Advances in Lasers for Skin of Color

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The popularity of cutaneous laser surgery has soared; however, the use of lasers in patients with skin of color has been quite challenging. The main obstacle with cutaneous laser surgery in darker-skinned patients is epidermal melanin absorption of laser energy. The absorption spectrum of melanin ranges from 320 to 1200 nm, with the greatest absorption observed in the lower end of this spectrum. The main objective in treating patients with skin of color is to avoid epidermal melanin absorption of laser energy and resultant thermal injury. Laser surgery in darker-skinned patients must be approached carefully to avoid this unwanted adverse effect of postinflammatory pigment alteration. In this article, we will review the advances in lasers for skin of color.

To treat acne scars in skin of color, CO_2 lasers have been used. However, the usefulness of CO_2 lasers has been limited because of the risks of hyperpigmentation and scarring. For that reason, other modalities have been investigated for achieving optimal results when treating acne scars in skin of color.[1]

FRACTIONAL DEVICES

The Fraxel SR1500 is a novel, nonablative erbium:glass laser treatment for facial rejuvenation.[2] It is also used for the treatment of melasma and acneform scarring. Fractional photothermolysis is performed with a mid-infrared laser, which creates microscopic columns of thermal injury. These zones of thermal injury, called microthermal zones (MTZs), have a diameter that is energy dependent ranging from 100 to 160 µm. At the energies commonly used for facial rejuvenation (8–12 mJ/MTZ), the depth of penetration ranges from 300 to 700 µm.[3] Relative epidermal and follicular structure sparing accounts for rapid recovery without prolonged downtime. Melanin is not at risk of selective, targeted destruction; therefore, fractional resurfacing has been used successfully in patients with skin of color.

Studies have demonstrated the effectiveness of fractional photothermolysis in the treatment of acne scars. Alster et al[4] examined the use of fractional photothermolysis in the treatment of atrophic scars. Fifty-three patients with Fitzpatrick skin types I to V and mild to moderate atrophic facial acne scars received monthly treatments with the Fraxel 1550-nm erbium-doped fiber laser. Clinical response to treatment was determined by 2 independent investigators at each treatment visit and 6 months after the final treatment session. Ninety-one percent of patients had at least a 25% to 50% improvement after a single treatment. Eighty-seven percent of patients receiving 3 treatments demonstrated at least a 51% to 75% improvement in the appearance of their scars. Skin type did not significantly affect the clinical response observed. It was concluded that treatment with the Fraxel SR1500 and the Fraxel 1550-nm erbium-doped fiber laser were effective in treating acne scars in all skin types.

Hasegawa et al[5] specifically examined Fraxel SR1500 procedures in Asian patients with acne scars and Fitzpatrick skin types IV and V. One treatment consisted of 4 passes of the Fraxel SR1500 device to achieve a final microscopic treatment zone of thermal injury with a density of 1000 to 1500/cm^2. The fluence was set to 6 mJ/MTZ. The treatment was repeated up to 3 times

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at 2- to 3-week intervals. Clinical improvement was achieved in all patients. Rare adverse events included mild transient erythema. Patients showed no scarring or hyperpigmentation as a result of treatment.

Tanzi and Alster[6] compared the 1320-nm Nd:YAG laser and the 1450-nm diode laser in the treatment of atrophic scars in patients with Fitzpatrick skin types I to V. In this study, both devices offered clinical improvement without significant adverse effects.

PHOTOREJUVENATION

In general, all ethnicities are susceptible to photoaging. However, it is clear that in patients with Fitzpatrick skin types IV to VI, photoaging is delayed and less severe than in lighter-skinned patients. This is due to the photoprotective role of melanin. Published studies on photoaging in darker-skinned patients have been limited to African Americans. In lighter-skinned African Americans, photoaging is more prominent. In addition, the signs of photoaging may not be apparent until one reaches their late 50s and 60s. Clinically, the signs of photoaging in African Americans can include fine wrinkling, mottled pigmentation, and dermatosis papulosa nigra. In Asian and Hispanic patients, photoaging is most prominently manifested by solar lentigos and other pigmentary changes.[7]

Fractional Devices

Kono et al[8] have described the use of fractional technology using the Fraxel SR750 for photorejuvenation in 35 Asian patients with Fitzpatrick skin types IV and V. It was noted that increased density was more likely than increased energy to produce swelling, redness, and hyperpigmentation. Kono et al[8] concluded that when the skin is treated with high fluences, patient satisfaction is significantly higher than when it is treated with high densities. Overall, they concluded that fractional photorejuvenation is safe and effective in skin of color.

532-nm Laser

Treatment of the pigmented and telangiectatic components of photoaged skin, although not prominent features in skin of color, has been reported.[9,10] Rashid et al[9] reported on the use of a quasicontinuous wave, 532-nm laser in the treatment of lentigines in patients with Fitzpatrick skin type IV. The investigators reported a 50% improvement in lesion clearance after multiple treatments, with a 10% incidence of hyperpigmentation and a 25% incidence of hypopigmentation. These adverse effects abated after 2 to 6 months.

Lee[10] reported on 150 patients with Fitzpatrick skin types I to V who were treated in multiple sessions with a 532-nm laser (4-mm spot size, 6–15 J/cm^2, 30- to 50-millisecond pulse duration), a 1064-nm laser (10-mm spot size, 24–30 J/cm^2, 30- to 65-millisecond pulse duration), or a combination of both. Sapphire-tipped contact cooling was utilized. Improvement in erythema, texture, pigmentation, and rhytides was reported in both study arms, but was highest in the combination group. A 5% incidence of postinflammatory hyperpigmentation was reported in patients with Fitzpatrick skin types III and IV who were treated with the 532-nm laser alone; hyperpigmentation resolved after 4 to 6 weeks.[9]

Safety data on the use of the 532-nm laser in skin of color are limited. For this reason, the use of conservative settings to achieve the desired results is prudent. Testing the laser on a small area of skin is essential to assess initial patient response and to decrease the risk of hypopigmentation, which can be challenging to treat.

1064-nm Laser

Long-pulsed and Q-switched 1064-nm lasers target melanin as well as hemoglobin and water. Although they are safer for darker skin, a diffuse heating of dermal tissue occurs because of the deeply penetrating nature of a 1064-nm laser. The typical depth of penetration ranges from 5 to 10 mm.[11]

Goldberg and Silapunt[12] have shown evidence of improvement with a Q-switched 1064-nm laser for nonablative treatment in patients with Fitzpatrick skin type IV. Sun-damaged areas of infra-auricular skin measuring 4×4 cm were exposed to a 1064-nm Q-switched Nd:YAG laser at a fluence of 7 J/cm^2 and a 3-mm spot size. Two laser passes with a 10% to 20% overlap were used on all subjects in an attempt to promote petechiae as the visible end point. Petrolatum dressings were applied for one week after treatment. Three-millimeter punch biopsy specimens were taken from each subject before treatment and 3 months after the last treatment. Histologic specimens were evaluated blindly by a board-certified dermatopathologist. Four of 6 skin biopsy specimens obtained 3 months after the last laser treatment showed mild fibrosis, with histologic improvement in pretreatment solar elastosis. There was a mildly thickened upper papillary collagen zone, with an improvement in the organization of collagen fibrils. The remaining 2 specimens showed no changes. Clinically, none of the treated, unbiopsied areas showed any evidence of pigmentary changes or scarring.

Dayan et al[13] utilized the 1064-nm Nd:YAG laser for rejuvenation of facial skin in patients with Fitzpatrick skin types I to V. Patient and blinded physician assessments demonstrated overall improvement. Specific improvement was also seen in coarse wrinkles and skin laxity. No adverse events were noted in this study. The Nd:YAG laser may offer greater safety in skin rejuvenation procedures in patients with skin of color.

Intense Pulsed Light

Another device for photorejuvenation is intense pulsed light (IPL). IPL is produced by a noncoherent flashlamp-pumped light source that is capable of emitting light ranging from 500 to 1200 nm.[11] The use of cutoff filters allows the elimination of some of the shorter wavelengths of the visible light spectrum, limiting melanin absorption. Different pulse widths can be chosen so that appropriate parameters match the thermal relaxation time of the targets. Cooling of the epidermis is achieved with contact cooling in the device head or with external cooling devices.

Negishi and colleagues[14] were among the first to investigate the use of IPL in Japanese patients with Fitzpatrick skin types IV and V. The investigators applied a thin layer of ice-cold gel and used a 550-nm cutoff filter. Settings were 28 to 32 J/cm^2 with 2.5- to 4.0-millisecond and 4.0- to 5.0-millisecond pulse durations. Excellent results (76%–100% improvement) were reported in 73 of 97 patients. No evidence of dyspigmentation was reported in either series. In another study, Negishi and colleagues[15] employed UV photography along with IPL to identify and treat subclinical epidermal hyperpigmentation in skin of color.

Although IPL has been used with success in patients with skin of color, it is prudent to use conservative settings to achieve a favorable result with the fewest adverse effects. Moreover, the use of IPL should be limited in Fitzpatrick skin types V and VI because of the significant risk of hyperpigmentation.

Light-Emitting Diode

Light-emitting diodes (LEDs) offer another advance in visible spectrum, monochromatic light therapy for photoaged skin. Typically, LEDs in devices are arrayed in panels. Each LED emits visible light in a 10- to 20-nm band around the dominant emitted wavelength. Energy output is less than 25 W, representing a fluence of approximately 0.1 J/cm^2.[16] The mechanism of action of LED devices is thought to be the targeted stimulation of fibroblast mitochondrial metabolic activity. In addition, concomitant up-regulation of procollagen and down-regulation of matrix metalloproteinase I have been demonstrated.[17,18] Although there have been no studies on the use of LEDs in the treatment of skin of color, these devices are generally considered safe because of their mechanism of action.

SKIN TIGHTENING

Radio Frequency

Radio frequency (RF) is electromagnetic radiation in the frequency range of 3 kHz to 300 GHz. RF devices induce dermal heating, denature collagen, and induce collagen remodeling. Wound-healing mechanisms promote wound contraction, which ultimately enhances the clinical appearance of skin that is mildly to moderately lax. One RF device, ThermaCool, has been reported to be effective in the treatment of skin laxity involving the periorbital area and jowls.[19] Because RF energy is not dependent on a specific chromophore interaction, epidermal melanin is not targeted, and treatment of all skin types is possible.

Kushikata et al[20] reported the use of RF in a series of 85 Asian patients with Fitzpatrick skin types IV and V and concluded that RF treatment was effective for tightening the facial skin of Asian patients. Although there is a small risk of hyperpigmentation with RF treatments in skin of color, RF offers safe and effective treatment of ethnic skin laxity.

Infrared Tightening

An infrared device, the Titan, uses infrared light to volumetrically heat the dermis. It is designed to thermally induce collagen contraction, with subsequent collagen remodeling and neocollagen synthesis. The epidermis is protected using pretreatment, parallel, and posttreatment cooling. With this device, improvements in skin laxity and facial and neck contours have been achieved. Response rates are variable and can be influenced by patient selection.[21]

Chua et al[22] investigated the effect of infrared light on 21 patients with Fitzpatrick skin types IV and V. At 6-month follow-up, 86% of patients had improvement as measured by the physician assessment. The investigators concluded that the Titan device was effective in achieving gradual, mild to moderate clinical improvement of facial and neck skin laxity. The procedure is associated with minimal downtime and is safe for use in patients with darker skin, including those with Fitzpatrick skin types V and VI.

LASER-ASSISTED HAIR REMOVAL

Laser-assisted hair removal also targets pigment, but the pigment is in the hair follicles, not the skin. The 694-nm ruby was the first laser introduced for laser-assisted hair removal. The light from the laser is highly absorbed by all melanin in the skin, including not only the targeted melanin in the hair follicles but also epidermal melanin. The 755-nm alexandrite and 800- to 1000-nm diode lasers were later introduced for laser hair removal. These lasers have longer wavelengths than the diode, allowing for a larger variety of patients to be treated.

Breadon and Barnes[23] reported on 150 patients with Fitzpatrick skin types IV to VI who were treated with a long-pulsed 755-nm alexandrite laser with a 40-millisecond pulse width. Prior to treating each patient,

a fluence of 16 J/cm^2 was used on a test site. The patient's response was evaluated, and an energy fluence was selected to treat the patient based on his or her response. The authors reported an overall complication rate of 2.7%; however, only 2 patients with Fitzpatrick skin type VI were included in the study, and both patients developed blistering. Nouri et al[24] reported on 4 women with Fitzpatrick skin type VI who were treated with a 755-nm alexandrite laser with a 3-millisecond pulse width. In this study, lower fluences were used (8–14 J/cm^2), and no adverse effects were noted. Although treatment of Fitzpatrick skin types IV to VI is possible with the alexandrite laser, the associated risk is still great.

The diode laser has been studied with greater success in the treatment of darker-skinned patients. The 800-nm diode laser, with pulse widths of 30 milliseconds and 100 milliseconds, was studied. Adrian and Shay[25] reported that although both settings could be used safely, longer pulse widths (eg, 100 milliseconds) allowed higher fluences to be utilized with fewer complications. Greppi[26] evaluated the use of the 810-nm diode laser to treat 8 patients with Fitzpatrick skin types V and VI. These patients were treated with a low fluence of 10 mJ/cm^2 and a pulse width of 30 milliseconds. Transient blistering and pigment alterations were noted in some patients despite the lower fluence. Overall, the diode laser offers increased safety over the alexandrite laser in African American patients. However, complications remain an issue.

The 1064-nm Nd:YAG laser provides safe laser hair removal in patients of all skin types, including Fitzpatrick skin types V and VI. Alster et al[27] reported on 20 patients with Fitzpatrick skin types IV to VI who were treated with a series of 3 laser sessions. The pulse width used was 50 milliseconds, the fluence ranged from 40 to 50 J/cm^2, and a contact sapphire-tip cooling device was used. Adverse events from all 60 treatments included transient pigment alteration (5%) and rare vesiculation (1.5%). Ross et al[28] reported on 37 patients with pseudofolliculitis barbae who were successfully treated with the long-pulsed Nd:YAG laser and experienced few adverse effects.

The long-pulsed Nd:YAG laser is preferred for laser-assisted hair removal in patients with Fitzpatrick skin types IV to VI because of its high safety profile.[29]

SUMMARY

Laser procedures in darker-skinned patients are challenging but can be successfully performed if treatment guidelines are followed. Appropriate discussion of risks and patient expectations is essential in treating this patient population. Pretreatment and posttreatment cooling can be helpful to minimize adverse effects and improve patient comfort. This is especially true with laser hair removal.

Photorejuvenation can be successfully achieved with low risk when the appropriate settings are used. Fractional technology has increased treatment options for rhytides and atrophic scars. Although there are no studies on LED treatment in patients with skin of color, LEDs can be used as either a primary or adjunctive treatment modality with low risk. The 532-nm laser proved to be risky when used to treat patients with skin of color, and conservative guidelines should be followed when using it. On the other hand, some of the 1064-nm lasers may offer greater safety when treating rhytides and acne scars in skin of color. IPL is an option for treating skin of color, although it is advisable to limit its use in patients with Fitzpatrick skin types V and VI. Lastly, newer tightening technologies and RF are safe modalities to treat skin laxity in skin of color.

Test spots are no longer necessary when performing laser hair removal using long-pulsed Nd:YAG lasers since their safety in darker skin types is well established.

When treating darker-skinned patients, the use of conservative settings to achieve desired results is prudent. By following these conservative treatment guidelines, the clinician is likely to achieve favorable results with few adverse effects.

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