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The Use of Lasers in Darker Skin Types

Eliot F. Battle, Jr, MD,*,† and Cylburn E. Soden, Jr, MD, MA*

The demographics of the US population continue to change at an extremely rapid pace. As of 2008, Asians, Hispanics, and African Americans accounted for 31% of the US population, and it is estimated that by the year 2050 half of the population of America will be represented by darker ethnic skin types. With the increase in the total number of individuals of skin of color, the demand for safe and effective laser therapy in darker skin types continues to increase. However, despite the increase in demand, the current literature regarding the use of lasers in darker skin remains limited. Most of the treatment parameters defined for laser platforms have been established primarily through extensive testing on skin phototypes I to III, and those studies that have been conducted on darker skin phototypes have been overwhelmingly conducted on Asian skin. Nevertheless, it has become clear that effective cutaneous laser surgery in darker skin types can be accomplished despite a relative overall greater risk for complications. Therefore, as the diversity of America continues to grow, the laser surgeon needs to maintain a clear understanding of the complexities associated with treating ethnic skin and remain mindful of the current, and ever-changing, therapeutic modalities available. This will allow the conscientious physician to maximize outcome and minimize risk when performing laser surgery on darker skin types.
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The demographics of the US population continue to change at an extremely rapid pace. As of 2008, Asians, Hispanics, and African Americans accounted for 31% of the US population, and it is estimated that by the year 2050 half of the population of America will be represented by darker ethnic skin types.[1] With the increase in the total number of individuals of skin of color, the demand for safe and effective laser therapy in darker skin types continues to increase. However, despite the increase in demand, the current literature regarding the use of lasers in darker skin remains limited. Most of the treatment parameters defined for laser platforms have been established primarily through extensive testing on skin phototypes I to III, and those studies that have been conducted on darker skin phototypes have been overwhelmingly conducted on Asian skin. Nevertheless, it has become clear that effective cutaneous laser surgery in darker skin types can be accomplished despite a relative overall greater risk for complications. Therefore, as the diversity of America continues to grow, the laser surgeon needs to maintain a clear understanding of the complexities associated with treating ethnic skin and remain mindful of the current, and ever-changing, therapeutic modalities available. This will allow the conscientious physician to maximize outcome and minimize risk when performing laser surgery on darker skin types.

Most of the inherent risks involved in treating darker skin types with cosmetic lasers relate to melanin's very wide absorption spectrum (250-1200 nm). Melanin can be targeted by visible, ultraviolet (UV), and infrared light (Fig. 1). In darker skin types, epidermal melanin competes as a significant chromophore and may lead to excessive heating of the surrounding tissue. Unintended nonspecific thermal damage may ensue, resulting in epidermal blistering, transient or permanent dyspigmentation, textural changes, and scarring.

Increased epidermal melanin absorption in skin of color also reduces the amount of laser light reaching the intended chromophore. As a result, the efficacy of lasers in persons with darker skin types may be reduced when using equivalent fluences. The peak absorption of melanin lies within the UV range and decreases rapidly as wavelength increases (Fig. 1). Consequently, longer wavelengths not only reduce the absorption of laser light by epidermal melanin but also penetrate deeper with more selective absorption of dermal targeted chromophores. Thus, lasers generating longer wavelengths that are less efficiently absorbed by endogenous

*Department of Dermatology, Howard University College of Medicine, Washington, DC.

†Cultura Cosmetic Dermatology & Laser Center, 5301 Wisconsin Ave., NW, Washington, DC.

Address reprint requests to Eliot F. Battle, Jr, MD, 5301 Wisconsin Ave. NW, Ste. 110, Washington, DC 20015–2068. E-mail: drbattle@culturamed.com.

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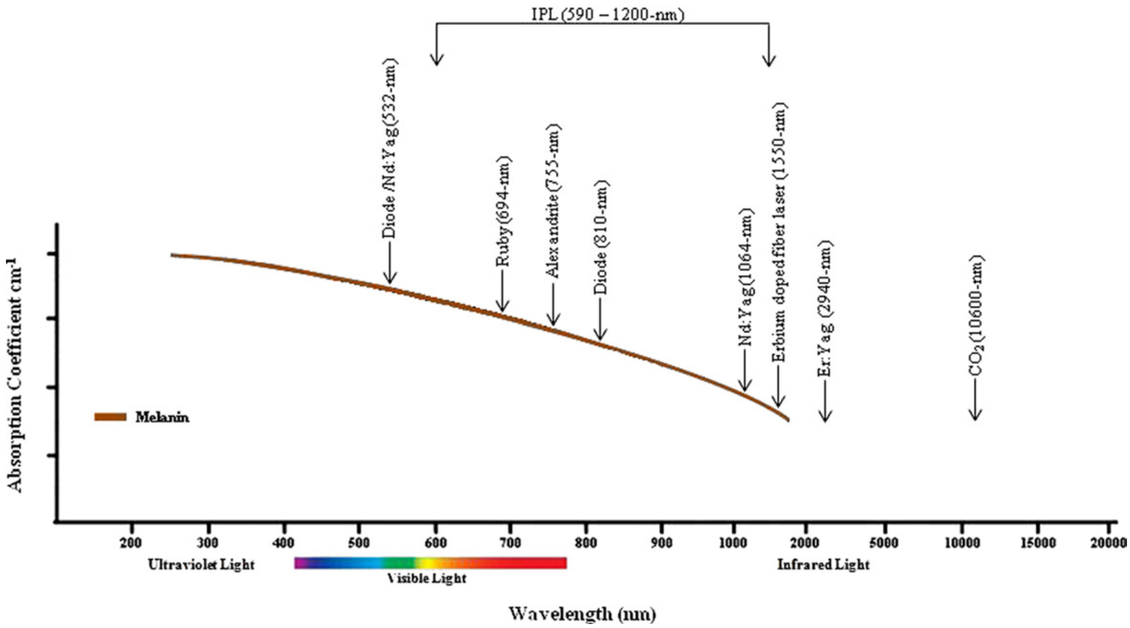

Figure 1 Absorption spectrum of melanin.

melanin, such as the 810-nm diode and particularly the 1064-nm Nd:Yag, can provide a greater margin of safety while still allowing appropriate clinical results to be achieved in skin types IV to VI. Nevertheless, differential absorption even among darker skin types remains quite variable. Type VI skin may absorb as much as 40% more energy when irradiated with visible light as compared with phototypes I or II when irradiated with the same fluence and pulse duration.[2]

The thermal relaxation time (TRT) is the time it takes the target chromophore to cool down by 50% of its initial temperature. The TRT is directly proportional to the diameter of the target. The melanosome is a small structure, has a TRT in the nanoseconds, and therefore loses heat rapidly. Melanosomes are potentially destroyed when Q-switched lasers are used, given their nanosecond pulse durations, and spared when pulse durations in the milliseconds are used.

Efficient cooling devices (eg, sapphire-cooled tip, cryogen spray cooling, and forced air cooling) are essential in the treatment of darker ethnic skin types. Light absorbed by epidermal melanin is converted to heat and, without efficient cooling, this heat creates unwanted thermal injuries, including blistering, dyspigmentation, and scarring. Cooling can be performed by contact (cooling device touching the skin) or noncontact (eg, cooling the skin with a cooling spray, air or gas). The use of excessive cooling is not without risk for darker ethnic skin types. Cryogen spray can reach temperatures as low as −26.2°C. Excessive cryogen spray and delay parameters can result in unwanted side effects, including blistering and postinflammatory dyspigmentation. The exact mechanism in which cold air cooling is associated with dyspigmentation after laser irradiation is unknown. However, in a study evaluating the incidence of continuous cold air cooling on postinflammatory hyperpigmentation (PIH) after Q-switched Nd:Yag laser treatment of bilateral nevus of Ota, 62% of patients developed PIH on the cooled side and only 24% developed PIH on the uncooled side. The authors hypothesized that laser irradiated melanocytes or keratinocytes may be more reactive to stimuli, such as cold temperature.[3]

In short, with the continued development of novel lasers that use longer wavelengths, increased pulse durations, an expanded range of available treatment fluences, and more efficient cooling devices, the laser surgeon can decrease the likelihood of adverse events while effectively treating darker skin types.

Hair

Since its inception, laser-assisted hair removal has become an increasingly popular procedure. In skin types I to III, where the hair tends to be straight and fine, laser hair removal typically functions in a purely cosmetic manner that reduces the treatment time and monotony of repetitive shaving. In contrast, in patients with darker skin types, especially African Americans, where the hair tends to be coarse and curly, dermatologic conditions such as pseudofolliculitis barbae and hirsutism often do not respond to conventional methods of hair removal. Shaving with a straight or electric razor, plucking the hair, chemical depilatories, and electrolysis does temporarily reduce hair growth but does not address and can even exacerbate the initial condition, resulting in additional inflammatory papules and postinflammatory hyperpigmentation. However, as laser hair removal addresses the underlying issue of the continued hair growth, it essentially becomes a medical necessity for the treatment of conditions, such as pseudofolliculitis barbae and hirsutism, in darker skin types in which there is truly no other viable therapeutic alternative.

Because melanin in the epidermis and in the hair follicle have nearly identical absorption spectra, laser hair removal poses a real risk of epidermal injury, especially in darker skin

Figure 2 (A) Baseline photograph of a patient with type IV skin before laser-assisted hair removal of the face. (B) Photograph 2 years after 9 treatments with a diode laser (Lightsheer, Lumenis, Inc., Santa Clara, CA), using 100-msecond pulse duration.

types. Complications of overly aggressive treatment may include blistering, dyspigmentation, and scarring. Currently, available laser and light sources available for photo-epilation include the long-pulsed ruby (694 nm), long-pulsed alexandrite (755 nm), long pulsed diode (810 nm), long-pulsed Nd:Yag (1064 nm), and noncoherent intense pulsed light (IPL; 590-1200 nm).[4] Among these lasers, the food and drug administration (FDA) has approved 2 systems for photo-epilation in darker skin types: the long pulsed diode (810 nm) and Nd:Yag (1064 nm).[5] These 2 devices have combined longer wavelengths, extended pulse durations, and active epidermal cooling to provide the greatest efficacy with the lowest side effect profile in treating skin phototypes IV through VI (Figs. 2-6).

When the long-pulsed diode to treat skin phototypes IV-VI is used, pulse durations of 100 milliseconds or longer improve the ability to treat darker skin more safely (Fig. 2). In terms of treating very dark skin, phototype VI, Battle and Hobbs[6] reported that very long pulse durations (>400 ms) and aggressive adjunctive skin cooling are required.

Because of its longer wavelength, the Nd:Yag has been shown to be the safest laser to treat darker skin types (Figs. 3-6).[7] Its longer wavelength minimizes epidermal melanin absorption and maximizes wavelength penetration to the dermal hair follicular unit. Therefore, shorter pulse durations can be more safely used with the Nd:Yag lasers as compared with diode lasers. When the Nd:Yag is combined with aggressive skin cooling and pulse durations >30 milliseconds, it can safely treat type VI skin[8] (Fig. 6). With regard to overall hair reduction, however, the longer wavelength of the Nd: Yag is probably slightly less effective because of its reduced melanin absorption.[8,9] A study conducted by Galadari[8] showed a 35% reduction in hair at 12 months after 6 treatments with the Nd:Yag compared with a 40% reduction observed with the diode after a similar number of treatments and follow-up period.

Paradoxical hypertrichosis has been consistently reported as a complication of laser assisted hair removal.[10-13] Currently, published studies have reported this complication after alexandrite (755 nm) and IPL (590-1200 nm) treatment.[11,12] In the authors' experience, this complication is not dependent on a light source and may occur with

Figure 3 (A and C) Baseline photograph of a patient with type IV skin before laser-assisted hair removal of the face and neck. (B and D) Photograph of patient 4 years after 10 treatments with a long pulsed Nd:Yag laser (Coolglide, Cutera, Inc., Brisbane, CA).

Figure 4 (A) Baseline photograph of a patient with type V skin before laser-assisted hair removal of the upper lip. (B) Photograph of patient 2 years after 10 treatments with a long pulsed Nd:Yag laser (Gentlelase, Candela Corp, Wayland, MA).

any wavelengths used with photoepilation, including the diode (810 nm) and Nd:Yag (1064 nm). Evidence suggests that individuals with darker skin (phototypes III-V) may be at increased risk,[10,13] particularly patients of Mediterranean or Pacific Asian descent. The current reported incidence of paradoxical hypertrichosis after laser hair removal has varied between 0.6% and 5.1%.[10,12] With respect to location, hair growth may occur both within and beyond the treated sites.[12]

The exact mechanism of photostimulation remains unknown, but it is speculated that low fluences can stimulate the transformation of vellus hairs into darker terminal hairs. Laser epilation may also synchronize the cycling of hairs growing within the treatment site,[10] and certain wavelengths of energy may directly or indirectly have photo-stimulatory effects on the hair follicle.[12] In the authors' experience, potential methods of limiting this complication include using the maximal possible safe energy, cooling outside the treatment area to avoid vellus hair stimulation, and minimizing the treatment to only where the hair is located. Yet, because it is not possible to predict which patients will develop laser-induced hypertrichosis, this complication should be discussed during the informed consent process.

Tattoos

Cosmetic tattoo removal is regularly practiced by many laser surgeons; however, there have been few technological advances during the last decade and, thus, tattoo removal still involves many challenges. Tattoos often consist of multiple pigments, and their removal may require the use of several wavelengths involving both the visible and near infrared spectrum. Furthermore, tattoos can respond unpredictably to laser irradiation not only because the components used in their makeup are highly variable but also because they can be placed in the deep dermis. Tattoo treatment becomes even more difficult and unpredictable in patients with skin phototypes IV through VI because of the presence of significant amounts of epidermal melanin that can absorb laser energy.[14]

The Q-switched 694-nm ruby laser was the first laser to be used in the treatment of tattoos.[15,16] It is highly effective in removing black-and-blue tattoo pigments, and it is the most effective laser for removing purple and violet pigments.[17] Studies have demonstrated the effectiveness of the Q-switched ruby laser to remove blue and black pigments in skin types V and VI with excellent clearance and only transient hyperpigmentation.[18] However, its shorter wavelength is strongly absorbed by epidermal melanin, and its potential for inducing long-term dyspigmentation is rela-

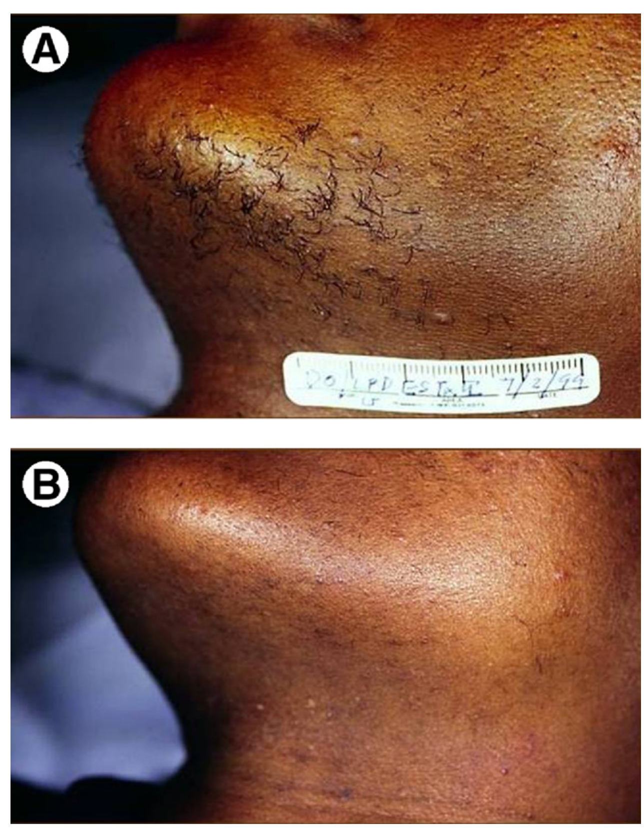

Figure 5 (A) Baseline photograph of a patient with type V skin before laser-assisted hair removal of the chin and neck. (B) Photograph of patient 1 year after 12 treatments with a long pulsed Nd:Yag laser (Coolglide, Cutera, Inc., Brisbane, CA).

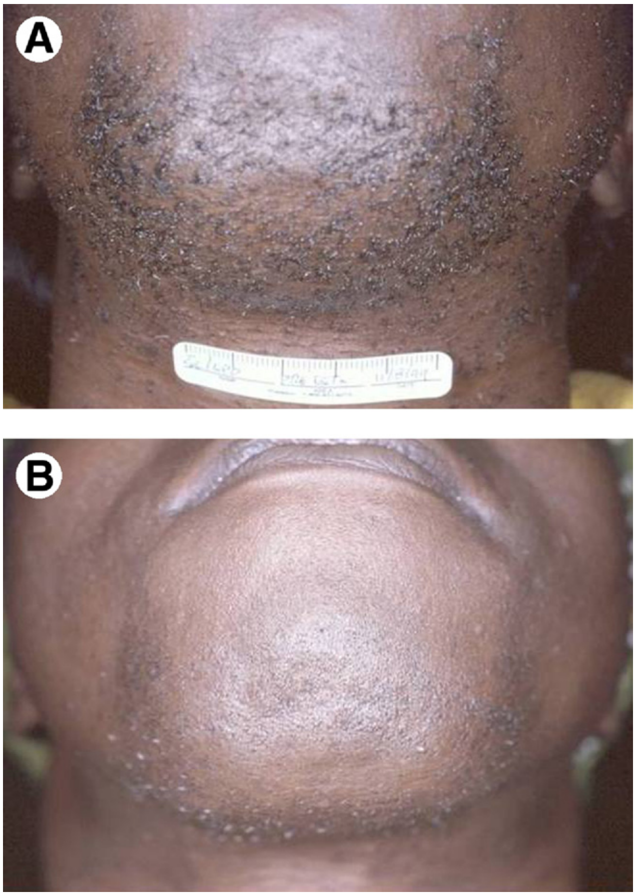

Figure 6 (A) Baseline photograph of a patient with type VI skin before laser-assisted hair removal of the chin, cheeks, and neck. (B) Photograph of patient 2 years after 12 treatments with a long pulsed Nd:Yag laser (Coolglide, Cutera, Inc., Brisbane, CA).

tively high in patients with darker skin types when compared with lasers that use longer wavelengths.

The Q-switched alexandrite laser emits light at 755 nm, an intermediate wavelength between the ruby and Nd:Yag lasers. Similar to ruby lasers, alexandrite lasers are capable of removing blue and black tattoo pigments and have become the treatment of choice for removing green tattoo pigment. Studies involving the use of alexandrite laser in the treatment of blue and black tattoos in skin types III and IV have shown that it is effective treatment with minimal side effects.[19,20] However, because of its relatively short wavelength, its energy is also strongly absorbed by epidermal melanin. Therefore, it must also be used with extreme caution in skin types V and VI.

Q-switched Nd:Yag laser are capable of emitting 2 wavelengths of light, 532 and 1064 nm. At its shorter wavelength of 532 nm, it is the most effective treatment for red brown, dark brown, and orange pigment.[17] At the same time, because of its shorter wavelength, when treating pigmented-skin, the 532-nm has a greatest risk of transient or even permanent hypopigmentation. Compared with the Q-switched ruby and Q-switched alexandrite, at its longer wavelengths, the Q-switched Nd:Yag tends to minimize epidermal melanin absorption, thereby reducing the risk of hyperpigmentation and permanent hypopigmentation. As a result, the Nd:Yag remains the safest laser in the treatment of blue and black tattoos in darker skin types[21,22] However, in the author's experience, higher fluences must often be used with the long pulsed Q-switched Nd:Yag compared with the Q-switched alexandrite or ruby to achieve similar efficacy.

Regardless of the laser used, multiple treatments, on average 8-12 treatments, may be required with a minimum of 6-8 weeks between sessions. Side effects of laser tattoo removal on pigmented skin can be limited by starting at the minimum fluence necessary to produce immediate lesional whitening, signaling the destruction of intracellular melanosomes. When treating phototype VI skin with the Q-switched Nd: Yag, a 3-mm spot size and starting fluences between 3.4 and 3.6 J/cm^2 are recommended. With each successive treatment, fluences are gradually increased to account for the clearing of the chromophore. Greater fluences resulting in pinpoint bleeding and tissue splattering are more likely to lead to transient hyperpigmentation, permanent hypopigmentation and scarring. Rarely does one see 100% clearing, but most tattoos clear to the point of being cosmetically acceptable. Some brighter colors may not clear well because of a greater chance of hypopigmentation associated with shorter wavelengths necessary to target lighter pigments.

Laser for Pigmented Lesions

Dermatologic conditions that result in altered skin pigmentation, such as *Melasma*, postinflammatory hyperpigmentation, lentigines, and dermatosis papulosa nigra continue to be a primary concern among patients with darker skin tones. Although chemical peeling, light eletrodessication and, in cases, even cryotherapy have been used in their treatment, lasers have continued to gain widespread acceptance and, at times, may be considered a first-line treatment or, at least, a therapeutic alternative when conventional methods are not successful (Fig. 7).

Melasma is a commonly acquired hypermelanosis that occurs most frequently on the face of women and tends to be especially prominent in women of color. Although topical agents remain the first-line treatment for epidermal and mixed type of *Melasma*, lasers are commonly used for more refractory cases. Before the physician initiates laser therapy, all patients should be placed on a topical regimen, including exfoliating and bleaching agents and sunscreen.

IPL sources have shown promise in the treatment of *Melasma* for a subset of skin type IV patients. In a study conducted by Wang et al,[23] IPL was found to be effective for the treatment of refractory dermal *Melasma* in Asian patients. By using 570-nm and 590- to 615-nm filters at 4-week intervals for 4 treatments, the IPL was able to produce a 39.8% improvement of the relative melanin index in the treatment groups compared with 11.6% improvement in the control group at week 16. However, the authors noted some repigmentation at the end of the 36-week treatment session, suggesting that maintenance therapy may be required.

A more recent investigation evaluated the treatment of therapy resistant *Melasma* in 89 Chinese female subjects

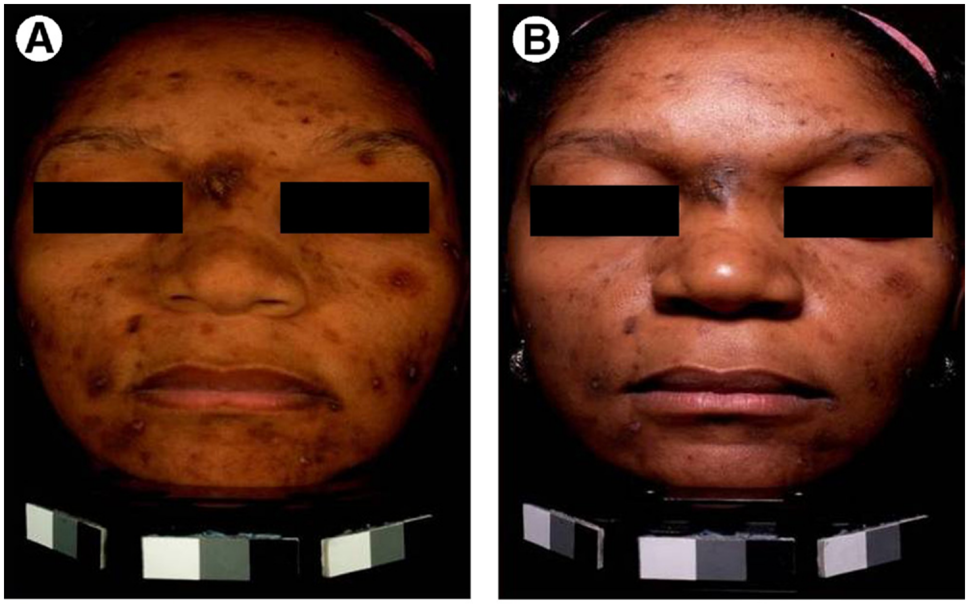

Figure 7 (A) Facial hyperpigmentation in a patient with type VI skin. (B) Photograph 1 month after 4 treatments with microsecond Nd:Yag (Cutera Genesis, Cutera, Inc., Brisbane, CA). (C) Photograph of patient 6 months after 10 treatments with microsecond Nd:Yag (Cutera Genesis, Cutera, Inc., Brisbane, CA).

(skin types III and IV) with use of a new IPL device (Lumenis one, Lumenis, Inc., Santa Clara, CA) incorporating optimal pulse technology (OPT). Patients received 4 IPL treatments at 3-week intervals with fluences ranging from 13 to 17 J/cm^2 and 560-/590-nm filters for epidermal type and 590-/615-/640-nm filters for mixed type *Melasma*. Mean melasma area and severity index scores decreased from 15.2 before the treatment to 5.2 after 4 sessions and 4.5 at 3-month follow-up. Adverse events were limited with IPL treatments and mainly involved transient erythema and slight edema resolving 0.5-12 hours after treatment. Temporary microcrusts lasting 7-10 days were noted on the cheekbones of 72 patients, and 3 patients with mixed-type *Melasma* had obvious PIH after 1 or 2 treatment sessions. No scarring or hypopigmentation were noted during or after the treatment.[24]

IPL treatments may result in IPL-induced *Melasma*-like hyperpigmentation despite the presence of apparently normal skin. Negishi et al,[25] explained this concept by noting the presence of "very subtle epidermal *melasma*" when using UV photography among 63 of 223 Japanese women. From their observations, high fluences resulting in immediate postirradiation erythema within areas of pigmentation previously identified by UV photography that lasted for several minutes to hours after irradiation were postulated to exacerbate melanocyte activity, thus inducing postirradiation hyperpigmentation. These findings, although observed in the skin of Asian patients, may also be extrapolated to lighter-skinned African-American or Hispanic patients in whom wood's light examination identifying the presence of "subtle *melasma*" should prompt the physician to treat these patients less aggressively, reducing the possibility of exacerbating their *Melasma* or inducing PIH.

Although not as widely used as the IPL, the Q-switched 1064 Nd:Yag laser has also been shown to be effective in the treatment of refractory dermal *Melasma* in pigmented skin through repetitive subthreshold pulsed laser treatments.

With the use of a Medlite C6 Q-switched Nd:Yag laser (6-mm spot, 10 Hz and 3.4 J/cm^2), 8-10 treatments performed at 1-week intervals were able to produce >80% reduction in hyperpigmentation.[26] It is thought that subphotothermolytic fluences (<5 J/cm^2) in conjunction with larger spot sizes allow melanin granules to be fragmented and dispersed into the cytoplasm, facilitating their reabsorption without causing cell damage or cell death.

Fractional photothermolysis (Reliant Technologies, Palomar Medical Technologies) is the newest technology to be used in the treatment of *Melasma* and it is currently the only FDA-approved laser therapeutic modality for this condition (Fig. 8).[27,28] This modality involves the use of a 1550-nm erbium-doped fiber laser to create noncontiguous microthermal zones (MTZs), which are microcolumns of thermal injury to the level of the dermis surrounded by normal tissue. Although initial histologic evaluation of these MTZs revealed the presence of primarily microscopic epidermal necrotic debris, more recent evidence suggests that in addition to epidermal debris, dermal contents, such as melanin and elastotic debris of solar elastosis, may also be eliminated through these channels of thermal injury.[29] In fact, melanin content within these columns of damage has been found to be significantly greater than in the surrounding normal tissue.[30] This increased melanin content has lead to the theory of a melanin shuttle in which the damaged pigmentation of the basal layer is eliminated by the rapid migration of the viable keratinocytes present at the wound margins. This concept was recently corroborated by Goldberg et al,[29] who noted posttreatment ultrastructural changes in the skin of *Melasma* patients after fractional photothermolysis, which included a decrease in the number of melanocytes and the amount of melanin granules within keratinocytes.

Early studies in which the authors studied fractional photothermolysis in the treatment of *Melasma* (skin types III-V) used 6-12 mJ/MTZ and relatively high densities of 2000-3500 MTZ/cm^2 for 4-6 treatments. Approximately 60% of patients experienced 75-100% clearing, and only 1 of 10 patients experienced postinflammatory hyperpigmentation.[27] More recent studies by Lin et al[31] involving darker skin types showed a reduction in pain and downtime by the use of lower energy and density (125 MTZ/cm^2 at energy of 8 mJ, every 2-4 weeks) without a significant reduction in efficacy. The authors concluded that greater density is not significantly more effective and carries an increased risk of hyperpigmentation and rebound in darker skin types. In our experience, patients should be treated with low energies (6-8 mJ at 1000-2000 MTZ/cm) for 2-3 treatments. Similar to IPL, fractional photothermolysis (FP) carries a risk of PIH, especially in individuals that may have hyperactive melanocytes. However, the use of lower energy and density settings in combination with liberal skin cooling during and after treatment helps minimize these risks.

Freckles and lentigines are common findings in skin of color, especially Asian patients. Although freckles are a normal aspect of development, lentigines represent a sign of aging and photodamage. Nevertheless, lentigines and freckles are common reasons for consultation with laser surgeons.

Q-switched lasers produce photomechanical effects within the epidermis and are effective for treating both freckles and lentigines. The commonly used Q-switched systems are the Q-switched ruby 694-nm, Q-switched alexandrite 755-nm and frequency-doubled Q-switched Nd:Yag 532-nm. All produce immediate whitening and subsequent macrocrusting at the treated sites, which typically lasts 7-14 days. Lentigines are often eradicated after 1 or 2 treatments with Q-switched lasers. PIH is the most common side effect and tends to resolve within a few months. Reported rates of PIH associated with the use Q-switched lasers in Asians have ranged from 4% to 25%.[32,33] However, this is significantly lower than what we have experienced in treating pigmented skin, with PIH more likely occurring in 35-50% of treated patients.

Intense pulse light sources are also capable of treating both freckles and lentigines in a subset of skin type IV patients. In contrast to the Q-switched systems, IPL requires multiple treatments; however, in that it produces primarily photothermal effects within the epidermis, the side effects of pigmentary alteration are less common, and ensuing microcrusting is less severe.[34] Wang et al[35] compared the Q-switched alexandrite laser (AlexLAZR, Candela Corp, Wayland, MA) and IPL

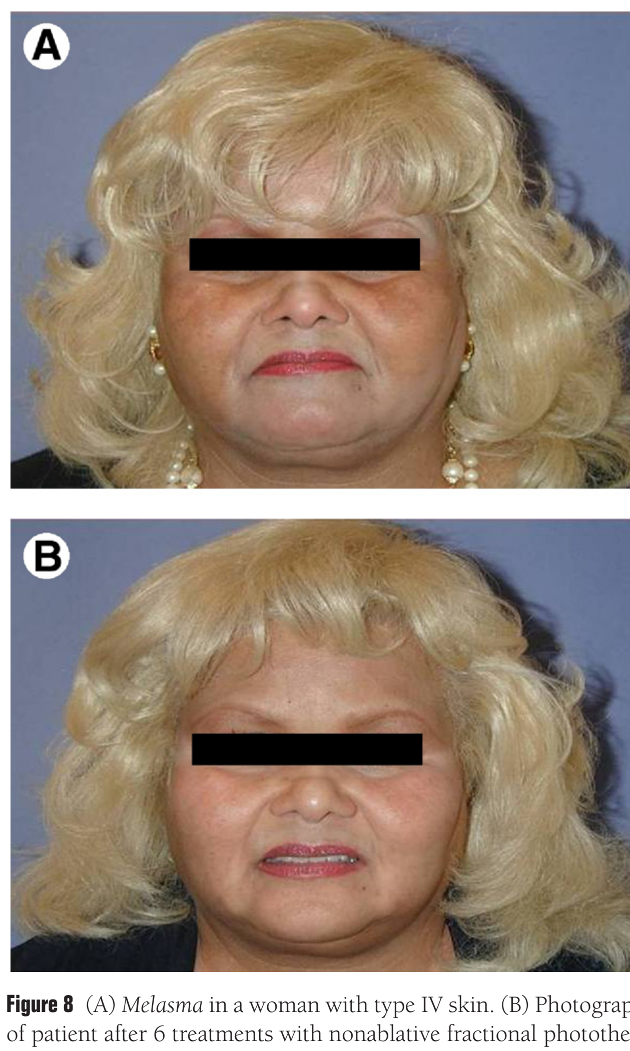

Figure 8 (A) *Melasma* in a woman with type IV skin. (B) Photograph of patient after 6 treatments with nonablative fractional photothermolysis (Palomar Medical Technologies, Inc., Burlington, MA).

(Quantum SR IPL device, ESC Medical Systems Ltd, Yokneam, Israel) for the treatment of freckles and lentigines in Asian patients (skin phototypes III to IV). They found that the Q-switched alexandrite in 1 session (755 nm, 50 ns, 3-mm spot size, 6.5-7.5 J/cm^2) was superior to 2 sessions with the IPL (560-1200 nm, double mode, 3.2/6.0 ms, intervals 40 ms, 26-30 J/cm^2 for session 1 and 28-32 J/cm^2 for session 2) for freckle treatment. However, IPL was better tolerated with respect to treatment of lentigines. Specifically, PIH was not encountered after IPL therapy but was noted after Q-switched alexandrite therapy in 47% of patients with lentigines and 7% of patients with freckles. Additionally, with respect to lentigines, the results after IPL were superior to those of the Q-switched alexandrite among those patients with PIH induced by Q-switched alexandrite therapy.

Freckles, lentigines, and dermatosis papulosa nigra (DPN) can be treated with the 532-nm frequency doubled Q-switched lasers or 532-nm non–Q-switched lasers. The lowest fluence to obtain the desired popping sound signifies the therapeutic end point in which the lesion should look darker in color. Lesions usually respond after 1 to 2 treatments. The spot size should be smaller than the lesion to minimize the risk of unintended surrounding PIH. When the appropriate fluence is used, the risk of PIH is low. Spoor[36] treated 34 patients (88% African American, 6% Asian, and 6% Hispanic) with DPNs with the 532-nm diode laser (Iridex Corporation, Mountain View, CA). He used settings of 8 J/cm^2, 3 W, and a 4-Hz repetition rate along with a chilled gel for anesthesia. Clearance was obtained after one treatment in 90% of patients. As expected, the treated sites hyperpigmented and sloughed off during a 3-week period. Only one patient experienced transient hypopigmentation. In addition to 532-nm Q-switched lasers, in a recent case report, the long-pulsed 1064 Nd:Yag laser was also shown to be effective in the treatment of DPN, providing excellent cosmetic results after a single treatment.[37] Nonetheless, despite the continued advances in laser therapy, it is the opinion of the authors that light electrodessication is preferable, just as effective, and financially more affordable.

Skin Rejuvenation

Nonablative devices are desirable therapeutic options for skin rejuvenation of darker phototypes. Ablative laser have been used infrequently on darker skinned individuals, and the increased risk of transient and permanent dyspigmentation as well as scarring renders it impractical for most ethnic patients. However, recent advances in laser technology are allowing both nonablative and, in cases, even ablative laser skin rejuvenation therapies to become more commonplace in skin phototypes IV to VI.

Although purely ablative lasers such as the erbium Yag and CO_2 remain the gold standard for the treatment of photoaging, they have grown out of favor in darker skin types primarily because of the increased risk of complications, namely the excessive recovery period, scarring, and prolonged postinflammatory changes. PIH has been reported to occur in up to 68% of patients with skin type IV.[38] Fractional CO_2 devices have also begun to become more common in dermatology. These lasers offer the advantages of traditional ablative therapy in combination with reduced healing times associated with rapid keratinocyte migration seen with FP. Tan and colleagues[39] evaluated a novel nonsequential fractional CO_2 device (Ultrapulse® Encore; Lumenis, Inc., Santa Clara, CA) for the treatment of photodamage in 7 patients of Fitzpatrick skin types IV and V. With a single pass, all patients experienced a subjective improvement in their specific skin condition as well as texture. No PIH was noted.

Although the verdict has yet to be established with regard to the use of novel fractional ablative lasers on darker skin types, the 1550-nm erbium fiber Fraxel laser, currently FDA approved for the treatment of periorbital rhytides, *Melasma*, pigmented lesions, skin resurfacing, acne, and surgical scars, has shown promise in the treatment of darker skin types. In a study by Alster et al,[40] 53 patients (phototypes I-V) with mild-to-moderate atrophic acne scars were treated with a 1550-nm erbium-doped fiber laser at fluences of 8-16 J/cm^2 and densities of 125-250 MTZ/cm^2 in 8-10 passes with total energies of 4-6 kJ delivered per session. Ninety percent of patients experienced clinical improvement averaging between 51% and 75%. Furthermore, although transient erythema and edema occurred in most patients, no dyspigmentation, ulceration, or scarring was noted.

In general, when compared with standard ablative therapies, fractional resurfacing carries a reduced side effect profile and faster recovery times. Instead of potentially lasting several weeks, erythema and edema tend to resolve within a few days. However, as many as 4-6 treatments may be necessary to achieve a desired clinical effect in contrast to the 1-2 treatments necessary when treating with ablative lasers. Fractional photothermolysis, however, appears to provide more rapid improvement with regard to acne scars and wrinkles when compared to other nonablative therapies. Postinflammatory hypopigmentation, a relatively common complication occurring in darker skin types may also be effectively treated by FP.[41]

Complication rates of FP treatment were recently reported in large retrospective study of 961 patients treated with the 1550-nm erbium doped laser in skin phototypes I-V.[42] Seventy-three treatments (7.6%) resulted in complications. The most common complications were acneiform eruptions (1.87%) and herpes simplex outbreaks (1.77%). These side effects were equally distributed across different ages, skin types, body locations, laser parameters, and underlying skin conditions. However, as expected, the incidence of PIH increased with increasing skin type with the incidence of hyperpigmentation in skin types III, IV, and V noted to be 2.6%, 11.6%, and 33%, respectively. When treating darker skin types with FP, it is advisable to reduce treatment energy and treatment density to minimize the possible prolonged erythema, edema as well as postinflammatory hyperpigmentation more likely to be encountered in darker skin types.

During the past several years, the concept of noninvasive skin tightening has become increasingly more popular. At the forefront of this field are devices that use radiofrequency (RF) current or a light source targeting water as its chromophore to produce dermal heating. This dermal heating results in an initial transient collagen fiber contraction followed by a well-documented inflammatory wound response that ultimately results in dermal remodeling and neocollagenesis. Unlike other laser surgical procedures that directly or indirectly heat the epidermis while attempting to target their specific chromophore, RF devices accomplish their objective by deep dermal heating while keeping the epidermis relatively cool. Current applications include rhytid reduction, tightening of lax facial and neck skin, lower eyelid rejuvenation and treatment of atrophic facial scarring.

Although the body of literature to date has been obtained primarily via skin types I through III, the ability of these devices to provide deep dermal heating while concomitantly providing epidermal cooling should allow for the effective treatment of Skin types IV through VI with a lessened concern for complications, such as dyspigmentation and scarring.

With regard to current radiofrequency-induced tissue tightening both monopolar and bipolar RF devices are available. Thermage, a monopolar RF, has been the most widely studied device and is approved by the FDA for the treatment of facial rhytides. Early studies suggest that Thermage appears to be both safe and effective in darker skin types. In a study involving 85 Japanese females, Kushikata et al[43] demonstrated improvement in nasolabial folds, marionette lines, and jowls in skin types III-IV after a single treatment with Thermage. Overall, objective improvement rates at 3 months after treatment were 78.0% for jowls, 69.5% for marionette lines, and 73.8% for nasolabial folds. High patient satisfaction was noted at both the 3-month initial and 6-month final evaluation time points. Interestingly, the objective physician evaluation of facial rhytid reduction based on digital photography were more than 10% better at the 6-month period than were noted at the initial 3-month follow-up while the subjective patient evaluation had fallen slightly by a few percentage points in all categories at the 6-month follow-up. Minor complications ranging from edema, burning and blistering to secondary hyperpigmentation were noted in 7 patients. In all cases, the complications were transient and resolved without permanent sequelae.

The use of Thermage in darker skin types requires additional study, but other applications are likely amenable to all skin types. Thermage has shown effectiveness in the treatment moderate eyelid laxity.[44] It also shows promising results in the treatment of severe acne vulgaris and atrophic facial scarring where it may not only activate dermal remodeling resulting in scar reduction but also directly inhibit sebaceous gland activity, improving acne lesions.[45]

Bipolar devices include the Polaris and ReFirme from Syneron as well the Aluma from Lumenis. Both the Polaris and ReFirme incorporate bipolar radiofrequency with diode laser systems (780-910 nm for the Polaris and 700-2000 nm for the ReFirme). The Aluma is a bipolar device with an attached vacuum. The vacuum has not only been found to reduce pain but also brings the electrodes closer to the deep dermal tissue, reducing the energy for an effective treatment. The Accent from Alma Lasers incorporates both unipolar and bipolar RF. Superficial heating is accomplished with bipolar RF while unipolar RF produces deeper dermal heating.

In addition to RF devices, the other type of energy being used in tissue tightening is broadband infrared light in the range of 800-1800 nm. Similar to RF technology infrared technology appears to be safe and effective in treating darker skin tones (Fig. 9). In a recent study, an infrared nonablative heating device (Titan, Cutera, Inc., Brisbane, CA) was shown to be effective in achieving mild-to-moderate gradual improvement in the treatment of facial and neck laxity in type IV to V Asian skin without persistent dyspigmentation or scarring.[46]

By and large, noninvasive tissue tightening offers the advantages of essentially a nonexistent postoperative period, a very low risk of serious adverse effects, and promising results in the treatment of darker skin types. Dose selection should be based on each patient's pain and tolerance levels. Most reported complications tend to arise when nerve blocks or excessive topical anesthetic are employed, blunting the patient's response to pain, and subsequently hindering the physician's ability to correct an excessively high energy. In addition, due to a relative increase in collagen density noted in ethnic skin, fewer treatments may be necessary to achieve similar clinical results noted in skin phototypes I-III. However, regardless of skin type, continued remodeling may continue to occur for several months after the initial treatment. Nevertheless, patients should be counseled regarding the potentially modest results despite the significant skin tightening often observed immediately after the procedure.

Figure 9 (A) Baseline skin laxity in a patient with type IV skin. (B) Photograph of patient 1 year after 3 treatments with infrared skin tightening (Titan, Cutera, Inc., Brisbane, CA).

Conclusions

When performing cutaneous laser surgery, one must proceed with caution regardless of skin type. However, because of the increased risk of epidermal side effects when performing laser therapy on skin of color, the laser surgeon must proceed with a greater degree of concern and possess a thorough knowledge of the numerous and varied laser-tissue interactions that are possible among darker skin types. This conservative approach used to treat darker skin phototypes IV to VI can also be extrapolated to "tan" skin. The increased pigmentation seen with both immediate and delayed tanning can similarly result in excessive energy absorption and diffusion, thus producing complications, such as pigmentary changes, blistering and scarring that might otherwise not be seen in an individual normally of skin type II or III in their natural nontanned state.

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