The Role of Sunscreen in Melasma and Postinflammatory Hyperpigmentation

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Abstract
Photosensitive conditions such as melasma and postinflammatory hyperpigmentation (PIH) are exacerbated by exposure to ultraviolet (UV) rays and visible light making sunscreen use an essential component of treatment. This is especially true in skin of color patients who are less likely to use photoprotection, even if diagnosed with these photoexacerbated conditions. We aimed to evaluate the body of literature to provide evidence for the use of sunscreen in the treatment of melasma and PIH. We reviewed English articles from PubMed, Journals@Ovid Full Text, and Embase using the search terms “sunscreen” and either “melasma” “PIH,” or “post-inflammatory hyperpigmentation.” Nine relevant publications provide evidence that a broad spectrum of protection, including UVA, UVB, and visible light within sunscreens can play an adjuvant role in therapy for melasma and PIH by stabilizing and improving these pigmentary disorders in skin of color patients. This review illustrates the advantages and limitations of sunscreen use, as well as practice gaps in photoprotection in the skin of color patients with melasma and PIH.

Key Words: Melasma, postinflammatory hyperpigmentation, sunscreen, ultraviolet light, visible light

Introduction
Pigmentary disorders, such as melasma and postinflammatory hyperpigmentation (PIH), involve an increase in melanin production in response to multiple factors. The hyperpigmentation that develops can have a profound impact on the quality of life in these patients, especially when exposed areas, such as the face, are involved.¹ It is estimated that the disorders of pigmentation are the 11th most common condition seen by dermatologists, with approximately 24.7 million dermatology visits made between 1994 and 2010 for the management of dyschromias.¹,²

A search of the National Ambulatory Medical Care Survey by Kang et al. found that photoprotection was the tenth most common treatment option prescribed to Asians and the sixth for African Americans as compared to the third most common in Caucasians for the treatment of dyschromia.³ This discrepancy highlights the lack of awareness regarding the use of photoprotection in certain populations who are also more vulnerable to these changes. In melanocompetent individuals, the higher melanin content and more responsive melanosomes lead to a greater risk of hyperpigmentation, which is often more prominent and longer lasting when compared to lighter-skinned individuals.¹,⁴ These factors, in combination with others, manifest as varying incidences of melasma in susceptible individuals around the world: 1.8% in Ethiopia, 3.4% in Beirut, 8.8% in Dallas, TX, USA, and 10.1% in Peru.⁵ Here, we review the literature on sunscreen use in melasma and PIH in skin of color patients to illustrate the importance of photoprotection in the management of these pigmentary disorders.

Materials and Methods
A review was performed by searching the PubMed, Journals@Ovid Full Text, and Embase databases for studies published in English using the keywords “sunscreen” and either “melasma,” “PIH,” or “post-inflammatory hyperpigmentation.” Inclusion criteria included a study population in skin of color patients. Study methods were analyzed and the reproducibility of the studies was graded. Outcome measures varied from study to study.
and included colorimetric measurements, self-evaluation, Melasma Area and Severity Index (MASI) scores, and mexametry.

Results
Nine publications detailing results from over 600 patients were critically analyzed for the use of sunscreen in melasma and PIH. The results were classified as educational awareness and practices regarding photoprotection or trials comparing the effectiveness of sunscreen in skin of color patients.

Education and practices of photoprotection
One of the challenges in treating pigmentary disorders is the lack of education regarding sun protection and noncompliance with photoprotection, especially in skin of color patients. African-Americans are significantly less likely to use sunscreen compared to other races (odds ratio = 0.49, $P < 0.045$) despite their increased propensity for developing pigmentary disorders. This trend persists across the globe. von Schirnding et al. estimated that only 50% of beachgoers in Cape Town, South Africa, used sunscreen.[6] In Brazil, a survey of 109 pregnant women revealed that 27% of women used sunscreen daily. When asked why they did not use sunscreen, almost 70% stated a lack of habit as their reason.[7] Even more concerning, especially for dermatologists, was that only 35% of these women were counseled regarding the risks of sun exposure.[7] This represents a gap in communication between physician and patient that, if addressed, could help stabilize and possibly improve melasma and PIH as well as other photoexacerbated conditions.

Improved communication regarding photoprotection is especially necessary in patients who suffer from pigmentary disorders. In a survey of over 300 Indian patients with melasma, only 35% used sunscreen and only 10% used a sun protection factor (SPF) >50.[6] A discrepancy even exists among those with melasma and PIH. Maymone et al. found that those with melasma were 6.7 times more likely to use sunscreen as compared to patients with PIH.[5] This may be because patients with melasma are more likely to cite the Sun as a cause of their condition.[9] These studies underscore the limited awareness and the use of photoprotection in skin of color patients. Increased efforts by dermatologists must be made to educate and actively engage patients on sunscreen use in the management of these disorders.

Melasma
Melasma is a pigmentary disorder that presents as sharply demarcated brown-to-gray macules, with a predilection for sun-exposed areas.[10] Although the pathogenesis of melasma is multifactorial, estrogen is considered a key element, as pregnancy is known to trigger melasma.[11] During pregnancy, hydroquinone, a popular treatment for melasma, is not recommended due to its high absorption and possible adverse effects on the fetus.[12] In lieu of hydroquinone, sunscreen is a safer option. This was studied by Lakhdar et al. in 185 Moroccan women who were >3 months pregnant.[13] Women applied a broad-spectrum SPF 50+, ultraviolet (UV) A-protection factor 28 sunscreen containing drometrizole trisiloxane, terephthalylidene dicamphor sulfonic acid, octocrylene, titanium dioxide, and butyl methoxy dibenzoylmethane every 2 h [Table 1].[6,9,13-19] Changes in pigmentation were assessed by colorimetry and self-evaluation over three visits during a 12-month study.[13] With regular application of sunscreen, only five new cases of melasma (2.7%) occurred.[11] This is in comparison to an incidence of 53% observed in a previous study performed by the same investigators under similar conditions (same time frame and region). Furthermore, eight of 12 participants with preexisting melasma saw marked improvement.[13] Colorimetric data showed that the degree of epidermal pigmentation decreased or remained stable in 79% of the participants.[13] The authors concluded that sunscreen was effective at preventing the development of melasma, although this study was limited by the lack of a control group.[13]

With regard to sunscreen use in currently existing melasma, Ahmed et al. compared the efficacy of Polypodium leucotomos extract, an oral antioxidant, and a broad spectrum topical sunscreen versus the sunscreen alone in 33 Hispanic women in a randomized, double-blinded trial. The primary end-point was a change in the melanin index between pigmented and normal skin as assessed by a narrowband reflectance spectrophotometer over the course of 12 weeks. The group with oral Polypodium leucotomos extract resulted in a 28.8% improvement and the group that simply used sunscreen resulted in a 13.8% improvement in the melanin index. Although both results were statistically significant in improving pigmentation, the difference between the two treatments was not significant. This study concluded that sunscreen can improve melasma and that oral antioxidants may also have a role in preventing photoexacerbation of melasma [Table 1].[14]

Recent studies by Mahmoud et al. and Kohli et al. show that visible light (VL) also induces pigmentation. VL acts synergistically with minimal amounts of UVA1 to produce greater pigmenatry changes.[20,21] Specifically in melasma, shorter wavelengths of VL (415 nm) lead to greater pigmentation than longer wavelengths (630 nm).[22] Castanedo-Cazares et al. conducted a study assessing the efficacy of sunscreen in treating melasma when its spectrum of protection included VL.[15] In total, 61 participants were treated with 4% hydroquinone and one of two types of sunscreen over 8 weeks.[15] The primary end-point of change in pigmentation was assessed using MASI scores.[15] One group of participants
### Table 1: Characteristics of included studies on melasma and postinflammatory hyperpigmentation

| Study                                | Objective                                                                 | Participants                          | Results                                                                                                                                  | Conclusion                                                                 | LOE* |
|--------------------------------------|---------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|
| Von Schirnding et al. 1991[6]        | Determine sunbathing practices of beachgoers at 3 Cape Peninsula beaches in South Africa | 231 adult beachgoers                  | 50% of respondents were wearing sunscreen on the day of the interview                                                                  | Major effort is needed to improve sun protection behaviors in South Africa | III  |
| Purim and Avelar 2012[7]              | Evaluate habits of photoprotection among pregnant women in Brazil         | 109 pregnant women                    | 80% were exposed to 1–2 h of sunlight, and of those, 72% did not apply any sunscreen. Only 34% reported a discussion of the risks of sun exposure | These women were exposed to the sun without proper guidance or photoprotection | III  |
| Krupa Shankar et al. 2014[8]         | Investigate the epidemiology of melasma in India                         | 331 patients with melasma             | 35% were using sunscreen and only 10% were using sunscreen with SPF >50                                                                | Sun exposure can precipitate melasma, but the majority of people do not use sunscreen | III  |
| Maymone et al. 2017[9]               | Examine photoprotective behaviors in patients with pigmentary disorders  | 404 adults with disorders of hyperpigmentation | The odds of a patient with melasma versus PIH using sunscreen were 6.7 times (P<0.001). The OR of sunscreen use among African–Americans compared to whites was 0.31 (P=0.008) | Patients with PIH, men, and those with disease under 1 year had lower sunscreen usage | III  |
| Lakhdar et al. 2007[13]              | Evaluating the effectiveness of sunscreen in the prevention of melasma    | 185 Moroccan women <3 months pregnant | Incidence of melasma was 2.7% in sunscreen users compared to 53% in the general population                                             | Sunscreen was effective in preventing the development of melasma            | I    |
| Ahmed et al. 2013[14]                | Comparing improvement in melanin index after treatment with PLE versus a broad spectrum sunscreen | 33 Hispanic women in Texas            | Oral PLE led to a 28.8% improvement in melanin index versus 13.8% in sunscreen                                                        | Oral PLE is not significantly better than sunscreen application, though both caused significant improvement | I    |
| Castanedo-Cazares et al. 2014[15]    | Assessing the efficacy of sunscreen containing VL and UV protection versus UV protection only | 61 women in San Luis Potosí, México   | A 75% reduction in MASI score in the UV-VL group versus 60% in UV group. This difference was also supported by colorimetric and histologic data | Sunscreen including VL coverage offers increased protection against melasma | I    |
| Guevara and Pandya 2003[16]          | Comparing a UV only sunscreen against a hydroquinone and sunscreen-containing cream | 35 Hispanic women                     | 15 of the 20 women with hydroquinone plus sunscreen improved compared to 2 of the 15 on sunscreen alone based on mexametry         | Treatment with hydroquinone offers better outcomes when compared to sunscreen alone in treatment of melasma | I    |

Contd...
received a 50+ SPF product containing drometrizole trisiloxane (Mexoryl SX, XL, L’Oreal, Clichy Cedex, France), titanium dioxide, octocrylene, Tinosorb S, avobenzone, and ethylhexyl triazone, while the second group received an SPF 60 product, which included benzophenone-3, octinoxate, octocrylene, titanium dioxide, zinc oxide, and iron oxide as active ingredients that protected against both UV and VL.\textsuperscript{[23,24]} The study showed a 75% reduction in MASI score in the UV + VL sunscreen group compared to a 60% reduction in the UV sunscreen group, which was statistically significant.\textsuperscript{[15]} There was also a significant improvement in lightness values and a greater decrease in melanin content based on histology in those applying UV + VL sunscreen when compared to the UV only sunscreen group. This reinforces the role of VL in inducing hyperpigmentation and the utility of sunscreens with VL and long wavelength UVA1 protection due to the synergism of VL with UVA1 to induce pigmentation [Table 1].\textsuperscript{[15,21]}

Other studies have looked at combination therapies versus sunscreen alone. In one study, 35 Hispanic women with Fitzpatrick Skin Types III–IV were followed over 12 weeks, with a 2:1 ratio of women using the study cream (10% glycolic acid, 4% hydroquinone, Vitamins C and E, and sunscreen containing octocrylene, oxybenzone, and avobenzone) versus a sunscreen alone with the same filters as those included in the sunscreen used in the study cream.\textsuperscript{[16]} Of note, the sunscreen used in this study does not protect against VL, which is reflective of the infrequent use of VL filters in broadly available sunscreens. The results of the study were scored by MASI and mexameter measurements over the course of four visits.\textsuperscript{[16]} Mexameter estimates the melanin and hemoglobin content of the skin, which corresponds to pigmentation and erythema, respectively.\textsuperscript{[25]} Mexameter results showed that 15 of 20 participants on the study cream improved, while only two out of 15 participants improved with sunscreen alone [Table 1].\textsuperscript{[16]} This study found that UV-only sunscreen played a role in improving melasma, but combination treatment was more efficacious. A limitation of this study was the use of a UV-only sunscreen as opposed to UV + VL, which did not represent the full scope of protection offered by available sunscreens.

The treatment of melasma is complex; there are numerous creams, depigmenting agents, and procedures available. Photoprotection, especially the regular use of a UV + VL broad-spectrum sunscreen, plays an important role as an adjuvant treatment in the prevention and treatment of melasma. In pregnant patients, sunscreen may be the only therapeutic option available, making it important to educate patients regarding the effects of sun exposure and appropriate broad-spectrum photoprotection.

**Table 1: Contd...**

| Study                              | Objective                                                                                                                                                                                                                                                                                                                                 | Participants                                                                 | Results                                                                                                                                                                                                 | Conclusion                                                                 | LOE* |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|
| Wanitphakdeedecha et al. 2014\textsuperscript{[17]} | Determining whether a broad-spectrum sunscreen on the 1st day of fractional CO2 laser reduces the incidence of postlaser PIH                                                                                                                                                    | A statistically significant difference in melanin index at 1 week: 230.77 (control) versus 197.98 (sunscreen) | The use of sunscreen on the 1\textsuperscript{st} day after ablative fractional laser reduces the incidence of PIH at 1 week                                                                                     | I                                                                                                            |      |
| Halder et al. 2015\textsuperscript{[18]} | Studying the effect of sunscreen use on preexisting pigmentation in skin of color                                                                                                                                                                                                                                                       | 89 African and Hispanic women                                                                                           | Chromameter measurements showed decreased intensity of hyperpigmented macules in 81% of patients, decreased number of macules in 59% of the patients, and overall lightening of skin in 85% of patients | Preexisting hyperpigmentation improved over 8 weeks with the regular application of sunscreen | I    |
Postinflammatory hyperpigmentation

PIH is a reactive hypermelanosis, more commonly found in skin types IV–VI, which occurs in response to inflammation caused by numerous stimuli, such as acne, radiation. Exposure to UV rays and VL can induce an inflammatory response stimulating melanocytes through mediators, such as reactive oxygen species, resulting in exacerbation of preexisting hyperpigmentation. There is even a difference in how certain skin types respond to UV light, as darker-skinned individuals experience greater pigmentation with UVA as opposed to fairer-skinned individuals. Despite the prevalence of PIH among patients in darker skin and the acceptance of sunscreen as a treatment modality, there are relatively a few studies comparing the efficacy of sunscreen to other therapeutic options. One study addressed this by comparing the unprotected minimal pigmenting dose (MPDu) and the protected minimal pigmenting dose (MPDp) after 7 days of UV exposure in 10 individuals wearing differing concentrations of terephthalyldiene dicamphor sulfonic acid (TDSA). With stronger concentrations of TDSA, there was a greater difference between the MPDp/MPDu means, ranging from 6 with TDSA 2% to 12.5 with TDSA 8%. By combining TDSA and drometrizole trisiloxane (DT), synergistic effects are also observed as 2% TDSA and DT offer an MPDp/MPDu mean of 7.4 compared to 6.4 and 4.3 for TDSA 4% and DT 4%, respectively. Both TDSA and DT are broad-spectrum UVA and UVB filters that are effective in preventing pigmentation, more so, in combination. However, some controversies exist with sunscreen use in darker-skinned individuals as sunscreen use may prevent adequate Vitamin D absorption. To address this, the American Academy of Dermatology recommends a daily dose of 1000 IU of vitamin D in high-risk patients.

PIH is a common concern following laser-based therapy. Patients undergoing procedures that can induce PIH, such as laser-based therapies, are often told to apply sunscreen regularly for several weeks prior to the procedure and to avoid sun exposure. This is to help prevent hyperpigmentation that normally presents 7-14 days after laser treatment and can last up to 6 weeks. A study to assess sunscreen use after ablative fractional CO₂ resurfacing was performed in 26 patients with skin prototype IV. After their procedure, they were instructed to treat one side of their face with petrolatum ointment four times a day and the other side with petrolatum ointment and a broad-spectrum sunscreen (Eucerin Sun Fluid SPF 50+, Beiersdorf, Germany). The sunscreen side demonstrated a significantly lower melanin index 1 week after laser treatment as compared to the control side. This study demonstrates the value in sunscreen application in decreasing the formation of PIH after fractional skin resurfacing.

With respect to the effects of sunscreen use on existing PIH, Halder et al. conducted a study with 89 African–American and Hispanic individuals to assess if daily sunscreen usage leads to improvement in the skin, measured by objective and subjective means. Photographs of the hands and face, as well as chromameter readings, were used as assessment tools. The participants were randomized to receive either an SPF 30 or 60 sunscreen applied daily over 8 weeks during the summer. The results showed lightening of preexisting hyperpigmented macules in 81% of patients, a decrease in the number of macules in 59% of patients, and an overall skin lightening in 85% of patients by week 8 (Table 1). Furthermore, those using the SPF 60 sunscreen showed greater improvements in overall skin lightening and the number of macules compared to the SPF 30 sunscreen patients. The results demonstrate that sunscreen use can improve outcomes in PIH and that higher SPF sunscreens may be more effective. The study concluded that regular sunscreen use improved dyschromia and lightened skin in patients with darker skin, although the lack of a control was a limiting factor of this study.

PIH is common in individuals with darker skin. Although the use of sunscreen is accepted as part of PIH treatment, there are relatively a few studies in the literature that directly assess its efficacy in skin of color patients, especially sunscreens that offer UV + VL coverage. Large, randomized controlled studies are warranted.

Conclusion

Disorders of hyperpigmentation, including melasma and PIH, significantly impact self-esteem and the quality of life for many patients, especially individuals with skin of color. Patients often report feelings of embarrassment and self-consciousness, causing them to avoid social interactions and change their clothing choices, leading to an overall poor emotional well-being. To prevent these psychosocial sequelae, it is important to optimize treatment for these patients. Sunscreen with both UV + VL protection is an important adjuvant therapy to prevent the exacerbation of hyperpigmentation and to improve the appearance of these conditions. Furthermore, counseling on proper sunscreen use and application as well as the development of better broad-spectrum sunscreens are necessary to maximize outcomes for our patients. Large, randomized controlled trials on the use of sunscreen in melasma and PIH are warranted. However, these studies will not occur unless our broader dermatology community understands the potential benefits of photoprotection for melanocompetent populations. We hope this paper helps address this gap.

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Conflicts of interest
IK is a subinvestigator for Ferndale laboratories, Estee Lauder, Johnson and Johnson, Allergan and Bayer and is a Consultant for Chromaderm, Pfizer and Bayer. TFM is a subinvestigator for Ferndale laboratories, Estee Lauder, Johnson and Johnson, and Allergan. IHH received honoraria as an advisory board member for Aclaris. IHH is also a consultant for Pfizer and an investigator for Ferndale Laboratories, Estee lauder, Allergan, and Johnson and Johnson. Other authors declare no conflict of interest.

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