The Open Dermatology Journal

Content list available at: https://opendermatologyjournal.com

OPINION ARTICLE

Personalized Medical Photoprotection: Determining Optimal Measures for Susceptible Patient Groups

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Abstract:

Background: Increasing knowledge regarding the deleterious effects of sun exposure and the mechanisms of photodamage has enabled the development of tailored photoprotection strategies based on skin type and the existence of underlying conditions. Dermatologists play an essential role as they identify the specific skin photoprotection needs of their patients. This translates into specific recommendations of suitable protection measures, both in terms of the length and time of the day these patients can be exposed to the sun and the use of sun protection products.

Purpose: Our purpose was to overview optimal photoprotection strategies for patients with dermatological pathologies or alterations. Methods: Increasing evidence supports the use of sunscreens containing not only organic and inorganic filters but also non-filtering biological ingredients that can enhance sunscreen protection efficacy. Examples of these biologicals are DNA repair enzymes, antioxidants including vitamins and other biological agents, including those of botanical origin.

Results: Oral photoprotection is also an area of increasing interest that contributes to an integral protection against sun-related alterations.

Conclusion: This article provides the skin care specialist with a simple, easy-to-use guide to identify appropriate measures for patients presenting pathologies or conditions requiring specific sun protection needs, including (but not limited to) photodermatoses (polymorphic light eruption, porphyrias); inflammatory dermatoses (atopic dermatitis, rosacea, psoriasis); pigmentation disorders (hyperpigmentation, vitiligo), photoaging, skin pre-cancerous lesions and cancers, and photosensitive or sensitized skin (patients undergoing specific drugs treatments or skin-related procedures), ensuring the choice of personalized protection for susceptible groups within the general population.

Keywords: Photoprotection, Sunscreens, Organic filters, Inorganic filters, DNA repair enzymes, Antioxidants.

1. INTRODUCTION

In recent years, much progress has been made to better understand the roles of solar wavebands in photocarcinogenesis, photoaging and photodermatoses, and the various biological pathways by which this damage occurs. Ultraviolet B (UVB) light essentially causes erythema and direct damage to DNA and skin immune defenses, while ultraviolet A (UVA) light causes indirect damage to skin structures through the formation of reactive oxygen species (ROS) leading to DNA damage, photodermatoses, melanogenesis, mitochondrial and extracellular damage. Visible light (VL), especially high-energy blue-violet light (HEVL) causes, or aggravates, photodermatoses, skin aging and hyperpigmentation, especially in darker skin phototypes (SPT III-VI), mostly by inducing oxidative stress. Chronic
exposure to infrared A (IR-A) radiation can accelerate skin aging through increased metalloproteinases (MMPs) expression. Due to the various effects exerted by the different wavelengths of the electromagnetic spectrum, photoprotection measures should take into consideration specific measures to contrast these wavelengths and the pathways activated, as well as individual patient physio-pathological skin conditions.

The first step to optimize photoprotection is to obtain an accurate diagnosis of the patient’s skin condition and identify factors that could present a risk or promote the worsening of the pathology. Skin phototype is perhaps the single most important factor in determining skin response to solar radiation. However, other aspects such as lifestyle, exposure conditions, environmental factors (weather, climate, environmental contamination in the form of particles in suspension, toxic substances, etc.); as well as concomitant dermatological conditions such as inflammatory dermatoses, previous history of dermatological illnesses [1 - 5], hormonal imbalances [6 - 8] and use of photosensitizing drugs [9] need to be taken into consideration (Fig. 1).

Once an accurate diagnosis of skin conditions and risk factors has been obtained and their biological implications understood, the physician can begin to evaluate photoprotection alternatives suited to the patient’s needs. Different recent studies have begun to identify and set out specific UVB-UVA-VL protection measures for different skin phototypes and dermatological illnesses, particularly with respect to sun exposure habits and the use of filtering sunscreens [10, 11]. In addition to avoiding direct sun exposure and wearing photoprotective clothing (including hats and sunglasses), ideal filtering characteristics of sunscreens include very high SPF and lower UVA-PF formulations are required by lighter phototypes, whereas darker phototypes require less SPF, but more UVA-PF (including UVA1) and VL-PF [10, 12].

There is increasing evidence, however, that not all sun damage can be prevented with the use of sunscreens. Additional factors include incorrect and insufficient sunscreen application; lack of regular re-application; sunscreen inability to prevent the formation of every type of ROS; lack of photostability of some sun filters; non-uniform spectral filtering activity over the whole UVB, UVA and VL spectrum; inadequacy of SPF & UVA-PF designations to accurately consider all types of damage; damage caused by sub-erythemal doses of UV radiation, and scarce protection against visible light and IR-A. Many conventional organic and inorganic filters display one or several of these deficiencies, requiring the inclusion of other non-filtering biological actives and oral photoprotection to ensure optimal protection, especially in highly sensitive patient groups.

Our purpose was to overview optimal photoprotection strategies for patients with dermatological pathologies or alterations.

2. METHODS

An international panel of 5 experts in clinical dermatology, clinical photobiology, photoprotection and pharmacological pathways conducted a narrative review of the literature. We developed a comprehensive search with PubMed (2002 onward) including the keywords (non-MeSH) “photoprotection”, “sensitive skin”, “pathological skin”, “biological filters”, “photodermatoses”, “inflammatory dermatoses”, “pigmentation disorders”, “sunscreen” and “oral photoprotection”. The search was restricted to English and Spanish language articles.

3. RESULTS AND DISCUSSION

As indicated above, after conducting an extensive literature review, Chen and co-workers concluded that topical filters were not sufficient to provide complete protection and that “sunscreens with broad-spectrum UV protection only reduce free radical formation by 55% [13].” They suggested that topical delivery of antioxidants could “provide additional benefit to complement the protection from UV filters”. In 2020, Schalka and Coelho Donato demonstrated that the presence of Fernblock®, a standardized extract from the fern Polypodium leucotomos, could significantly increase sunscreen efficacy with respect to DNA and immunoprotection, aging and pigmentation [14]. In 2011, Aguileria and co-workers demonstrated that this fern plant extract could increase HIF (Human Immunoprotection Factor) provided by UVA and UVB filters by 18% [15]. DNA repair enzymes such as endonuclease, photolyase and glycosylase have demonstrated important DNA repair activity in vitro [16 - 19]. Moreover, Fernblock® can provide biological protection against VL [20 - 22]; while tinted titanium dioxide and iron oxide provide a physical shield against VL radiation [23, 24]. The well-described DNA repair and lightening activities of niacinamide also make it an interesting component of sunscreen formulations [25, 26]. Based on patient skin characteristics and needs, physicians can improve prevention measures by seeking topical formulations which combine UVA and UVB filters with these non-filtering biological agents.

Due to often incomplete protection provided by sunscreen formulations (even those containing additional biological activities), oral sun protection can provide a useful tool to boost protection against skin damage, particularly important in patients with important photo-aggravated conditions. Oral photoprotection can help increase the natural resistance of the skin against sun damage, reducing erythema and preventing and/or repairing DNA and oxidative damage. Oral photoprotective actives with demonstrated efficacy include antioxidants (e.g. carotenoids), niacinamide [27] and Fernblock® [14, 28, 29]. Studies have shown that the use of Fernblock® can improve both the prevention and treatment of hyperpigmentation [30] and reduce relapse in patients with Actinic Keratosis (AK) [31]. It has also been shown to be a useful adjuvant in the treatment of photodermatoses [32] and vitiligo [33].

Table 1 provides a brief, but comprehensive, overview of optimal photoprotection strategies for patients with dermatological pathologies or alterations, including photodermatoses, photo-aggravated inflammatory dermatoses (lupus, dermatomyositis, atopic dermatitis, rosacea, acne and psoriasis), pigmentation disorders (hyperpigmentation, vitiligo), photoaging, photo-induced skin pre-cancer and cancer, and photosensitive or sensitized skin (drugs, procedures). Recommendations include filter selection, the use of additional non-filtering biological actives and the main features of specific cosmetic formulations, that were outlined in Table 2. Also, we have illustrated strategies based on sun protection needs for healthy skin and patients with dermatological pathologies or alterations.
## Table 1. Photoprotection strategies for patients with dermatological pathologies or alterations.

<table>
<thead>
<tr>
<th>PATHOLOGY</th>
<th>RISK FACTORS</th>
<th>MAIN PATHWAYS INVOLVED</th>
<th>SPECIFIC PHOTOPROTECTION INCLUDING NON-FILTERING BIOLOGICAL ACTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHOTODERMATOSES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acne</td>
<td>- Stress</td>
<td>- Th1/Th2 imbalance</td>
<td>- very high, broad spectrum protection incl. VL protection</td>
</tr>
<tr>
<td></td>
<td>- Acne</td>
<td>- Immunosuppression (UCA, Langerhans cells)</td>
<td>- anti-inflammatory actives &amp; immunomodulating actives</td>
</tr>
<tr>
<td></td>
<td>- sunlight exposure</td>
<td>- type I hypersensitivity response (chromophores. Production of nuclease recognized by IgD)</td>
<td>- oral photoprotection</td>
</tr>
<tr>
<td>Solar Urticaria</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- photosensitizers</td>
<td>- Sunlight exposure (UVB/UVA-V)</td>
<td>- very high, broad spectrum protection incl. VL protection</td>
</tr>
<tr>
<td></td>
<td>- photosensitizers</td>
<td>- vasoconstriction (inflammatory IL-1, IL-8, prostaglandin E2, F2, TNF-α)</td>
<td>- anti-inflammatory actives &amp; immunomodulating actives</td>
</tr>
<tr>
<td></td>
<td>- photosensitizers</td>
<td>- Neuropeptides (TRPV1, substance P)</td>
<td>- oral photoprotection</td>
</tr>
<tr>
<td></td>
<td>- photosensitizers</td>
<td>- Th1/Th2 imbalance</td>
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<td>- type I hypersensitivity response (chromophores. Production of nuclease recognized by IgD)</td>
<td>- oral photoprotection</td>
</tr>
</tbody>
</table>

### SENSITIVE SKIN

- **Non-filtering biological actives**
  - *Pigment-control actives* | Fernblock® [20], Niacinamide [34], vitamin E [35], 25, Vitamin C [36], kojic acid [37], arbutin [38], caffeic acid [39], ferulic acid [40], Glutathione [41], alafinamide [42], Forskolin [43], among others. |
  - *Antioxidant actives* | Resveratrol [44], Fernblock® [45], Pomegranate fruit extract [46], Green tea extract [47], Genistein [48], vitamin D [49], Vitamin E [50], carotenin [51], ginseng [52], Arganin [53], Pycnogenol [54], Carotenoids [55], Curcumin Q10 [56], among others. |
  - *Anti-inflammatory & calming actives* | Physcionbenzyl [57], Entain [58], Hyaluronic acid [59], Niacinamide [59], among others. |
  - *Visible light protection actives* | Carotenoids [60], Fernblock® [20], Flavonoids [61], Mucoprotein-like amino acids (MAAs) [62] |
  - *Molecules and compounds with DNA-repair activity* | Repair-rate enzyme (61), nacinamide [59], Fernblock® [59], among others. |
  - *Immunomodulating actives* | Vitamin D [50, 62], Sterins [60], Fernblock® [59], Iprad [67], among others. |
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Fig. (1). Strategies based on sun protection needs for healthy skin and patients with dermatological pathologies or alterations.

Table 2. Specific photoprotection including filtering and non-filtering biological actives.

<table>
<thead>
<tr>
<th>PATHOLOGY</th>
<th>FILTERING INGREDIENTS</th>
<th>NON-FILTERING INGREDIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very High, Broad</td>
<td>Antioxidants</td>
</tr>
<tr>
<td></td>
<td>Spectrum Protection</td>
<td>DNA repair Actives</td>
</tr>
<tr>
<td></td>
<td>Specific VL Protection</td>
<td>Immune-modulating Actives</td>
</tr>
<tr>
<td>PHOTO-INDUCED SKIN PRECANCER AND</td>
<td>-</td>
<td>Anti-inflammatory &amp; Calming</td>
</tr>
<tr>
<td>CANCER</td>
<td>-</td>
<td>Actives</td>
</tr>
<tr>
<td>HYPERPIGMENTATION</td>
<td>-</td>
<td>Specific Pigment-control</td>
</tr>
<tr>
<td>VITILIGO</td>
<td>-</td>
<td>Actives</td>
</tr>
<tr>
<td>PHOTOAGING</td>
<td>-</td>
<td>Non-greasy</td>
</tr>
<tr>
<td>ATOPIC DERMATITIS</td>
<td>-</td>
<td>Oral Photoprotection</td>
</tr>
<tr>
<td>ROSacea</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ACNE</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>PSORIASIS</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>OTHER: LUPUS, DERMATOMYOSISTIS</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>PHOTODERMATITIDES</td>
<td>-</td>
<td></td>
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<tr>
<td>SENSITIVE SKIN</td>
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</tbody>
</table>

CONCLUSION

Patients with skin alterations and sun-induced pathologies can benefit from personalized photoprotection strategies targeting specific wavelengths and biological pathways. A correct diagnosis of the patient’s needs together with the expert recommendation of appropriate sun exposure behavior, photoprotective filters, biological actives, cosmetic formulations, and oral photoprotection can provide an optimal level of protection even for the most photosensitive groups, reducing the deleterious effects of sun exposure and thus increasing the patient’s quality of life.

AUTHORS’ CONTRIBUTIONS

SG: conceptualization. SG, AR-L, MVdeG, MdeT, P C-P: discussion, original draft preparation and writing, review and editing.

LIST OF ABBREVIATIONS

DNA = Deoxyribonucleic Acid
UVB = Ultraviolet B
UVA = Ultraviolet A
ROS = Reactive Oxygen Species
VL = Visible Light
HEVL = High-energy Blue-violet Light
IR-A = Infrared A
MMPs = Metalloproteinases
SPF = Sun Protection Factor
HIF = Human Immunoprotection Factor
Personalized Medical Photoprotection

The Open Dermatology Journal, 2023, Volume 17

CONSENT FOR PUBLICATION
Not applicable.

FUNDING
None.

CONFLICT OF INTEREST
S.G. has a consultant role for Cantabra Labs. The remaining authors declare no conflict of interest.

ACKNOWLEDGEMENTS
Declared none.

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