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Review Article

Hair removal options in darker skin types through laser innovation and energy-based modalities

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ABSTRACT

The rapid growth of aesthetic dermatology has amplified demand for hair removal among individuals with Fitzpatrick skin types IV-VI. However, traditional laser technologies, developed with lighter phototypes in mind, pose heightened risks of post inflammatory hyperpigmentation, scarring, and paradoxical hair growth in melanin-rich skin. This comprehensive review reconceptualizes the hair removal paradigm in skin of color (SOC) by integrating recent clinical data, histologic insights, and safety profiles across diverse technologies. Using dermal penetration models and comparative energy delivery diagrams, we demonstrate how long-pulsed Nd:YAG (1064 nm) lasers offer deeper follicular targeting with minimal epidermal melanin interaction, establishing them as the preferred modality in darker skin tones. We explore the emergence of melanin-independent radiofrequency (RF) and RF microneedling (RFM) systems, which generate controlled dermal heating without chromophore reliance, expanding their use in pseudofolliculitis barbae and scarring conditions. Topical alternatives like thioglycolates and eflornithine are re-evaluated for their synergistic potential in combination therapies, emphasizing safe regimens supported by evidence-based pre/post-treatment protocols. Importantly, this review addresses the critical gaps in dermatologic curricula, clinical trials, and device safety testing for SOC populations. Through an intersectional lens, we call for the development of Fitzpatrick-stratified laser protocols, standardization of treatment parameters, and inclusion of curl pattern morphology in care planning. By visualizing risk stratification trends, procedural pathways, and Melan in-histology interactions, this review offers a blueprint for delivering inclusive, precision-based cosmetic dermatology to historically underserved communities.

Keywords: Darker skin types, Depilatory agents, Eflornithine, Fitzpatrick skin types IV-VI, Laser hair removal, Radiofrequency microneedling

INTRODUCTION

Aesthetic procedures such as laser hair removal and skin rejuvenation operations are some of the most frequently performed dermatological procedures globally. However, their safety and efficacy are highly variable according to different skin types, and individuals with Fitzpatrick skin types III-VI, who account for a substantial amount of the world's population, are characterized by comparatively higher melanin content. This increased melanin content increases long-lasting risks for complications in patients of color, such as hyperpigmentation, hypopigmentation, blistering, and crust formation, when treated with energy-based devices targeting melanin.[1] This is mainly due to the occurrence of light absorption in the epidermis, where it is transferred into heat energy, instead of the melanin in the hair shaft being targeted originally. Additionally, Lanigan et al reported that the highest incidence of side effects was observed in patients with darker skin upon treatment with the long pulsed ruby laser.[2] This reiterates the importance of selecting laser modalities with higher penetrative abilities and lower melanin affinities, especially in patients with SOC. Ismail et al supported the usage of long pulsed Nd:YAG lasers (1064 nm) for Fitzpatrick types IV to VI due to its longer wavelength and lower absorption by melanin.[3] Additionally, Nd:YAG lasers achieved effective hair reduction with minimal adverse effects in patients with SOC, and remains the most suitable option for permanent hair reduction due to its cooling techniques and spared thermal injuries. These findings altogether deeply emphasize the requirement for tailored laser beam selections, based on Fitzpatrick skin types, to minimize complications and prioritize patient safety and diversity.

In the past few years, there has been a surge in aesthetic procedures among individuals with Fitzpatrick types IV to VI. This trend has been charged by increasing global representation of such procedures, the normalization of cosmetic interventions across different cultures as well as advancing technology ensuring procedural safety, especially on darker skin tones. Buren et al predicted that ethnic and racial minority groups are bound to become the majority by 2045, a trend that is already observed due to the growing volume of patients with SOC in dermatological clinics.[4] This observed demographic shift further accentuates the need for safety in such procedures, that are inclusive of all skin tones. Patients with SOC are now a substantial portion of the aesthetic dermatology industry, having hair removal and skin rejuvenation being among the most in-demand services. Ismail et al compared long-pulsed Nd:YAG laser and IPL hair removal in dark-skinned women, reporting a 79.4% hair reduction and a clear patient preference for the Nd:YAG laser due to its efficiency and safety for colored skin.[3] Similarly, a survey had found increased satisfaction scores with a mean of 84.2 and minimal complications in patients with SOC undergoing Nd:YAG laser hair removal, reinforcing the high demand and better tolerability in populations with SOC. Rao et al also reiterates the high patient satisfaction and minimal reported adverse effects, most commonly on patients with Fitzpatrick type IV.[5] These studies highlight the increased involvement of lasers in addressing aesthetic concerns prevalent in SOC populations, such as pseudofolliculitis barbae, hyperpigmentation, and excess facial hair, conditions that have psychosocial effects due to visibility and negative societal perceptions. With a diversifying cosmetic industry, there are rising demands among SOC patients, indicating an urgent need to transition to culturally competent care and targeted education, with a common aim of advocating for inclusive practices.

Individuals with Fitzpatrick skin types IV to VI have historically been underrepresented in clinical dermatology research and trials, despite the growing demand for cosmetic procedures among patients of color. This exclusion has led to a knowledge gap in understanding the safety and efficacy of aesthetic treatments in SOC, exacerbating health inequalities and limiting the generalizability of published treatment protocols. Jacobs et al reported that among 278 race-specified trials, 69.1% of the participants were white/ Caucasian, while 16.5% were African American/ Black participants, highlighting a systemic bias in participant recruitment.[6] Hereford et al highlighted that dark skin is extremely underrepresented in clinical photographs published in notable journals, such as JAAD and JAMA derm, with 85% of photographs being classified as light skin.[7] Dark skin was represented in 5.6% of JAAD's clinical photographs and 4.1% of JAMA derm's photographs, contributing to lower rates of diagnostic accuracies in patients with SOC. Additionally, dermatology residents have reported to have lower confidence handling patients with SOC, due to a lack of SOC incorporation in lectures, educational resources catered to lighter skin, and in some cases, incorporation of only one type of SOC education into residents' curricula.[8] With a lack of SOC inclusion into trials and medical education, clinicians risk applying flawed knowledge targeted to a single group, to other underrepresented populations lacking published data. Addressing these gaps is vital in reaching equity and inclusivity in cosmetic dermatology.

The global market for aesthetic procedures has expanded, yet patients with darker skin tones remain underrepresented in clinical trials that evaluate device safety and effectiveness. The initial development of laser technologies focused on lighter skin types because they used melanin as a chromophore, which led to higher risks of epidermal injury for patients with SOC skin types.

The development of longer-wavelength lasers (Nd:YAG 1064 nm) together with RF devices and RFM systems provide safer hair removal and skin rejuvenation solutions for these patient groups. The development of optimal treatment protocols continues while clinical evidence faces challenges because research studies fail to consistently include diverse skin types.

This review combines existing data about laser and energy-based and chemical depilation technologies for hair removal and dermatologic concerns in patients with Fitzpatrick skin types III to VI. The review examines the prevalence of aesthetic procedures among patients of color together with their distinctive procedural risks and new methods to reduce adverse effects. The review identifies essential educational and research deficiencies that lead to cosmetic dermatology care disparities while promoting evidence-based, culturally sensitive treatment methods that emphasize safety, effectiveness, and equity.

PATHOPHYSIOLOGIC CONSIDERATIONS IN SKIN OF COLOR

The histological and cellular characteristics of FST IV-VI influence the interaction between laser energy and skin tissue. In FST IV-VI, there is an increased density and distribution of melanin within the basal layer of the epidermis.[9,10] Another distinct histologic characteristic of these skin types is the presence of larger melanosomes that are more dispersed within keratinocytes, which was visually reported with tomographic imaging by Hurbain et al.[9] Furthermore, the literature reviewed in this work demonstrates that the increased melanin density associated with FST IV-VI correlates with higher absorption of laser energy. For example, a narrative review conducted by Soares et al reported that, as a competing chromosphere, melanin absorbs laser energy.[11] Consequently, individuals with FST IV-VI may have a higher risk of thermal damage following laser therapy, as these skin types tend to have larger, widely dispersed melanosomes. This can lead to adverse effects such as alterations in skin texture and pigment, scarring, and blistering of the adjacent skin. Moreover, a review article by Shah et al explored how melanin content can influence the interaction between laser and tissue, particularly in relation to absorption coefficient and laser wavelength.[12] It was found that skin containing higher amounts of melanin absorbs more laser energy than skin with lower amounts of melanin. The study also reported that the absorption capacity of melanin, which is measured by its absorption coefficient, decreases exponentially as laser wavelengths increase.[12] These findings underscore the importance of choosing the correct laser wavelength for melanized skin to ensure desirable outcomes, safety, and low risk of developing adverse effects.

There is also a relationship between melanin-rich skin and fibroblast activity. A study conducted by Shi et al found that the proliferation and migration of fibroblasts and the synthesis of collagen were all significantly promoted by the melanin secreted by melanocytes.[13] A strong positive correlation between melanin and the Keloid Area and Severity Index was also reported. Another pilot study by Shen et al reported that keloids form when melanocytes are active, confirmed with *in vivo* experiments showing that melanocytes in keloids are more active than those in normal scar tissue.[14] It was also found that the exosomes secreted by melanocytes upregulate the transforming growth factor-β/Smads pathway, which helps promote the proliferation of fibroblasts. Due to fibroblast-induced fibrogenesis playing a central role in keloid pathogenesis, individuals with melanin-rich skin types, such as FST IV-VI, are at higher risk for the formation of keloids because of the heightened fibroblast activity.

Hair curl types 4A, 4B, and 4C are commonly seen in individuals of African descent.[15] Type 4A includes tightly coiled, well-defined S-shaped curls, and type 4B is defined by a Z-shaped pattern with less defined curls. These strands are typically densely packed. Type 4C hair presents as the most tightly coiled and fragile. With no defined curl pattern, type 4C is susceptible to breakage and dryness.[15-18] The follicular curvature characteristic of hair curl types 4A, 4B, and 4C plays a significant role in the pathogenesis of pseudofolliculitis barbae and ingrown hairs. As outlined in a study by Ogunbiyi and a literature review by Perry et al the emerging hair shafts in these hair types grow at an angle relative to the surface of the skin.[19,20] As a result, there is a tendency of the coiled hair to curve and re-enter the epidermis instead of growing away from the skin, creating a localized inflammatory response, which can lead to the formation of papules and post-inflammatory hyperpigmentation. In addition, the coiled hair may also curve into the follicular wall before leaving the skin. These processes play a significant role in the development of both pseudofolliculitis barbae and ingrown hairs. Consequently, the follicular curvature of hair curl types 4A, 4B, and 4C contributes to the increased risk of pseudofolliculitis barbae and ingrown hairs.

Table 1: Comparison of melanosome distribution in lightly and moderately pigmented versus highly pigmented skin, outlining the difference in melanosome localization within the epidermis.

Skin pigmentation	Melanosome distribution
Lightly and moderately pigmented	Mainly distributed in the basal layer of the epidermis[9]
Highly pigmented	Widely distributed throughout the entire epidermis, with clusters concentrated in the basal layer of the epidermis[9]

CONVENTIONAL LASER MODALITIES AND LIMITATIONS IN SOC

Lasers to treat the skin operate using selective photothermolysis which acts to cause thermally induced injury of microscopic tissue targets via selective absorption of radiation pulses by the targets and chromophores.[21] In the context of laser hair reduction the target chromophore is melanin within the hair follicle. Light absorption for melanin ranges between 300 and 1200 nm. While various lasers fall within this range, each laser may not be well suited for every patient depending on its mechanism.

The Alexandrite laser (755 nm) has been well documented to cause several unwanted side effects including post inflammatory hyperpigmentation (PIH), scarring and increased pain in darker skin toned patients. In one study, Güdük et al 17.9% of 39 patients with Fitzpatrick skin types III and IV developed PIH after treatment with Alexandrite for solar lentigines.[22] In another study of 150 patients with Fitzpatrick skin types

IV to VI treated with Alexandrite 755 nm lasers with a 40 msec pulse duration, 2.7% experienced complications including PIH, hypopigmentation, blistering and folliculitis. More so, while only 2 patients in this study were Fitzpatrick VI, both developed a blistering reaction post treatment.[23]

Similarly, diode laser (800-810 nm) has well documented risk of primarily PIH within increasing Fitzpatrick skin types. In Fitzpatrick I-II diode lasers are safe and the risk of PIH and scarring is relatively low. Contrarily, in patients with Fitzpatrick IV- VI, the risk of PIH is significantly higher with studies reporting up to 28% of darker skin patients experiencing this adverse effect even when manufacturing protocols are followed.[24] Interestingly, looking at FDA reported complications with lasers, Diode (800-810 nm) had the second highest medical device reports with the most common adverse event being blisters and burns.[25] One group studied Diode 810 nm in 8 patients with Fitzpatrick V and VI and while it should to be efficacious in hair reduction, it was not without complications of transient hyperpigmentation and hypopigmentation even at a lower fluence of 10 mJ/cm^2.[26]

Neodymium-doped yttrium aluminum garnet also known as Nd:YAG laser operates at the 1064 nm wavelength allowing for deeper penetration and less scattering in the skin in comparison to other lasers at shorter wavelengths used for hair removal including Alexandrite and Diode. As a result of its longer wavelength, Nd:YAG lasers have a lower absorption of melanin which contributes to deeper penetration. Nd:YAG penetrates into the dermis at a depth of 5 to 7 mm which extends deeper beyond the location of the hair follicle which resides approximately 2-5 mm into the dermis.[27] This allows for sufficient thermal injury to the hair follicle while limiting injury to the epidermis. In sum, these factors would make Nd:YAG a safer alternative for laser hair removal patients with darker skin types. In addition to efficacy, patients report increased satisfaction with outcomes after treatment with Nd: YAG.[28]

Laser hair removal in patients with darker skin tone presents unique challenges that require extensive analysis of their safety. Amongst the infrared lasers, Nd:YAG has demonstrated the safest profile with less adverse effects given its deeper penetration. Additionally, damage to epidermal melanin can be further minimized by in one study, Rao et al reported that long-pulsed Nd:YAG lasers reported 86% of patients with Fitzpatrick skin types IV to VI had no complications.[29]

MECHANISM AND APPLICATION OF RF AND RFM-BASED DEVICES

RF refers to an oscillation rate of electromagnetic radiation ranging within a range of frequencies spanning from 3 kilohertz up to 300 gigahertz. RF devices function by generating an electrical current within an electromagnetic field, converting the energy to heat due to skin tissue resistance. Dissimilar to lasers, which rely on melanin as a chromophore to absorb light, RF modalities depend on the internal impedance or resistance of the tissue to transfer energy.

Distinct types of RF devices exist, including monopolar, bipolar, and fractional RF, which differ based on electrode configurations. Monopolar devices use a singular electrode to deliver energy, which allows for better penetration into the dermis.

Contrarily, bipolar devices employ a second electrode, allowing for more approximated superficial delivery of energy.[30] Fractional devices utilize similar RF energy in addition to microneedles. RFM is a minimally invasive treatment that operates by causing small penetrations into the epidermis while simultaneously delivering RF into the dermis.[31] The depth of penetration is adjustable and dependent on the length of needle penetration, which can range from as low as 0.5 mm on the face to 8 mm for some areas on the body.[32,33] In addition to the mechanical trauma, the heat generated creates focal microscopic thermal zones in the dermis, which together result in denaturation of the collagen, fibroblast activation, angiogenesis, and granulation tissue development. Over time, this promotes skin remodeling via the formation of new collagen and elastin in the dermis, resulting in a tighter, smoother appearance of the skin.[33]

Several studies have reported the successful use of RF for hair removal, particularly in combination with intense pulsed light. Garden et al studied the use of bipolar RF with IPL in 94 patients, of whom 20 were Fitzpatrick IV and 14 made up Fitzpatrick V and VI. The bipolar RF operated at 6.78 MHz, and the IPL operated at wavelengths of 550 to 1200 nm, emitting single pulses at 2 to 4 J/cm^2 depending on patient tolerability for hair removal of the axilla, lower back, leg, forearm, nape of neck, sideburns, jawline, upper lip, and chin. The results showed immediate post-treatment transient erythema (4.6%), edema (1%), and pruritus (1%) without any reports of PIH, scarring, or other side effects.

In another study, Garden et al analyzed use of a combined RF/IPL device in a small subset of 8 patients who were Fitzpatrick IV-VI.[34] Patients divided into maintenance groups who received additional monthly treatment after initial hair removal vs. no maintenance. Hair reduction at 6 and 12 months for the maintenance group was 56% and 52%, respectively, while the non-maintenance group had 47% and 37% hair reduction, respectively. Notably, transient erythema was only adverse effect reported.[34]

Interestingly, several studies indicate that RF modalities are generally well tolerated by patients, with no studies indicating pain levels that led to discontinuation of treatment, but further research is needed to quantify pain scores.

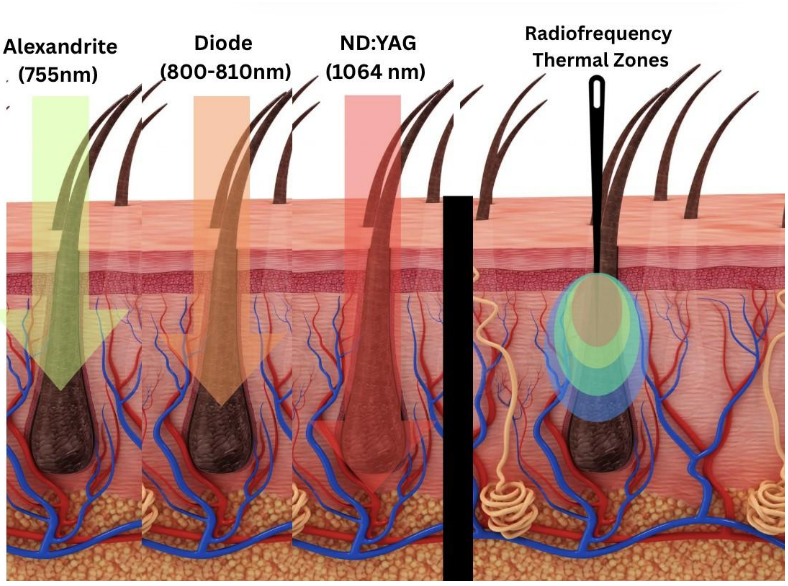

Figure 1: Alexandrite, diode and Nd: YAG lasers penetrating into the dermis layer of the skin (From left to right). RF thermal zones depicting areas of tissue that are heated and destroyed using RF energy.

TREATMENT OF PSEUDOFOLLICULITIS BARBAE AND RECURRENT INGROWN HAIRS

While laser therapy is not the first-line treatment for pseudofolliculitis barbae (PFB), it is the only definitive treatment. Prevention strategies and symptom management such as modifying shaving habits, and reducing inflammation, hyperpigmentation, and keloid scarring are prioritized. In acute cases of PFB, cessation of shaving is often recommended with the use of mild chemical peels or azelaic acid to reduce hyperpigmentation.[19] This is because the PFB is caused by a flare which can easily be resolved without significant medical intervention. In severe cases of PFB or instances where patients cannot stop shaving, corticosteroids and antibiotics are used to suppress the immune system and clear bacteria, usually *Staphylococcus aureus*.[19] The lasers are utilized when these medications still do not help resolve the PFB. Figure 1 highlights the treatment paths taken to treat PFB.

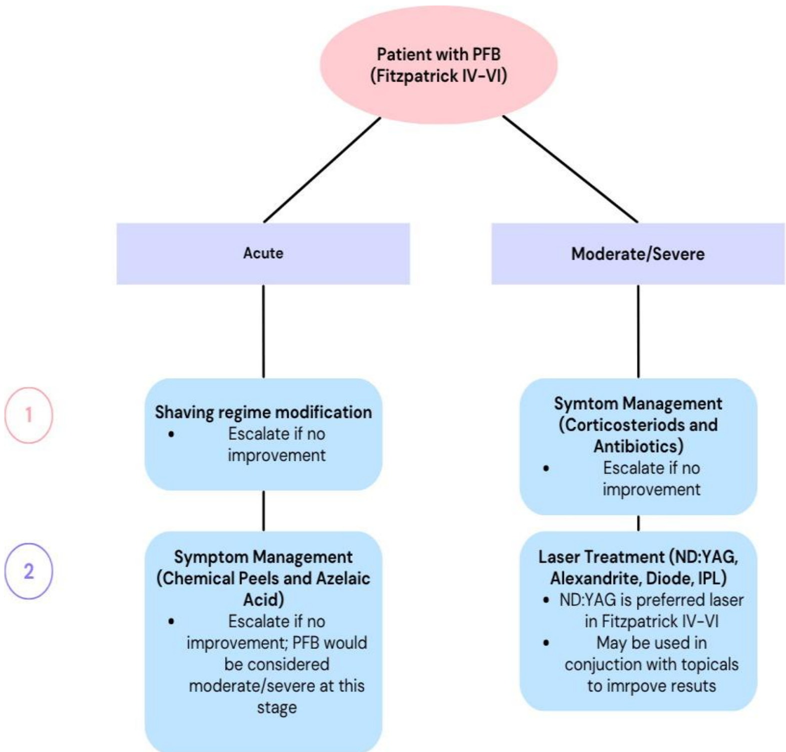

Figure 2: Treatment options in pseudofolliculitis barbae.

Laser treatments are beneficial to manage PFB however use in skin of color must be considered. Laser treatments such as Alexandrite and Diode often lead to post-treatment complications in Fitzpatrick IV-VI patients due to the high melanin concentration in the hair bulb. A split-face study with 30 patients comparing Alexandrite and intense pulse light found that three patients experienced post-inflammatory hyperpigmentation and all three patients had Fitzpatrick skin type IV.[35] Due to this long-pulsed neodymium:yttrium-aluminum-garnet laser (Nd:YAG) is often the preferred laser, but its efficacy in PFB is still being investigated. Shokeir et al evaluated the efficacy of Nd:YAG laser alone, eflornithine cream alone, and the combination of the two treatments.[36] Forty-five patients with Fitzpatrick skin types IV-V participated, however, 5 cases were dropped. There was a significant decrease in the number of inflammatory papules at 16 weeks of treatment in all treatment groups, with a combination of laser therapy and eflornithine showing the greatest improvement; however, there appeared to be a recurrence by 12 weeks post-treatment. Despite the recurrence, it was not nearly as severe as when the participants started the study. This indicates that continuous maintenance treatment is required in order to retain the results seen around 16 weeks of treatment.

Similar results were achieved in the Xia et al study. This was a split neck study with 27 participants (24 were African-American), where on one side of the neck, the Nd:YAG laser was used with eflornithine cream between treatments, and on the other side both the Nd:YAG laser and a placebo cream were used.[37] Both sides showed a significant decline in the number of inflammatory papules and ingrown hairs, with Nd:YAG showing a median decline of 85%, and Nd:YAG plus eflornithine cream showing a median decline of 99%.[37] These studies highlight the benefits of the use of the Nd:YAG laser in Fitzpatrick skin types IV-VI in eliminating the PFB while simultaneously reducing post-treatment complications such as hyperpigmentation, scarring, etc. Individualizing treatment based on skin type and hair curl pattern is vital to effectively treat a condition and also reduce undue psychological stress accompanied by the condition itself, as well as complications arising from treatment.

DEPILATORY AGENTS AND TOPICAL ALTERNATIVES IN SOC

Thioglycolates and eflornithine are topical agents that serve as great alternatives to laser and RF devices, especially for patients with Fitzpatrick skin types IV-VI who are more prone to post-inflammatory hyperpigmentation, scarring, and pseudofolliculitis barbae. Unlike lasers, which are usually melanin dependent, these topical treatments work independently of melanin, therefore lowering the risk of pigment alteration after procedures. However, despite their pigment-sparing mechanism of action, both thioglycolates and eflornithine can still cause local irritation, contact dermatitis, or sensitivity reactions, especially in patients who have a compromised skin barrier or are utilizing a stronger formulated product.[38] This makes patch testing alongside pre- and post-treatment care essential for reducing unwanted side effects, as thioglycolate products are sold over the counter and can be seen as low risk.

Thioglycolate-based depilatories chemically degrade disulfide bonds found in keratin in order to weaken the hair shaft. This method is commonly used by African American men with PFB in order to reduce skin trauma caused by shaving. In a randomized control study of 73 Black men, different depilatory formulations were compared to razor shaving. In composition 2, a powder-based thioglycolate paste that required mixing resulted in the highest incidence of irritant contact dermatitis (ICD), with 8/35 participants developing significant skin irritation. However, this was attributed to user error due to variability in concentration and application. In contrast, composition 3, a cream-based thioglycolate depilatory, was better tolerated, where only 1/28 participants developed mild ICD. Despite the differences between compositions, participants preferred the depilatory-treated side in comparison to the shaved side due to its smoother texture as well as reduced bumps.[39] When application is done and composition is chosen correctly, thioglycolate depilatories seem to be a viable alternative, especially for those wanting to avoid the negative side effects associated with shaving.

Eflornithine hydrochloride 13.9% cream does not remove hair like thioglycolate depilatories but slows hair growth over time. It works by inhibiting the enzyme ornithine decarboxylase, which is required for polyamine synthesis-a process that is essential for rapidly dividing hair follicle cells.[40] Eflornithine extends the telogen phase of the hair cycle, eventually reducing the rate of hair growth. In a randomized comparative study, 45 male patients with PFB were divided into three groups: eflornithine alone, ND-YAG laser alone, and a combination of the two. 12 patients with Fitzpatrick skin types IV-V were treated with eflornithine alone over 16 weeks, applying the cream twice a day. They were instructed to apply the cream twice a day in a thin layer on the neck. The cream alone had significantly reduced inflammatory papules found in PFB, with noticeable improvement beginning at week 4. By week 16, all 12 participants reported a very good satisfaction, and only two experienced mild inflammation during treatment but no other pigmentary changes were observed. Although recurrence occurred at 12 weeks after stopping treatment, symptoms still were better than baseline levels.[41] No pigmentary changes or long lasting inflammation being observed is very important as it suggests eflornithine is tolerated well within skin of color. Another randomized trial focused on women with idiopathic facial hirsutism, comparing intense pulsed light (IPL) both with and without eflornithine. The study emphasized combination therapy of both IPL and eflornithine as this group saw a greater reduction in hair (90.44%) over the course of 6 months, where eflornithine was applied twice a day and one IPL session per month compared to IPL only.[41] The enhanced response of the combination therapy can also help further reduce the number of laser sessions needed for patients, which can be efficient for patients who may not be able to afford all treatments.

When compared to laser and RF treatments, topical treatments are generally a safer alternative for patients with skin of color. Since these treatments are not melanin dependent, there is lower risk of PIH or inflammation. While lasers such as Nd:YAG are considered safer than Alexandrite or Diode lasers, adverse effects can still occur given improper settings.[42]

Chemical depilatories and topical treatments are more accessible and affordable. Thioglycolates are available over the counter, and although eflornithine needs a prescription, both treatments can be done at home without in-office treatments. However, effects of topical treatments are less pronounced in comparison to laser treatments.

Thioglycolates only remove hair temporarily, therefore requiring frequent reapplication whereas lasers offer longer-lasting results with fewer sessions. As mentioned previously, combining lasers with eflornithine can help enhance treatment outcomes, increasing hair reduction than either treatment alone.

Table 2: Methodology and safety of various hair removal procedures.

Methods	Duration	Mechanism	Safety in skin of color
Thioglycolates	Every 2-3 days	Breaks disulfide bonds in keratin to dissolve hair shaft	Generally safe: risk of irritation with stronger formulations[38,39]
Eflornithine	Twice daily	Inhibits ornithine ecarboxylase to slow hair growth[40]	Generally safe: very low risk of PIH [40,41]
Nd:YAG laser	4-6 weeks	Melanin absorbs light-photothermolysis	Relatively safe: PIH risk[37,41,42]
Alexandrite/ diode lasers	4-6 weeks	Melanin absorption	Moderately safe: risk of PIH/ scarring[42]
RF	4-6 weeks	Delivers thermal energy to the dermis to remodel tissue	Generally safe: low risk of PIH[34,42]

TREATMENT OPTIMIZATION AND PROTOCOL DEVELOPMENT FOR DARKER SKIN

Post-inflammatory hyperpigmentation is most frequently observed in Fitzpatrick skin types IV-VI, with the highest incidence in type VI. Hypopigmentation is uncommon across all skin types but may occasionally occur in type VI with aggressive treatment parameters.

Erythema is a common and expected side effect in all skin types, though it may persist longer in the darker phototypes.

Absence of complications is frequently reported when appropriate laser settings and cooling techniques are used; Nd:YAG lasers demonstrate the safest profile for darker skin types.

Table 3: Laser and light-based device parameters.

Device type	Fluence (J/cm²)	Pulse width (ms)	Spot size (mm)	Cooling protocol
1450-nm diode laser (Smoothbeam)	12.5	210	6	Dynamic cooling device (cryogen spray)[43-45]
Long-pulse alexandrite laser (755 nm)	Not specified (pre-test ed)	3	18	Dynamic cooling spray+air cooling[44,46]
1320-nm Nd:YAG laser	14-18	10-30	5-7	Cryogen or contact cooling[44,47,48]
1550-nm Er:Glass laser	Varies, avg. 10-40	Short fractional microthe rmal zones	Not clearly defined	Integrated cooling or post-treatment cooling gels[48]
IPL (Filtered)	10-24	10-30	8-12	Sapphire contact cooling or chilled gels [46,48,49]

Table 4: Fitzpatrick-type stratified complication trends.

Fitzpatrick type	Hyperpigmentation	Hypopigmentation	Erythema	No complications
Type I-III	Rare, <5%	Very rare	Common but mild (transient)	High percentage, most tolerate well[46,48]
Type IV	Occasional (5-15%), especially diode/IPL	Rare (<5%)	Moderate (10-20%), transient	Majority tolerate well with adjusted settings [43,48-50]

Continued.

Fitzpatrick type	Hyperpigmentation	Hypopigmentation	Erythema	No complications
Type V	Moderate risk (15-30%), esp. with 1450 nm	Occasional (<10%)	Moderate (15-25%), usually resolves	Often no permanent issues if parameters optimized[43,44,48]
Type VI	High risk (25-40%), sp. with high fluence	Slightly higher (5-10%)	Common (20-40%), more persistent	Requires cautious parameter selection [43,47,48]

Table 5: Chemical peels for Fitzpatrick IV–VI.

Category	Evidence-based recommendation
Patient criteria	FST IV-VI, age ≥18, no active dermatoses, keloids, herpes simplex, pregnancy, or isotretinoin use (within 6 months).[50-54]
Pre-peel prep	Stop retinoids 1 week before. Start SPF 30+ and moisturizer daily. Optional: 2–4 weeks of priming with hydroquinone, tretinoin, or glycolic acid for high PIH risk.[52-54]
Peel selection	FST IV: Glycolic 20-30%, salicylic 20%[52-54] FST V: Lactic 10-20%, glycolic 20%[52-54] FST VI: Mandelic 10-15%, lactic 10%[52-54]
Application and fluence	Apply evenly for 2-5 minutes. Avoid rubbing/overlapping. Stop at tingling, erythema, or pseudo-frost (for salicylic acid). Neutralize if needed (e.g., with sodium bicarbonate).[53,54]
Session spacing	Every 4-6 weeks. Wait for complete skin recovery before the next session[52-54]
Maximum sessions	Up to 6 sessions per year to reduce cumulative exposure and PIH risk.[53,54]
Post-peel care	Use bland emollient, avoid sun, apply SPF 30+ daily. Wait 5-7 days before restarting active topicals. Monitor for signs of PIH or irritation.[52-54]
Monitor and adjust	If PIH or erythema occurs, lower acid strength, increase spacing, or pause treatment. Always tailor to patient response.[52-54]

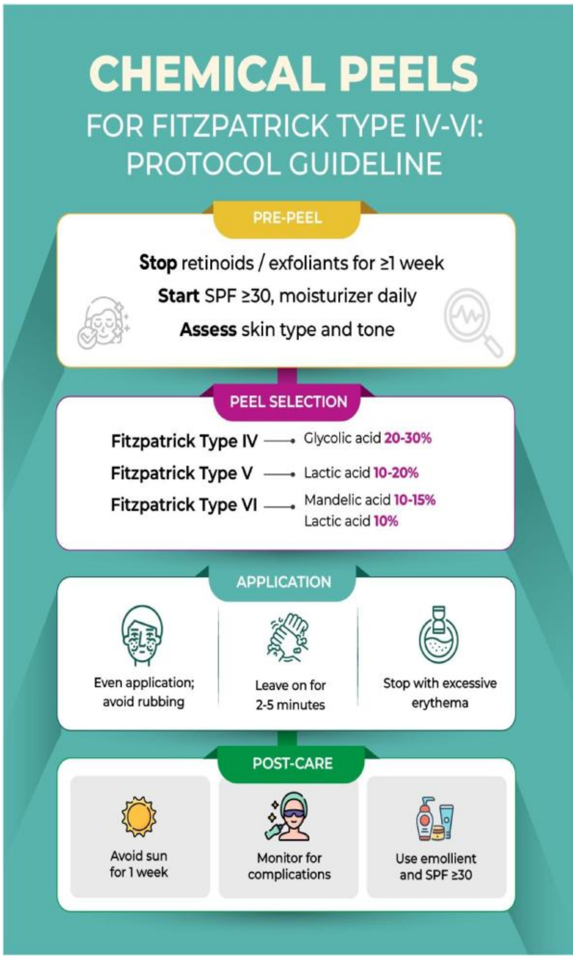

Figure 3: Chemical peels for Fitzpatrick type IV-VI: protocol guideline.

CONCLUSION

Patients with SOC, particularly patients with Fitzpatrick skin types IV to VI, are at an increased risk of PIH, thermal injury, and other scarring complications following laser hair removal and other energy-based technologies. These individuals have widely dispersed melanosomes in their skin and increased fibroblast activity, which result in greater laser absorption. SOC patients also often have hair types 4A-4C, which further increases the risk of pseudofolliculitis barbae and related ingrown hairs conditions due to the tightly coiled hair structure. Long pulsed Nd:YAG lasers remain the preferred modality for delivering consistent, safe and effective hair removal in SOC due to their longer wavelength that minimizes epidermal melanin absorption.

RF and RFM devices also demonstrate minimal epidermal melanin interaction and offer a safe adjunctive option for pseudofolliculitis barbae management. Combination therapies with chemical depilatories such as thioglycolates and medications such as eflornithine can offer well tolerated outcomes when properly selected and performed, though data is limited.

A major challenge in providing individualized laser treatments and care for scarring disorders in SOC lies in the lack of long-term and inclusive clinical trials that examine laser treatment parameters and safety outcomes. Quantitative studies on SOC are needed to guide clinicians in refining laser device selection and moving away from reliance on expert opinion, which is often anecdotal. Sparse SOC representation in clinical research hinders the creation of a standardized laser treatment protocol, which only heightens the risk of ineffective or even harmful outcomes for these patients.

It is essential to prioritize the development of a standardized Fitzpatrick stratified laser safety protocol that is grounded in quantitative, evidence-based and inclusive research. SOC-specific protocols and training are crucial to equip clinicians to provide confident, competent and safe care for all skin types.

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