

Treatment of Melasma Using a Novel 1,927-nm Fractional Thulium Fiber Laser: A Pilot Study

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BACKGROUND A 1,927-nm wavelength was recently added to the 1,550-nm erbium-doped fiber laser. This wavelength possesses a higher absorption coefficient for water than the 1,550-nm, conferring greater ability to target epidermal processes such as dyschromia.

OBJECTIVE To evaluate the efficacy and safety of a novel 1,927-nm fractional thulium fiber laser in the treatment of melasma.

METHODS Fourteen patients underwent three to four laser treatments (at 4-week intervals) at pulse energies of 10 to 20 mJ and total densities of 252 to 784 microscopic treatment zones per cm² (6–8 passes) using a 1,927-nm thulium fiber laser. Three blinded assessors and the patients evaluated clinical improvement of treatment areas at 1-, 3-, and 6-month follow-ups. Side effects were assessed, and pain was scored using a visual analog scale (0–10).

RESULTS A statistically significant 51% reduction in MASI score was observed at 1-month post 3 to 4 laser treatments. A 33% ($p = .06$) and 34% ($p = .07$) reduction in Melasma Area and Severity Index score was observed at the 3- and 6-month follow-up visits, respectively. Skin responses observed after treatment were moderate erythema and mild edema. No scarring or postinflammatory hyper- or hypopigmentation was observed.

CONCLUSION The 1,927-nm fractional thulium fiber laser is a safe, effective treatment for melasma.

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Melasma is a chronic cutaneous condition characterized by irregular brown patches on sun-exposed areas of the face such as the cheeks, forehead, and upper lip and commonly occurs in women. The pathogenesis of melasma is poorly understood, but contributing factors include sun exposure, hormonal factors, genetics, pregnancy, and systemic medications.^{1,2} This condition is often distressing to the patient and significantly affects quality of life measures.³ Melasma frequently affects darker Fitzpatrick skin types (FSTs), which poses a challenge to treating physicians, because the armamentarium of treatment options also frequently has risks of pigmentary alteration.^{4–6} Many therapeutic

modalities have been tried, with limited success, because melasma has a high tendency to recur. Treatments include the judicious use of sun protection and sun avoidance and bleaching agents with hydroquinone, kojic acid, arbutin, azelaic acid, and chemical peels.^{1,2} Intense pulsed light and lasers such as the Q-switched neodymium-doped yttrium aluminum garnet (1,064-nm),⁷ Q-switched alexandrite (755-nm),⁸ erbium-doped yttrium aluminum garnet (2,940-nm)⁹ and carbon dioxide (10,600-nm)¹⁰ resurfacing lasers have also had varying results. Postinflammatory pigmentary changes, flares, and recurrence of melasma have complicated the use of light sources and lasers to treat melasma.

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More recently, fractional photothermolysis (FP) has been added to the treatment modalities available for this indication.¹¹⁻¹³ In contrast to traditional resurfacing lasers, less-invasive methods such as nonablative FP allow for controlled dermal injury, which leads to neocollagenesis.¹⁴⁻¹⁸ This fractional approach creates microscopic columns of thermal injury, called microscopic treatment zones (MTZs). These precise columns permit rapid healing and less downtime, because tissue surrounding each column is left intact. The mechanism by which dyspigmentation is improved using FP is through the shuttling of melanin in columns of microscopic epidermal necrotic debris (MENDs) created using FP. The extraneous pigment is then exfoliated.¹⁵⁻¹⁷ FP using the 1,550-nm erbium-doped fiber laser has previously been shown to be effective and safe in the treatment of melasma.¹¹⁻¹³

A new addition to the 1,550-nm erbium-doped fractional device, using the novel 1,927-nm wavelength (Fraxel re:store DUAL, Solta Medical, Hayward, CA), was introduced in October 2009. This wavelength has a higher absorption coefficient for water than the fractional 1550-nm erbium-doped fiber laser (Fraxel DUAL 1550/1927; Solta Medical), conferring greater ability to target epidermal processes such as pigmentation and dyschromia. The other characteristic of this wavelength that makes it well suited for superficial epidermal indications is its maximum depth of penetration of 200 μm , compared with 1,400 to 1,500 μm for the 1,550-nm wavelength. This study investigates the safety and efficacy of the 1,927-nm thulium fiber laser in the clearance of facial melasma at a private dermatologic laser center.

Methods

This study was performed under the BioMed Institutional Review Board (San Diego, CA) approval at a private dermatology practice in Houston, Texas. Eighteen patients underwent an initial screening visit, and based on inclusion and exclusion criteria, were enrolled in the study after

informed consent was obtained. Patients were required to be between the ages of 30 to 80 with clinically identifiable facial melasma. Only FSTs I to IV were included in the study. Patients had not used topical steroids or retinoids on the treatment area within 3 months before enrollment in the study. All patients agreed to discontinue any topical or cosmeceutical agents on the treatment area (s) during the course of the study, unless the study investigators instructed them not to do so. Additional exclusion criteria were active localized or systemic infections; cigarette smoking; pregnancy; allergy to lidocaine; compromised wound healing ability; and a personal history of malignant melanoma, keloid scars, psoriasis, or systemic diseases that would preclude the use of topical anesthesia.

Patients

Eighteen patients (17 female, 1 male) with clinically diagnosed melasma were enrolled in this study and consented to participate. Two withdrew from the study before the first treatment. Two did not complete the study but not because of adverse events related to the laser treatments, one withdrew after the first treatment because she had an immediate family member become ill, and one did not return for the 6-month follow-up visit because she wanted to pursue other melasma treatment options and had incomplete clearance of melasma with the trial. Patient ages ranged from 32 to 62 (mean 48.2 ± 8.9). Five were FST II (31%), four were FST III (25%), and seven were FST IV (44%). Fifteen completed three laser treatments. Five were selected to undergo a fourth laser treatment based on clinical appearance of melasma after the third laser treatment (Partial clearing and patient preference were taken into account). Topical bleaching agents for melasma had failed in all patients in the study, and chemical peels, microdermabrasion, intense pulsed light, and other laser treatments had failed for many. Fourteen patients completed all three to four laser treatments and the 1- and 3-month follow-up. Thirteen completed the 6-month follow-up visit.

Treatments

The device used in this study was a 1,927-nm fractionated thulium fiber laser (Fraxel DUAL 1550/1927, Solta Medical). The area was cleansed before treatment using a mild cleanser (Cetaphil Gentle Skin Cleanser; Galderma Laboratories, L.P., Fort Worth, TX). A compounded double anesthetic ointment (23% lidocaine/7% tetracaine) was applied to the treatment area for 1 hour before treatment. Patients underwent three to four treatment sessions at 4-week intervals. Treatment 1 was performed at an energy of 10 mJ, using six to eight passes with 20% to 45% surface area coverage for a total density of 252 to 672 MTZ/cm². The average total energy used during Treatment 1 was 1.42 kJ. Treatment 2 was performed at 10 to 15 mJ with eight passes and a total density of 328 to 672 MTZ/cm². The average total energy used during Treatment 2 was 1.61 kJ. Treatment 3 was performed at 10 to 20 mJ with eight passes and a total density of 372 to 784 MTZ/cm², for an average total energy of 1.77 kJ. Treatment 4 was performed at 10 to 15 mJ with eight passes and a total density of 520 to 584 MTZ/cm², for an average total energy of 2.44 kJ. A cooling device (Zimmer Elektromedizin Cryo 5 device; Zimmer Medizin Systems, Irvine, CA) was used to mitigate patient discomfort (fan power 5–7, integrated into hand piece). After each laser treatment, the degree of erythema, edema, and other post-treatment responses were recorded. Patients were asked to score pain immediately after treatment based on a visual analog scale of 0 (no pain) to 10 (worst pain).

Patients were advised to avoid sun exposure for 7 to 10 days after the laser treatment and to use daily broad-spectrum sunscreen with ultraviolet (UV)A and UVB protection (minimum sun protection factor 30) on the treated areas. For wound care, patients were instructed to use Biafine topical emulsion (OrthoNeutrogena, Titusville, NJ) on treated areas three to five times daily for 7 to 10 days after treatment. Starting the fourth night

after laser treatment, patients were permitted to restart hydroquinone 4% cream while continuing to apply Biafine throughout the day. Starting the day of enrollment, patients were permitted to use hydroquinone 4% cream to the face before the start of laser therapy, which ranged from 1 week to 1 month. Most patients received their first laser treatment within 2 weeks of enrollment and screening.

Photographic documentation using identical camera settings (Nikon D70 camera; Canfield Imaging Systems, Fairfield, NJ), lighting, and positioning of the patient was obtained at the screening visit, baseline evaluation, all three to four treatment visits (before and immediately after treatment), and all follow-up visits. The two treating physicians assessed all side effects and examined the patients during the treatment series and in the follow-up visits, but in the efficacy analysis, three blinded, non-treating investigators who were not affiliated with this study assessed clinical improvement of treatment areas using independent photographic review, using a standard Melasma Area and Severity Index (MASI), as previously described.¹⁹ Other attributes assessed included fine wrinkling, lentiginos, mottled hyperpigmentation, and sallowness. Patients were given a satisfaction survey on which they could grade their level of improvement on each of the aforementioned parameters plus overall improvement in melasma, as well as any side effects after laser treatment at each treatment visit and at follow-up visits occurring 1, 3, and 6 months after the final laser treatment.

Results

Fourteen patients completed all laser treatments and the 1- and 3-month follow-up visits. Thirteen patients completed the 6-month follow-up visit. The combined (mean among the three blinded evaluators) MASI score was 10.1 ± 5.0 at baseline (Table 1). One month after the final laser treatment, the combined MASI score fell to 5.0 ± 3.1 ($p < .05$). The 3- and 6-month follow-up visit

TABLE 1. Blinded Evaluator Melasma Assessment Severity Index (MASI) Scoring

Time Point	MASI Score, Mean \pm SD (p-value)	Reduction in MASI Score from Baseline, %
Baseline	10.1 \pm 5.0	—
1-month follow-up	5.0 \pm 3.1 (<.05)	51
3-month follow-up	6.7 \pm 4.0 (.06)	33
6-month follow-up	6.7 \pm 3.9 (.07)	34

scores were 6.7 ± 4.0 ($p = .06$) and 6.7 ± 3.9 ($p = .07$), respectively, reflecting a slight recurrence of melasma over the follow-up period. In summary, a 51% reduction in MASI score was observed at the 1-month follow-up visit. At the 3- and 6-month follow-up visits, 33% and 34% reductions in MASI scores were observed, respectively. In terms of MASI scoring by investigators, there were no statistically significant differences appreciated between FST I or II and FST III or IV at all three follow-up time points when these categories were analyzed separately.

The assessors determined that the overall mean improvement in melasma was 1.8 ± 0.9 (0 = no improvement, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100% improvement), or moderate improvement at the 1-month follow-up (Table 2). At 3- and 6-month follow-up, patients demonstrated an overall melasma improvement score of 1.6 ± 1.6 and 0.7 ± 1.8 , respectively (mild to moderate improvement). Patients rated their overall

melasma improvement as 3.3 ± 1.1 (marked to very significant), 2.5 ± 1.2 (moderate to marked), and 2.2 ± 1.4 at the 1-, 3- and 6-month follow-up visits, respectively (0 = no improvement, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100% improvement). Figures 1 to 3 demonstrate moderate improvement in melasma at 6-month follow-up after three laser treatments. Enhanced ultraviolet photography (Canfield Mirror Imaging Software, Fairfield, NJ) is utilized to illustrate the reduction in pigmentation after the laser treatments. Patient satisfaction and scoring of improvement was significantly higher than investigators' scoring of improvement. Other parameters assessed were lentigines, fine wrinkling, mottled hyperpigmentation, and sallowness. See Table 2 for the blinded assessor evaluations of the aforementioned parameters. Pain, erythema, and edema scores for laser treatments 1 to 4 and both follow-up visits are summarized in Table 3. Overall, moderate erythema and mild edema were observed during this study. No instances of postinflammatory hyperpigmentation (PIH), or hyperpigmentation directly resulting from laser treatment, was observed. Also, no hypopigmentation or scarring was observed, and no other adverse events were reported.

Discussion

These data demonstrate the safety and efficacy of the 1,927-nm fractional thulium fiber laser in the treatment of facial melasma over 6 months of fol-

TABLE 2. Blinded Evaluator Assessment of Improvement Based on Photographic Review at 1-, 3-, and 6-Month Follow-Up

Parameter	One Month Mean \pm SD (p-value)	Three Months	Six Months
Overall melasma	1.8 \pm 1.7	1.57 \pm 1.6	0.7 \pm 1.8
Fine wrinkling	0.9 \pm 0.7 (.001)	0.79 \pm 0.7 (<.001)	0.1 \pm 0.6 (.005)
Lentigines	1.7 \pm 0.6 (.003)	1.29 \pm 1.0 (.006)	1.1 \pm 0.8 (.07)
Mottled Hyperpigmentation	1.9 \pm 1.3 (.01)	1.57 \pm 1.3 (.09)	0.6 \pm 1.9 (.50)
Sallowness	1.1 \pm 0.4 (<.001)	0.79 \pm 0.4 (<.001)	0.1 \pm 0.3 (<.001)

Overall melasma scores: 0 = none, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100% improvement. For all other parameters, a 0–3 severity scale was used (0 = none, 1 = mild, 2 = moderate, 3 = marked improvement).

low-up. FP has been a newer addition to the treatment options available for melasma. Rokhsar and Fitzpatrick conducted a pilot study in 2005 using

TABLE 3. Side Effects

Visit	Pain Mean	Erythema Mean \pm SD	Edema Mean \pm SD
Laser treatment 1	3.2	2.1 \pm 0.3	1.1 \pm 0.3
Laser treatment 2	3.8	2.0	1.0
Laser treatment 3	5.3	2.0	1.0
Laser treatment 4	5.8	1.6 \pm 0.5	0.6 \pm 0.5
1-month follow-up	N/A	0.1 \pm 0.3	0
3-month follow-up	N/A	0	0
6-month follow-up	N/A	0	0

Pain scoring is based on a visual analog scale (0 = no pain and 10 = worst pain). Erythema and edema scoring: 0 = none, 1 = minor, 2 = moderate, 3 = severe. No scarring, erosions, or postinflammatory hypo- or hyperpigmentation was observed. N/A, not applicable.

the 1,550-nm erbium-doped fiber laser on 10 female patients with treatment-refractory melasma. After four to six treatment sessions, 60% of patients achieved 75% to 100% clearing, and 30% had less than 25% improvement.¹¹ Since this pilot study, several other studies have shown therapeutic efficacy that did not differ significantly from conventional treatment with topical bleaching agents. As a result, the treatment of melasma using FP has remained controversial, with no clear consensus on treatment settings recommended for use during treatment.²⁰

Lee and colleagues treated 25 patients with four monthly FP sessions (1,550-nm erbium-doped fiber laser) at 15 mJ/MTZ at a density of 125 MTZ/pass and eight passes. One month after the final laser

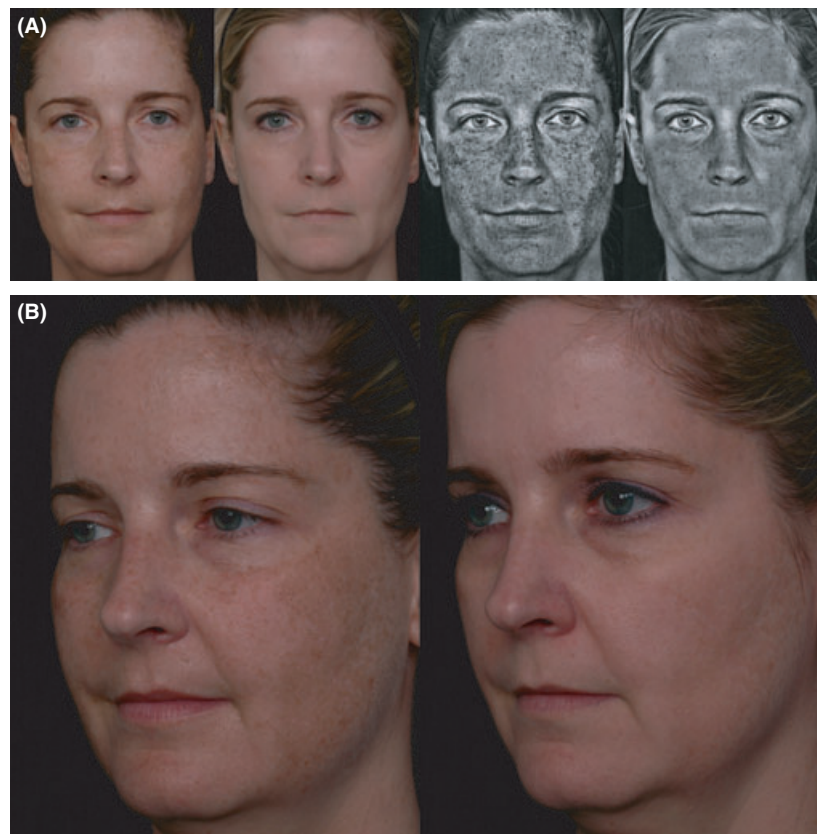


Figure 1. (A) Frontal view of a 41-year-old patient before (far left) and 6 months after (left) three laser treatments. Enhanced ultraviolet photography (Canfield Mirror Imaging Software, Fairfield, NJ) demonstrating diffuse moderate pigment deposition before (right) and decreased pigmentation after (far right) three laser treatments. (B) Side view of same patient before (left) and 6 months after after (right) three laser treatments.



Figure 2. Forty-three-year-old patient (side view) before (far left) and 6 months after (left) three laser treatments. Enhanced ultraviolet photography showing moderate pigment deposition at the glabella and upper lip area before (right) and decreased pigmentation after (far right) three laser treatments.



Figure 3. Forty-five-year-old patient (side view) before (far left) and 6 months after (left) three laser treatments. Enhanced ultraviolet photography showing moderate pigmentation at the right lateral forehead and cheek (right) and decreased pigmentation in these locations after (far right) three laser treatments.

treatment, investigators observed clinical improvement in 60% of patients, whereas 44% of patients observed improvement. These figures decreased to 52% and 35%, respectively, 6 months after the final laser treatment.¹² Katz and colleagues performed a retrospective review of eight patients treated using the 1,550-nm erbium-doped fiber laser at variable intervals of 3 to 8 weeks for a total of two to seven treatments. These patients were followed up for a mean of 13.5 months. At the last treatment, assessments revealed greater than 50% improvement in melasma in five of eight patients, with sustained efficacy observed in five patients, and recurrence in three patients.¹³ The authors concluded that FP can provide long-term clinical improvement in melasma.

Other studies have failed to show a greater benefit of FP than with traditional topical therapy for melasma. Wind and colleagues conducted a randomized, controlled, observer-blinded study with a

split-face design in 2010.²¹ Twenty-nine patients with melasma were randomly allocated to four to five nonablative 1,550-nm erbium-doped fiber laser treatments (15 mJ/microbeam, 14–20% coverage) or triple topical therapy (TTT; hydroquinone 5%, tretinoin .05%, triamcinolone acetonide 0.1% cream). TTT was applied daily for 15 weeks until the last laser treatment and then twice weekly during follow-up. Mean patient global assessment and treatment satisfaction were significantly lower on the laser treatment side ($p < .001$). At 6-month follow-up, a significantly higher number of patients preferred topical treatment. Given the high incidence of PIH (31% in this study), high energies were not recommended with the 1,550-nm erbium-doped fiber laser.

This is the first study to assess the safety and efficacy of the novel 1,927-nm fractional thulium fiber laser in treating facial melasma. In contrast to other studies using 1,550-nm FP for melasma,^{11–13}

our pilot study used a blinded independent photographic review of before and after photographs to assess improvement of melasma. Previous reports have demonstrated the safety of the 1,550-nm erbium-doped fiber laser.^{5,6} Our study demonstrates a similar safety profile, with moderate erythema and mild edema reported after treatment (Table 3). There was no evidence of scarring, erosions, or post-inflammatory hypo- or hyperpigmentation throughout the course of this study. Patients also reported occasional pruritus after treatment. Initially, conservative settings were used, given the indication of melasma and mostly darker FST. Treatment levels and energies were increased at subsequent laser treatment visits. We found greater erythema and edema when more aggressive settings were used. Erythema resolved in many patients by 7 to 10 days, although it persisted longer when aggressive settings were used. This trial took place during the spring and summer in Texas, so frequent re-application of sun protection and sun avoidance may have been difficult.

A small sample size limited this study; larger-scale trials are needed to define optimal settings and to capture additional unreported side effects. Although this study assessed subjects through the 3-month time point, longer-term studies are warranted because melasma frequently recurs. Hydroquinone 4% cream was used before treatment and in the post-treatment follow-up period to minimize risk of PIH with laser therapy. Hydroquinone cream is routinely used in our clinic before laser resurfacing in darker FSTs and has been used in several studies as an adjunct to laser treatments.^{10,13} When used in combination with laser therapy, hydroquinone cream has been shown to result in greater improvement than with laser resurfacing alone or bleaching cream alone.¹⁰ Low treatment levels (surface area coverage) were also chosen to minimize the risk of PIH. This was based on previous research showing that lower treatment levels using the fractional 1,550-nm erbium-doped fiber laser resulted in lower risk of PIH in darker skin types.⁴ Future studies using a randomized,

split-face design comparing the 1,927-nm wavelength with the 1,550-nm wavelength, in addition to studies comparing the 1,927-nm laser with traditional bleaching creams, would further define the role of FP in the treatment of melasma.

Conclusion

The novel 1,927-nm fractional thulium fiber laser represents a new addition to the FP armamentarium. This pilot study demonstrates a statistically significant 51% reduction in MASI scores at 1-month follow-up after three to four treatments using the 1,927-nm thulium device and a 33% ($p = .06$) and 34% reduction ($p = .07$) at 3- and 6-month follow-up, respectively. Six months after the final laser treatment, melasma disease severity increased marginally, although patients were still improved from baseline. This most likely reflects a slight melasma recurrence, and accordingly, patients should be informed of this appropriately before laser treatment. There were no statistically significant differences seen in MASI scoring between FST I or II and FST III or IV when these categories were analyzed separately. Post-treatment responses were moderate erythema and mild edema. There was no evidence of scarring, erosions, or post-inflammatory hyper- or hypopigmentation throughout the course of this study.

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