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Fractional Laser Treatment for Pigmentation and Texture Improvement

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ABSTRACT

Fractional laser treatment with the 1,550nm erbium fiber laser (Fraxel® Laser, Reliant Technologies) has bridged the gap between the ablative and nonablative laser modalities used to treat the epidermal and dermal signs of skin aging. By targeting water as its chromophore, the laser induces a dense array of microscopic, columnar thermal zones of tissue injury that do not perforate or impair the function of the epidermis. The significant skin remodeling that ensues can be used to treat, with limited downtime, epidermal pigmentation, melasma, and rhytides, as well as textural abnormalities that include acne-related and surgical scars.

Key Words: *ablative laser, pigmentation, textural abnormalities, photoaging, acne scars, surgical scars*

Although ablative laser modalities remain the gold standard for the treatment of photoaging, most patients cannot tolerate the 1–2 weeks of downtime required with these procedures. Additionally, ablative skin treatment carries the risks of pigmentary alteration, infection, and scarring. At the other end of the spectrum, nonablative modalities induce collagen remodeling through deep dermal heating, yet have no epidermal resurfacing effect.

The Fraxel® Laser is a 30watt, diode pumped, 1,550nm erbium fiber laser that targets water as its chromophore. Utilizing the concept of fractional treatment 70–100um wide and 250–800um deep, microthermal zones (MTZs) of tissue coagulation are produced. Tissue is not vaporized and the stratum corneum remains intact.

The epidermal coagulated tissue is expelled and replaced by keratinocyte migration. When there is significant damage to the basement membrane zone, dermal contents are also expelled as microscopic epidermal and dermal necrotic debris (MENDs). In this way, epidermal and dermal pigmentation can be treated without specifically targeting melanin as the chromophore. Zones of collagen denaturation in the dermis cause upregulation of the inflammatory cascade, which leads to collagen remodeling and new collagen formation.

In the first study of the fractional laser, 15 subjects received treatments of varying densities at test sites on the distal forearm. Biopsies were taken from the treated tissue at intervals of 48 hours, 1 week, 1 month, and 3 months in order to identify MTZs and to characterize the wound healing process.[1] This data supported the use of the device for coagulation of soft tissue and, in November 2003, the US FDA approved it for that purpose. Since then, the fractional laser device has received additional FDA clearance for the treatment of periorbital rhytides, pigmented lesions, melasma, skin resurfacing, acne scars, and surgical scars.

The fractional laser contains an intelligent optical tracking system that utilizes OptiGuide Blue™ tint, a water soluble FDC dye. The optical mouse in the laser handpiece recognizes subtle differences in the density of blue dye on the skin's dermatogliphs. The mouse communicates with the laser to lay down an even MTZ spot pattern independent of handpiece velocity. This system allows for a more even placement of MTZs, which is important in fractional tissue treatment where the optimal spacing between lesions allows for rapid re-epithelialization and prevents negative sequelae associated with fully ablative treatment at depths of 300–800um. The dye can be challenging to remove in patients with enlarged pores or with hyperkeratotic lesions, such as actinic keratoses. The use of a dimethicone-based sealant prior to blue dye application can assist in removal of the dye. Blue dye is best removed with a foam-based skin cleanser that increases the surface area of the surfactant in contact with the skin.

Pain Management

Pain management is one of the most significant hurdles of the procedure. Discomfort from the laser treatment is managed by use of topical anesthetics, e.g., LMX-5®, EMLA® (AstraZeneca), and other lidocaine/tetracaine formulations, such as 7% lidocaine/ 7% tetracaine (S-Caine™, ZARS), prior to procedure.

Forced air cooling (Zimmer Cryo 5®, Zimmer Medizin Sytems), which is often used concurrently with fractional laser treatment,[2] increases patient comfort significantly. Histologic analysis reveals a slight reduction in thermal damage zone width, but no statistically significant change in lesion depth. Forced cooled air should be used at the lowest possible setting to minimize alteration in the MTZs. When treating for superficial indications such as pigmentation and melasma, Zimmer settings should be 1–2. When treating deeper indications such as deep rhytides or scars, higher forced air settings, in combination with higher laser settings, may be used.

Oral anxiolytics and analgesics may be required in a small minority of patients who cannot tolerate the procedure with topical anesthetic alone.

Treatment Protocols by Indication

The current recommended treatment protocols are listed in Table 1. Important concepts to consider when using the fractional laser device are treatment energy, density, coverage, volume of tissue treated, and treatment intervals. The first three concepts, energy, density, and coverage, are closely related. The depth and width of the MTZs are proportional to energy. These are displayed in Figures 1 and 2. In order to achieve the desired coverage, densities should be lowered for higher energy treatments. For example, a 10mJ, 2,000MTZ/cm^2 treatment and a 20mJ, 1000MTZ/cm^2 treatment both have 20% coverage.

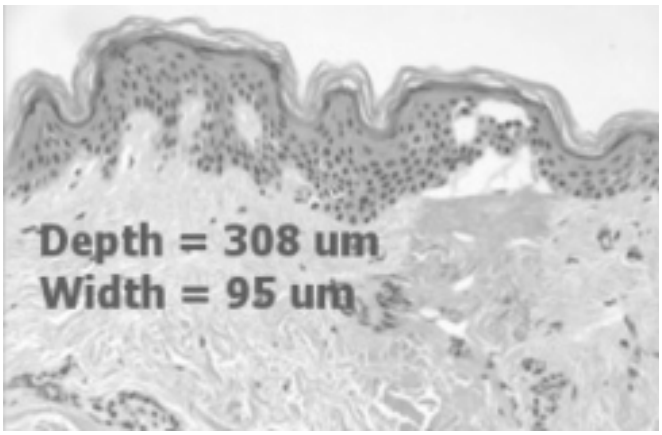

Figure 1: Depth coagulation at 8mJ

However, the 20mJ treatment results in twice the volume of tissue treated. This is important when treating deeper

indications such as scars or deep rhytides. Treatments can be spaced as close as 1 week and as far apart as 6 weeks. Higher energy treatments should be spaced every 2–4 weeks.

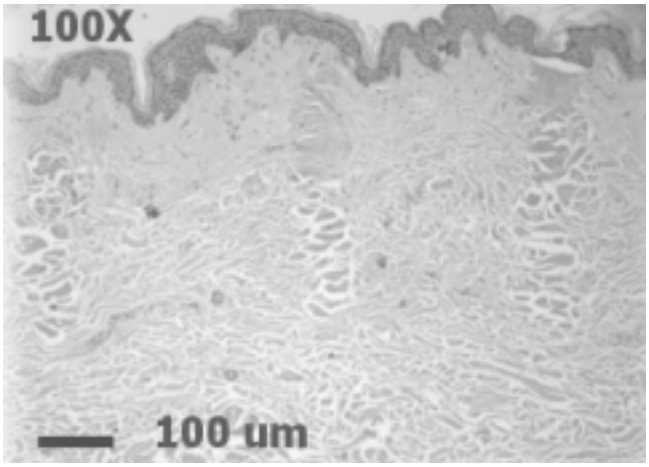

Figure 2a: Depth coagulation at 20mJ, 100X magnification

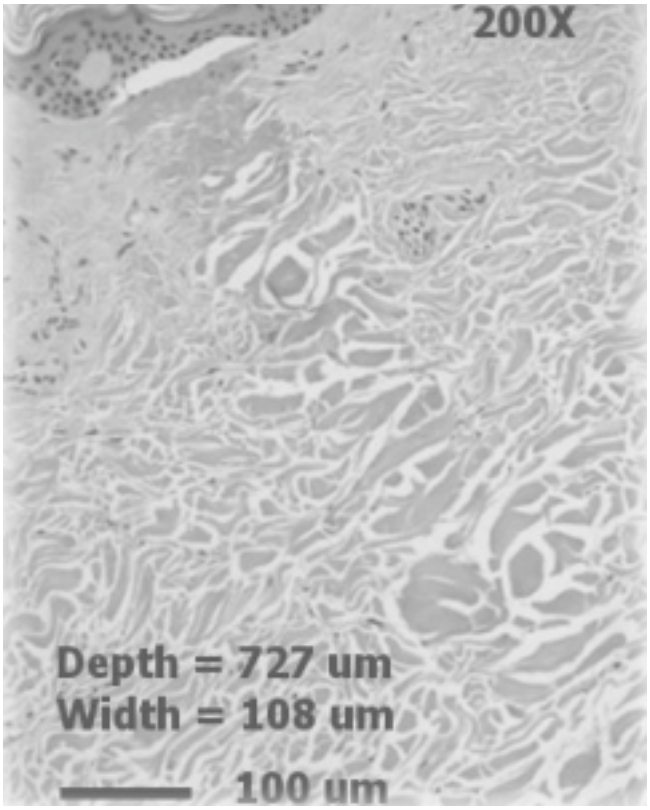

Figure 2b: Depth coagulation at 20mJ, 200X magnification

The energy counter on the machine allows the user to determine whether an adequate treatment has been performed. The calculations require knowledge of treatment energy, surface area treated, and total number of kJs used. On average, a full face treatment requires 5–8kJ.

Photodamage, Including Pigmentation and Rhytides

Treatment of dynamic wrinkles should include a combination approach, limiting muscle movement through the injection of neuromodulators. One "targeted" treatment for photodamage of the face uses higher energies in areas of deeper rhytides, such as in the perioral or periorbital region.[3] The forehead, cheeks, and nose can be treated at lower energies. Off-face resurfacing should be performed at lower energies, as well, except when treating acne scars or other indications requiring deeper penetration. Treatment algorithms can be tailored to suit patient expectations and the targeted indication. A greater number of "gentler" treatments (5+) with less downtime are required to achieve the same cumulative results as fewer (perhaps 4) "high-level" treatments that entail greater downtime. The probability of achieving 100% tissue coverage is far greater with five 20% treatments than with ten 10% treatments. This is due to the probability of targeting the same site with subsequent treatments. Clinical photographs of two patients reveal improvement of pigmentation and rhytides following a series of Fraxel® treatments. (See Figures 3, 4, and 5.)

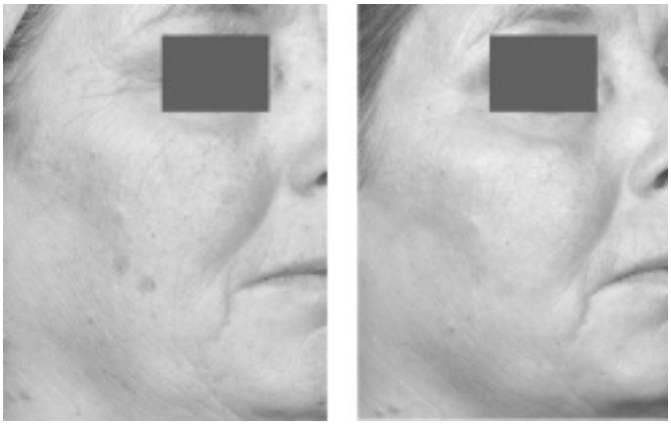

Figure 3: Treatment to improve pigmentation and rhytides using the Fraxel® Laser at baseline and after 4 treatments at 8mJ, 2,500MTZ/cm^2. Perioral: 15mJ, 1,500MTZ/cm^2

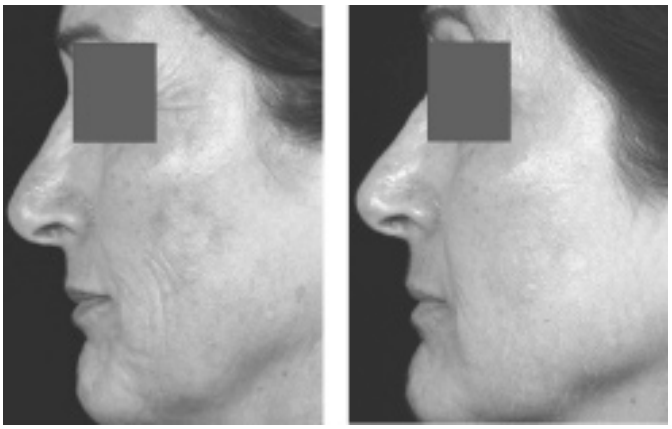

Figure 4: Treatment to improve pigmentation and rhytides using the Fraxel® Laser at baseline and after 4 treatments

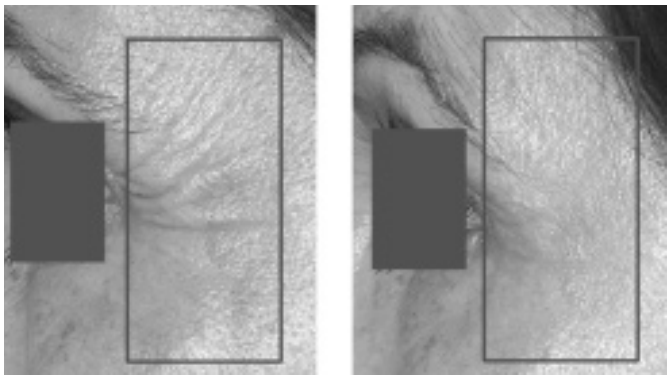

Figure 5: Treatment to improve pigmentation and rhytides using the Fraxel® Laser at baseline and after 4 treatments

Application	Energy	Treatment Density (MTZ/cm²)	Pass Density (MTZ/cm²)	Number of Passes	Coverage
Melasma	6mJ	1000	250	4	5%
		1500	250	6	7%
		2000	250	8	10%
	8mJ	1500	250	6	10%
		2000	250	8	14%
		3000	250	12	22%
Off-Face Resurfacing	8-10mJ	1500	250	6	10-14%
		2000	250	8	14-19%
		3000	250	12	22-29%
Mild-to-Moderate Rhytides* and Pigmentation (Glogau II-III)	8-10mJ	1500	250	6	10-14%
		2000	250	8	14-19%
		2500	250	10	20-24%
	12mJ	1250	125	10	15%
		1500	250	6	18%
		2000	250	8	24%
Severe Rhytides* and Pigmentation (Glogau IV)Scars**	15mJ	1000	125	8	15%
		1250	125	10	19%
		1500	125	12	23%
	20-25mJ	750	125	6	14-16%
		1000	125	8	19-22%
		1250	125	10	24-27%

Table 1: The current recommended treatment settings based on indication for the fractional laser device.

COVERAGE:	LOW	MID	HIGH

*Presently FDA cleared for periorbital wrinkles
** Presently FDA cleared for acne scars and surgical scars

Scars (Acne and Surgical)

Comparative data evaluating high vs. low energy treatments shows improved results with higher energy treatments.[4] Regardless of the energy used, the same percentage of the epidermis is treated. However, the use of high energies for deeper targets is based on the principle of a larger volume of tissue treated at higher energies. At equal surface area coverage of 20%, a 20mJ treatment treats twice the volume of tissue as a 10mJ treatment. This explains the greater efficacy seen for deep rhytides and acne scars with higher energy treatments. A clinical result of a Fitzpatrick skin type V patient undergoing treatment for acne scarring is shown in Figure 6.

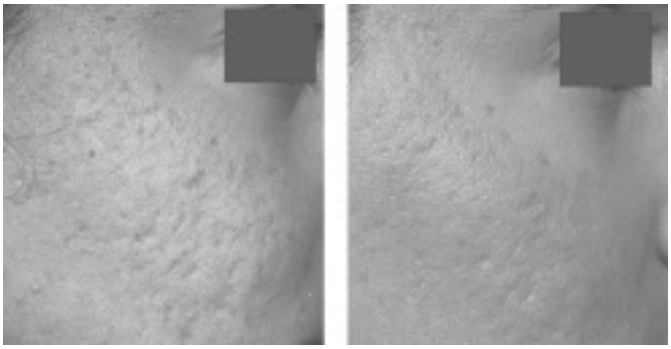

Figure 6: Treatment of acne scarring using the Fraxel® Laser at baseline and 1 month after 5 treatments q2wks, 15mJ, 1,500MTZ/cm^2

Melasma

Results in the treatment of melasma are encouraging. Before this treatment is commenced, the underlying etiology and hormonal factors should be elucidated. All patients should be placed on a bleaching regimen, must practice strict sun avoidance, and use high SPF sunscreens. Retinoids should be stopped 1 week prior to treatment as they blunt the heat shock response, which is essential to rapid reepithelialization following tissue injury.

Ideally, patients should be treated monthly at low energies of 6–8mJ at 1,000-2,000MTZ/cm^2.[5] Melasma patients usually require fewer total treatments. A regimen of 2–3 total treatments with a "touch-up" at 6 months is commonly prescribed, although touch-up treatments are not always necessary. There is a risk of postinflammatory change, particularly in those patients who have hyperactive melanocytes. In our experience, the postinflammatory changes that occur following treatment are likely more homogeneous and better tolerated than the mottled, uneven pigmentation of melasma. Melasma can be recurrent, particularly when the causative melanocytes and hormonal profile are present.

Side-effects and Postoperative Care

Postoperatively, patients can apply sunscreen and/or makeup. There is no oozing because there is no disruption in the stratum corneum, however some patients may experience excessive desquamation and even some crusting following an aggressive treatment. The majority of patients experience some degree of erythema, which resolves within 2–3 days following a gentle to modestly aggressive treatment. Erythema may persist for up to 1 week after more aggressive treatments.

Post-treatment edema is very patient-dependent. Some have little swelling. The average patient experiences edema for 1–3 days; <5% of patients have swelling for up to 1 week. The risk of edema also increases with higher level treatments. The majority of patients do well by applying ice at 10 minute intervals for the first 24 hours after treatment, and by sleeping on extra pillows. Although some physicians advocate the use of topical or short course systemic corticosteroids following treatment, the inflammatory cascade that leads to subsequent upregulation of collagen production may be best left unaltered.

There is always a risk of postinflammatory pigmentary alteration following any type of inflammatory process in the skin, and fractional laser treatments are no exception. Our own experience indicates an approximately 10%–12% incidence of hyperpigmentation after fractional treatments. This is most common in patients with a history of postinflammatory hyperpigmentation (PIH) or melasma. PIH is more common in patients of darker skin types (IV–V). A precautionary 6-week pretreatment with hydroquinone and a strict sun-protection regimen are advisable for these individuals.

Bulk heating can result from treating too large a fraction of the skin at one time, or from inadequate cooling between laser passes. To reduce this risk, the density of MTZs per pass should be halved to 125MTZ/cm^2 when using energies above 15mJ. Treating a small area without allowing the skin to cool between passes can lead to bulk heating, even at lower energies. Treatment of >35%–40% of the

skin in a single session may lead to adverse sequelae. Maintaining sufficient normal tissue between the deep zones of coagulated epidermis and dermis is essential for rapid healing following fractional treatments.

Conclusions

Fractional laser resurfacing is a safe and effective modality for the treatment of epidermal pigmentation and wrinkles associated with photoaging, melasma, and acne scars. Two years of clinical data and studies have allowed for optimization of treatment parameters with improved patient outcomes. In comparison with traditional ablative modalities, fractional laser treatment may be used to resurface any nonfacial part of the body, but is particularly useful on the neck, chest, and hands. For selected applications, fractional laser treatments may have greater efficacy than some other nonablative modalities; however, they have a similar, limited downtime.

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