attain a post-irradiation skin surface temperature between 39°C and 45°C, as measured by a thermal sensor contained within the laser handpiece. Using a non–pulse-stacking technique, two Nd:YAG laser passes over the treatment area were performed, producing a clinical endpoint of transient erythema and swelling without vesiculation. Side effects of each laser treatment were documented at every follow-up evaluation.

All subjects were evaluated and photographed immediately before each of the three treatment sessions and at 1, 3, 6, and 12 months after the final laser treatment. At the end of the study, the subjects documented their degree of satisfaction on a scale of 1 (lowest) to 10 (highest) for each treated area.

The clinical response of the atrophic scars to laser treatment was individually evaluated by two dermatologists independent of the investigator. Evaluations were based on digital photography in which the follow-up photographs were randomly presented for comparison with the known baseline photograph. The degree of improvement in the quality of skin texture was rated using a quartile grading scale (1: less than 25% = minimal to no improvement; 2: 25% to 50% = moderate improvement; 3: 51% to 75% = marked improvement; and 4: more than 75% = near total improvement).

Skin punch biopsies of scars were obtained from six patients at baseline, immediately after the first laser treatment, and at 1, 3, 6, and 12 months after the final laser treatment. Biopsy sites were photographed and documented to avoid duplication of specimens. All specimens were processed for masked evaluation by a board-certified dermatopathologist (M.C.W.).

Textural skin changes were evaluated using a 13 × 18-mm in vivo three-dimensional microtopography skin imaging system (PRIMOS; GFM, Teltow, Germany). Patients were seated with their head position fixed so that microtopography measurements could be consistently obtained within the targeted skin areas at baseline and at 1, 3, 6, and 12 months after the final laser treatment. Skin surface smoothness was
represented by the roughness average, defined as the mean skin height as calculated over the measured area. Differences between the pretreatment and posttreatment roughness average values of 1320-nm Nd:YAG and 1450-nm diode laser treated areas were tabulated and compared for each follow-up visit. Student's t-test (paired samples) was performed comparing the difference in roughness average values at baseline with follow-up visits in both 1320-nm Nd:YAG and 1450-nm diode laser-treated areas. A two-tailed p value of less than 0.05 was considered statistically significant.

Results
Maximum clinical improvement was evident at 6 months after 1320-nm Nd:YAG and 1450-nm diode laser treatment, with patients demonstrating modest improvements in atrophic facial scarring with a mean clinical score difference of 1.67 and 1.81, respectively (Table 1). At each postoperative visit, higher average clinical scores were seen on the 1450-nm diode laser-treated facial half (Figures 1A–C and 2A–C).

Table 1. Mean Clinical Scores: Blinded Assessments

<table>
<thead>
<tr>
<th>Laser</th>
<th>1 Month</th>
<th>3 Months</th>
<th>6 Months</th>
<th>12 Months</th>
</tr>
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<tr>
<td>1320-nm Nd:YAG</td>
<td>0.59</td>
<td>1.32</td>
<td>1.67</td>
<td>1.13</td>
</tr>
<tr>
<td>1450-nm Diode</td>
<td>0.89</td>
<td>1.69</td>
<td>1.81</td>
<td>1.34</td>
</tr>
</tbody>
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Grading scale: 1 = less than 25% improvement; 2 = 25% to 50% improvement; 3 = 51% to 75% improvement; 4 = more than 75% improvement.

Figure 1. (A) Atrophic scarring pretreatment. (B) Six months after three 1320-nm Nd:YAG laser treatments (improvement score 2). (C) Twelve months after three 1320-nm Nd:YAG laser treatments (improvement score 1).

Figure 2. (A) Atrophic scarring pretreatment. (B) Six months after three 1450-nm diode laser treatments (improvement score 2). (C) Twelve months after three 1450-nm diode laser treatments (improvement score 1).
Histologic evaluation demonstrated an increase in dermal collagen on both the 1320-nm Nd:YAG and 1450-nm diode laser-treated facial halves 6 months after the final laser procedure. Additional neocollagenesis was not observed at the 12-month follow-up visit (Figure 3A–D).

Improvement of skin surface texture was confirmed with a maximum decrease in mean roughness average values of 26.14 and 19.89 microns 6 months after three monthly 1450-nm diode and 1320-nm Nd:YAG laser treatments, respectively. One year after treatment, a decreased but still significant change in roughness average values from baseline was observed with each system (Table 2 and Figure 4A–D).

Posttreatment erythema was seen in all patients studied, persisting for 24 hours after treatment with the 1450-nm diode laser and 6 hours after 1320-nm Nd:YAG laser irradiation. Postinflammatory hyperpigmentation was observed in four patients after treatment with the 1450-nm diode laser (7% of 60 treatment sessions) and two patients after treatment with the 1320-nm Nd:YAG laser (3% of 60 treatment sessions). The difference in incidence of postinflammatory hyperpigmentation between the two lasers was not statistically significant. All cases of dyspigmentation resolved completely with the use of topical bleaching agents within 6 weeks. No hypopigmentation or hypertrophic scarring was observed in any study patient throughout the 15-month study period.

Patient satisfaction surveys at the end of the study revealed a mean satisfaction score of 4.6 on the 1320-nm Nd:YAG-treated facial half and 5.7 on the 1450-nm diode laser-treated facial half. Discomfort during treatment and lack of significant improvement were the most common concerns noted by those patients who were less satisfied with 1450-nm diode and 1320-nm Nd:YAG laser treatments, respectively.

**Discussion**

Although there are numerous studies demonstrating the use of nonablative laser systems for facial rhytides, evaluations of nonablative laser systems for the treatment of atrophic facial scarring have been limited.
Patel and Clement\textsuperscript{40} reported visible cosmetic improvement in 10 patients 4 months after a single 585-nm pulsed-dye laser treatment (350-μs pulse duration, fluence of 1.9 to 2.4 J/cm\textsuperscript{2}, 5-mm spot size); however, no objective study criteria were used to determine the degree of improvement produced by treatment in this small study group.

The data reported herein demonstrate that the 1320-nm Nd:YAG and 1450-nm diode lasers offer a safe and effective noninvasive technique to effect modest long-term clinical improvement of mild to moderate atrophic facial scars. Maximum clinical improvement was seen 6 months after a series of nonablative laser treatments—a finding consistent with previous reports in which nonablative lasers were used for facial rhytides.\textsuperscript{37,38} Diminution of clinical results at the 12-month follow-up evaluation suggests that maintenance treatments may be warranted to maintain and/or further enhance clinical improvement.

At the laser parameters chosen for treatment, greater clinical and topographic improvement was seen with the 1450-nm diode laser at all follow-up evaluations. However, since the initiation of this study, other investigators\textsuperscript{41} have reported histologic findings that suggest three passes with the 1320-nm Nd:YAG laser with fluence and surface skin cooling adjusted to a $T_{\text{max}}$ of 45°C to 48°C may yield improved clinical results. Therefore, further investigation is warranted to compare the clinical results after 1450-nm diode laser treatment to the more common current practice of performing three laser passes with the 1320-nm Nd:YAG laser.

To complement the independent clinical and histologic evaluations and subjective patient satisfaction surveys, the PRIMOS imaging system was used to provide rapid and quantitative three-dimensional measurements of objective changes in skin surface topography. Although optical profilometry using silicone rubber skin replicas has been used to measure surface textural changes successfully in the past,\textsuperscript{20–22} it can be operator dependent and is subject to a variety of artifacts.\textsuperscript{42,43} Although the PRIMOS system can also be difficult to master, once the technique is learned, its \textit{in vivo} optical imaging can provide superior resolution of skin topography. The topographic measurements obtained in our series of patients verified the associated clinical assessment scores and patient subjective responses, thereby solidifying the results of this study.

\textbf{Conclusion}

As public demand grows for less invasive modalities to treat common cosmetic skin concerns, dermatologic
surgeons must continue to explore new treatment options. Although a series of nonablative laser treatments can effect modest improvement in atrophic facial scars with minimal side effects, the degree of clinical improvement does not equal that typically seen after ablative laser skin resurfacing. It is essential for the dermatologic surgeon to identify those patients best suited for nonablative procedures (e.g., patients with mild to moderate atrophic scars unwilling or unable to undergo the prolonged postoperative recovery of an ablative laser skin resurfacing procedure) in order to offer realistic clinical expectations and enhance patient satisfaction. With ongoing research focused on defining optimal parameters for nonablative laser skin remodeling, advances in this field are likely to improve clinical outcomes.

References