The Use of Fractional Laser Photothermolysis for the Treatment of Atrophic Scars

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BACKGROUND Patients with atrophic scars commonly seek treatment for their removal but are often concerned about the prolonged recovery, short-lived results, and/or ineffectiveness of available therapies. A novel treatment using a 1,550-nm erbium-doped fiber laser to induce fractional photothermolysis of treated skin has been used to resurface photodamaged skin but has not been studied previously in patients with atrophic scars to determine its effectiveness for this condition.

PURPOSE To determine the effectiveness and safety of 1,550-nm erbium-doped fiber laser treatment on atrophic scars.

METHODS Fifty-three patients (skin phototypes I–V) with mild to moderate atrophic facial acne scars received monthly treatment with a 1,550-nm erbium-doped fiber laser (Fraxel, Reliant Technologies Inc., San Diego, CA). Clinical response to treatment was determined at each treatment visit and 6 months after the final treatment session by two independent assessors using a quartile grading scale. Side effects and patient satisfaction were monitored at each follow-up visit.

RESULTS Clinical improvement averaged 51% to 75% in nearly 90% of patients after three monthly laser treatments. Mean improvement scores increased proportionately with each successive laser session. Clinical response rates were independent of age, gender, or skin phototype. Side effects included transient erythema and edema in most patients, but no dyspigmentation, ulceration, or scarring.

CONCLUSIONS Atrophic scars can be effectively and safely reduced with 1,550-nm erbium-doped fiber laser treatment.

Tina S. Alster, MD, Elizabeth L. Tanzi, MD, and Melissa Lazarus, MD, have indicated no significant interest with commercial supporters.

Atrophic scars are dermal depressions commonly caused by the destruction of collagen after an inflammatory skin disease, such as cystic acne or varicella. Many patients not only seek treatment for the resultant physical disfigurement, but also because of the limitations placed on self-esteem, social interactions, and daily activities. Many different treatments, including chemical peels, surgical excision, punch grafting, dermabrasion, and tissue augmentation with a variety of fillers, have been used to ameliorate atrophic scars with varying degrees of success.[1] The clinical utility of these treatments has been limited by incomplete scar removal, poor intraoperative visualization, transmission of infectious debris, scar worsening, tissue fibrosis, and permanent pigmentary alteration.[1] Advances in laser technology have led researchers to study their potential use as a treatment for this therapeutically difficult condition.[1–3]

Over the past decade, laser skin resurfacing with carbon dioxide (CO_2) and erbium:yttrium-aluminum-garnet (Er:YAG) lasers has become popularized for the treatment of atrophic scars.[4–7] While highly effective in recontouring the skin and improving scar appearance, treatment with these ablative lasers has been associated with extended recovery periods, prolonged erythema, and other untoward side effects.[8,9] Because of these potential risks, nonablative technology using long-pulsed infrared [1,450-nm diode and 1,320-nm neodymium:yttrium-aluminum-garnet (Nd:YAG)] laser systems was developed as a

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safe alternative to ablative technology for creation of a controlled thermal injury to the dermis with subsequent neocollagenesis and remodeling of scarred skin.[10] Due to a need for more noticeable clinical improvement than these latter nonablative systems could provide, fractional photothermolysis was most recently introduced into the skin resurfacing market. This latest system involves the use of a midinfrared wavelength emitted by a 1,550-nm erbium-doped laser to create microscopic noncontiguous columns of thermal injury in the dermis (referred to as microscopic thermal zones or MTZ) surrounded by zones of viable tissue.[11] The spatially precise columns of thermal injury produce localized epidermal necrosis and collagen denaturation at 125 or 250 MTZ/cm^2.[12] Because the tissue surrounding each MTZ is intact, residual epidermal and dermal cells contribute to rapid healing. Maintenance of the stratum corneum ensures continued epidermal barrier function. Histologic evaluation of the MTZ demonstrates homogenization of the dermal matrix and the presence of epidermal necrotic debris (MEND), representing the extrusion of damaged epidermal keratinocytes by the viable keratinocytes at the lateral margin of the MTZ.[12]

Prior studies using fractional photothermolysis have demonstrated its effectiveness in the treatment of photodamaged skin;[13] however, only preliminary results on its use for scars have been reported.[14] Given the rapid healing associated with this procedure and its known effect on collagen remodeling, this study was designed to prospectively evaluate the use of fractional photothermolysis in the treatment of atrophic scars.

Materials and Methods

Fifty-three patients (39 women, 14 men; ages 19–78 years; mean age 39.6 years; skin phototypes I–V) with mild to moderate atrophic facial acne scars were identified and determined eligible for study entry (Table 1). Exclusion criteria included concomitant treatments to involved skin areas, propensity for keloid scarring, pregnancy, immunosuppression, isotretinoin use, and filler injections or ablative/nonablative laser skin resurfacing procedures within the preceding 6 to 12 months.

TABLE 1. Patient Characteristics

			Skin phototype				
Sex	*Number*	*Age in years (mean)*	*I*	*II*	*III*	*IV*	*V*
Female	39	19–78 (39.3)	8	19	7	3	2
Male	14	22–59 (40.7)	2	7	3	1	1
Total	53	19–78 (39.6)	10	26	10	4	3

The treatment areas were cleansed of debris (including dirt, makeup, and powder) using a mild cleanser and 70% alcohol. A water-soluble blue tinted tracking dye solution (OptiGuide Blue, Reliant Technologies, San Diego, CA) and 30% lidocaine ointment were applied to the sites for 60 minutes. Treatment was then delivered to the areas using a 1,550-nm erbium-doped fiber laser (Fraxel, Reliant Technologies) equipped with a 15-mm handpiece and concomitant forced air cooling (Zimmer MedizinSystems, Irvine, CA). Fluences of 8 to 16 J/cm^2 at densities of 125 to 250 MTZ/cm^2 were applied to the scarred regions in 8 to 10 passes, with total energies of 4 to 6 kJ delivered per session. Retreatments using identical laser parameters were performed at 4-week intervals until patients were satisfied with clinical outcomes and desired cessation of further treatment.

Patients were instructed to use a mild cleanser, thermal spring water spray mist, and moisturizer (Avene healing cream or LaRoche Posay Toleriane cream) several times daily for the first few days after each treatment session (or as long as xerosis was apparent). Oral valacyclovir (1 g daily) was prescribed for patients with documented histories of herpes labialis.

Photographic documentation using identical camera settings, lighting, and patient positioning were obtained at baseline, before each treatment session, and 6 months after the final treatment. Independent

TABLE 2. Clinical Improvement Scores*

	Treatment				
Score	*1*	*2*	*3*	*4*	*5*
0	5	3	0	0	0
1	44	25	3	0	0
2	4	7	10	2	1
3	0	3	10	5	3
Total patients	53	38	23	7	4
Mean score	0.98	1.26	2.30	2.71	2.75

*Scale: 0 = <25%, 1 = 25%–50%, 2 = 51%–75%, 3 = >75% improvement from baseline.

clinical assessments of treatment areas were conducted by two masked assessors' evaluations of comparative photographs using a quartile grading scale (0 = <25%, 1 = 25%–50%, 2 = 51%–75%, 3 = >75% improvement). Side effects and patient satisfaction surveys were recorded at each treatment session and follow-up visit.

Results

Thirty-eight patients (71%) received two or more treatments. Mean clinical improvement scores increased with each successive laser treatment session (Table 2). Those patients who opted to forego additional treatments tended to be those with the highest clinical improvement scores. Forty-eight patients (91%) had at least 25% to 50% improvement after a single treatment, whereas 87% of patients receiving three treatments demonstrated at least 51% to 75% improvement in the appearance of their scars. At the 6-month follow-up evaluation period, clinical scores remained unaltered from those reported 1 month after the final treatment session. Patient age, sex, and skin phototype also did not significantly affect the clinical responses observed (Figures 1 and 2).

The laser treatments were well tolerated without need for additional sedation in any patient. Side effects were limited to transient mild erythema (duration 2–3 days) and edema (1–2 days). Fifteen patients (28%) reported skin dryness and/or roughness lasting 2 to 4 days. Approximately 5% of treatment sessions resulted in transient acneiform eruptions, which resolved within 10 to 14 days. Acne was avoided altogether when oral doxycycline was administered concomitant with further laser treatment in these patients. One patient with skin phototype V developed transient postinflammatory hyperpigmentation after treatment using 250 MTZ, but not after subsequent treatment at 125 MTZ. No other side effects or complications were encountered.

Discussion

The results of this study support the use of fractional photothermolysis for the safe and effective treatment of atrophic scars and are consistent with previous published studies using the technique for cutaneous photodamage. Given the increased dermal density associated with scarring, it is curious that the mean clinical improvement scores of scars after three

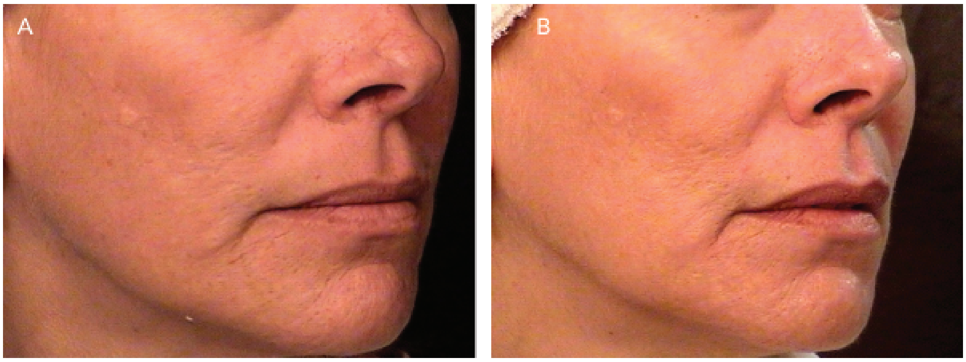

Figure 1. Atrophic acne scars in a 57-year-old woman before (A) and after (B) three successive monthly Fraxel laser treatments. Clinical improvement score = 1.

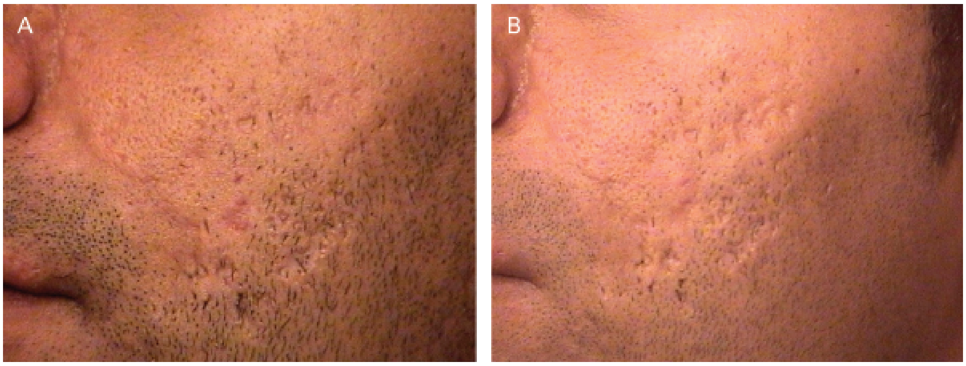

Figure 2. Atrophic scars in a 24-year-old man (skin phototype IV) before (A) and after (B) three successive monthly Fraxel laser treatments. Clinical improvement score = 2.

successive monthly laser treatments were higher (2.3) than those reported for facial rhytides (2.1) in a similarly designed and executed study.[13] Also surprising is the overall excellent response of scars to this relatively noninvasive laser treatment. Numerous studies using ablative CO_2 and erbium laser systems for scar revision have effected similar clinical improvement, but with longer postoperative recovery rates and greater side effect profiles.[4–9] Not surprisingly, however, the results obtained after nonablative laser scar revision using such systems as the long-pulsed 1,450-nm diode and 1,320-nm Nd:YAG lasers were not as impressive as those demonstrated herein with fractional laser resurfacing.[10]

While we can only conjecture as to the reason why fractional photothermolysis yields such positive responses in scarred skin, it is possible that the controlled, limited dermal heating initiates a cascade of events in which normalization of the collagenesis/collagenolyis cycle occurs. In addition, the delivery of high fluences permits deeper heating of the dermis to maximize tissue effect.

Finally, because the side effect profile and clinical effect were shown to be similar between different skin phototypes, we are encouraged about the use of fractional skin resurfacing in patients with darker skin phototypes who, in the past, were limited to less aggressive treatment approaches. As was demonstrated by the one patient who experienced transient dyspigmentation after use of 250 MTZ, the use of lower (125) MTZ in darker-skinned patients would be expected to produce less epidermal thermal injury with resultant decreased risk of postinflammatory hyperpigmentation.

Summary

The study outlined herein demonstrates the safe and effective use of fractional skin resurfacing for atrophic scars. It is the first prospective study that outlines the additive clinical benefit and longevity of multiple treatment sessions in patients with various skin phototypes.

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