Sun, Skin, and Sunscreen

The following is the first in a series of articles discussing sun, skin, and sunscreens, as they relate to laser hair removal. By Steven Finder, MD, MBA, MPH

Every morning, the sun rises in the East drenching our lives in ultraviolet light. This ultraviolet light arrives in different flavors, with both harmful and beneficial effects. Limiting the harmful effects of this ultraviolet light has led to one of mankind's greatest differentiators; our ability to change the color of our skin through the creation and production of melanin.

As providers of laser hair removal (and other light based cosmetic procedures) it is an ironic twist that our target and yet greatest risk, is melanin. While we target the melanin in hair, it is the melanin in skin that provides our greatest risk. If we are to provide the absolute best treatment possible, it is important to understand how ultraviolet (UV) light and our skin interact in addition to the proper application of sunscreen.

Negative effects of ultraviolet light

The most well known negative effect of ultraviolet light is its ability to cause cancer. These cancers come in three varieties, basal cell carcinoma, squamous cell carcinoma, and melanoma (see Table 1). Though the two most common of these cancers are not life threatening, they can be disfiguring and difficult to treat if not found early. But like many things in life, an ounce of prevention is worth a pound of cure.

Table 1. Types of skin cancer

Basal Cell	Most common (million cases/yr)	Easy to treat, not life threatening
Squamous Cell	(250,000 cases/yr)	Easy to treat, not usually life threatening
Melanoma	Least common (60,000 cases/yr)	Very serious cancer, life threatening if not found early

But a more common harmful effect of UV light is its photo-aging effect. Chronic exposure to UV light damages deeper layers of the skin and lead to changes such as:

- dark age spots on the face and chest
- deep wrinkles around the eyes
- fine lines across the face
- leathery skin and reduced elasticity

- a gradual thickening of the skin
- uneven complexion
- an increase of small blood vessels

Ironically, tanning (the desire to expose oneself to UV light so as to darken our skin and promote a "healthy" appearance) when one is younger only makes our skin look worse as we age.

A final category of negative effects of sunlight are "allergies" to light. In most cases, these reactions are actually caused by drugs and go away once the offending drug treatment is stopped. But in other cases, these are actual allergies to the chemical byproducts that we produce in our skin as a result of exposure to UV light. These products are a result of the damage caused by the UV light to which a susceptible persons has an allergic reaction. For these people, avoidance of sunlight is a constant mission.

Positive effects of ultraviolet light

Ultraviolet light does have positive benefits, the most important being its ability to synthesize vitamin D in the skin which is necessary for health. Low levels of vitamin D lead to a number of diseases, the most severe of which is rickets. Today, with vitamin D fortified foods and vitamins, sun exposure has become a less important source of vitamin D. In fact, during the winter in northern climates, there is not enough UV light for vitamin D synthesis to occur at all.

UV light is also used in the treatment of chronic skin diseases such as psoriasis and vitiligo. In these conditions, controlled UV light exposure can have a significantly beneficial effect.

Though there is no question that there are beneficial effects to UV light for most people it is still better to limit ones exposure to sunlight. Especially given that it is difficult to modulate ones exposure and there are better alternatives to acquiring vitamin D.

For those of us involved in cosmetic laser treatments, especially laser hair removal, it is even more important to limit UV exposure so as to improve the outcome of our treatments. This is in addition to the need to prevent the damage caused by UV light. Understanding how to do so, requires more detailed understanding of the types of UV light.

UV light in the electromagnetic spectrum

UV light is part of the electromagnetic spectrum, which begins with gamma rays, and then progresses through X-rays, UV light, visible light, infrared radiation, microwaves, and finally into radio waves. This spectrum is best defined by the concept of wavelength, in that all energy has a wave characteristic which can be described as the distance from one peak to another. Visible light, for example, has a wavelength of 400 nm to 750 nm (nm: nanometers or 1/billionth of a meter). Above 750 nm we enter the realm of infrared light while ultraviolet lies right below 400 nm. Table 2 describes wavelengths at which various parts of the spectrum are found.

Table 2. Electromagnetic Spectrum (around visible light)

Near Infrared	750 nm to 1,200 nm
Red light	650 nm to 750 nm
Blue Light	400 nm to 450 nm
UVA	320 nm to 400 nm
UVB	280 nm to 320 nm
UVC	200 nm to 280 nm

Notice that ultraviolet light is further subdivided into UVA, UVB, and UVC. This is the same as subdividing visible light into blue, green or red light. These subdivisions are based on specific wavelengths which impart different characteristics to these particular types of light. But before further discussing these specific types of UV light, it is important to understand the concept of ionization.

UV light as ionizing radiation

The shorter the wavelength of the electromagnetic spectrum, the higher the energy. For this reason, gamma radiation with the shortest wavelength carries the most wallop, followed by X-rays. Radio waves with very long wavelengths (up to meters long), have very low energy which is why they can pass through us without any effect. In addition, the shorter the wavelength the easier it is for a photon (the particle of electromagnetic energy) to directly hit an electron circling an atom. So a short wavelength, with quite a bit of energy, can directly hit an electron and impart its energy to that electron, much like a cue ball hitting a billiard ball. This strike knocks the electron from the molecule or atom which causes that molecule to become negatively charged or “ionized” and damages the molecule. This process is called ionization and radiation that can do this is called ionizing radiation.

At longer wavelengths, there is not enough energy to dislodge an electron nor is the wavelength short enough to directly hit an electron, and so ionization can not occur. And there is no intrinsic damage to the molecule or atom, though the molecule can absorb heat.

The threshold at which ionization ceases to occur is somewhere between 350 nm and 400 nm. What this means is that UV which is below 400 nm can physically damage molecules and proteins in the skin. And it is this damage which leads to photoaging effects when the damage is to collagen or proteins in the skin and to cancer when the damage is in the skin DNA.

While above 400 nm (visible light and infrared) there is no ionization and hence no potential to cause the same type of damage nor to cause cancer. Above 400 nm one can still have heat effects but that is a very different effect which leads to localized damage to skin structures but not to chronic photoaging or cancerous changes.

This marks the end of the first in the series. Subsequent articles will look at the types of ultraviolet light, their effect, and the strategies for protecting from them, particularly with sunscreens.

Sun, Skin, and Sunscreen

The following is the second in a series of articles discussing the issues surrounding sun, skin, and sunscreens, as they relate to laser hair removal.

We previously discussed ultraviolet (UV) light and its effect on skin. One important point was that unlike visible light, UV light is ionizing radiation, meaning that UV light will damage molecules. This can cause both malignant changes and other damage in the form of photodamage. In this article we will look closer at the two major types of UV light, that routinely reach the earth's surface; UVB and UVA.

Understanding UVA and UVB

Ultraviolet B (UVB): 280 nm to 320 nm

UVB is the most damaging ultraviolet light that normally reaches the surface of the earth. It is a shorter wavelength of UV, compared to UVA and is therefore more damaging to skin cells. This damage can cause mutations which result in pre-cancerous and cancerous growths in addition to causing a burn in the form of erythema (classic sunburn). In severe cases, this erythema (sunburn)) can be as severe as a second degree burn.

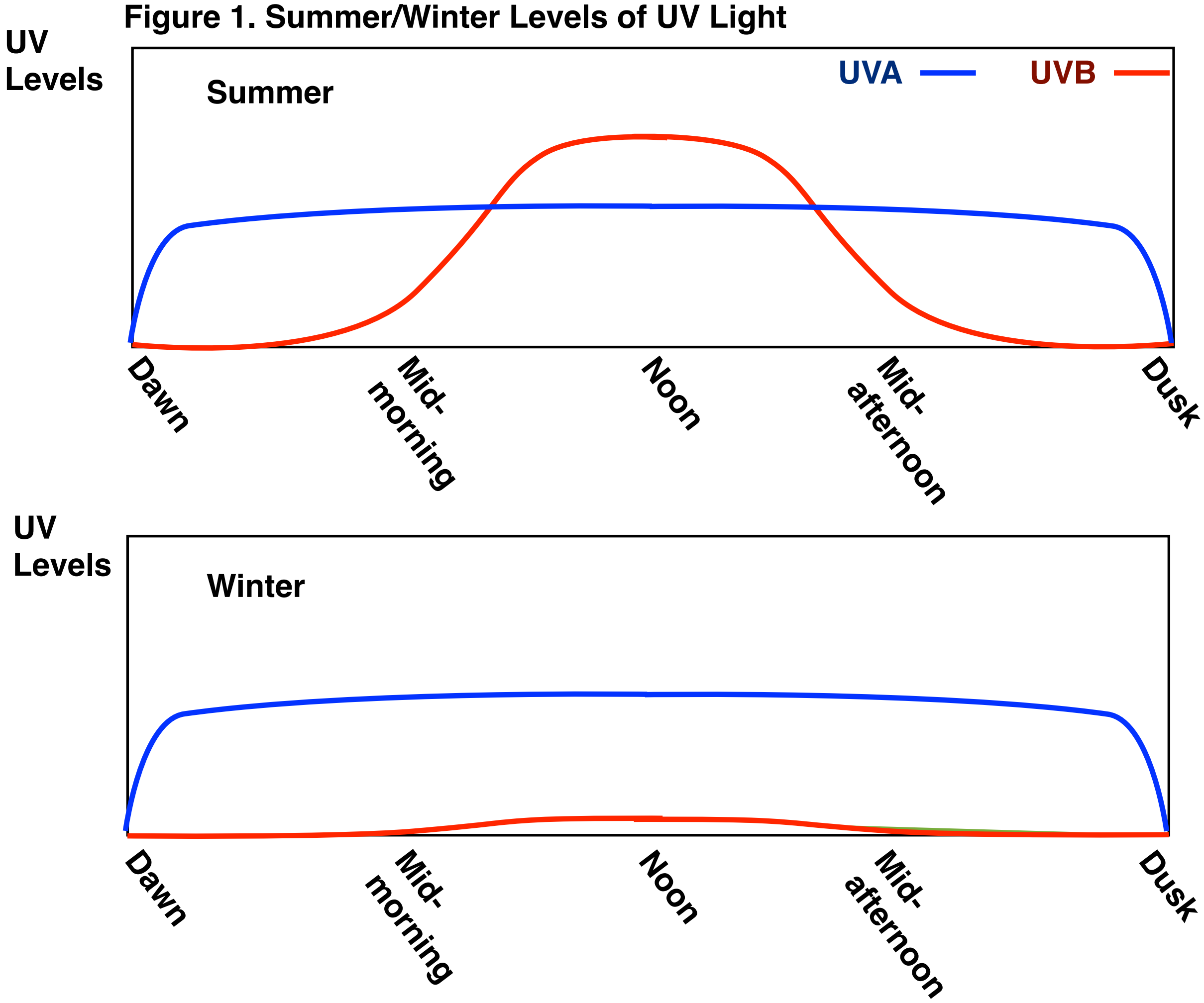
UVB also strongly stimulates tanning to produce melanin as a means of protecting the skin. This melanin production takes time to occur and has no effect on the immediate exposure, but over time it can darken the skin and afford it some protection from subsequent UVB exposure. This tanning also complicate lasers treatments which target melanin. In addition, UVB being a short wavelength, does not penetrate deeply into the skin. This is due to its scatter when it strikes the skin. The shorter the wavelength, the more it scatters and the less deeply it penetrates.

it is possible to use the erythema to the skin to measure UVB exposure. This is done by measuring the amount of erythema that develops after a period of UVB exposure. Though it is impossible to standardize that exposure because each person varies in how they respond to UVB, it is possible to use that measurement to tell how well something protects from UVB exposure. This measurement is called the Sun Protection Factor (SPF) and relates to how well a product protects against erythema compared to no product. The way that SPF is determined is quite interesting. On a volunteer, two areas of skin with similar color are marked. One area is covered with the product to be tested and both areas are exposed to a measured amount of UVB. What is determined is the amount of UVB required to cause a minimal amount of erythema (the point where redness begins to occur). By comparing the amount of UVB that cause this minimal amount of erythema the sun protection the product provides compared to no protection can be determined. When this type of analysis is done over many many people, the average amount of protection that a product provides is determined and this becomes the basis of its SPF.

Finally due of UVB's wavelength it is easily absorbed by the atmosphere and scatters little. Therefore, the more atmosphere it travels through the more UVB is absorbed and the less reaches the surface of the Earth. This means that during the summer in the middle of the day, when the sun is directly overhead, significant amounts of UVB reach the surface. But that same day, as the sun drops in the sky, the amount of UVB that reaches the surface drops dramatically. For this reason it is not easy to tan or burn early in the morning or late in the afternoon. In fact, in northern latitudes, significant amounts of UVB reach the surface of the earth only for a few hours before and after high noon (sun directly overhead).

In the winter the sun is lower in the sky and the light from the sun must travel through more atmosphere. Therefore there is little, if any, UVB that reaches the surface of the earth in northern latitudes. This is why it is not possible to tan during the winter, though as the sun begins to climb in the sky during spring, tanning becomes possible, especially in the South. (Figure 1 compares UVB in summer versus winter) On the other hand, it is possible to burn during the winter if one is at a high altitude, such as on a ski trip in the Rockies. On the top of a mountain, there is less atmosphere to block out UVB, so there can be significant amounts of UVB. Even though there may be none at the base of the mountain.

Figure 1. Summer/Winter Levels of UV Light



Ultraviolet A (UVA): 320 nm to 400 nm

Compared to UVB, UVA is less damaging to the skin. It causes so little acute (immediate) damage to the epidermis that it does not cause erythema and only weakly stimulates a tanning response. There is controversy over how much UVA causes cancerous and precancerous changes. Current theory is that UVA is less carcinogenic than UVB, but because it is much more abundant (more on this later) it may be equally dangerous. Regardless, UVA is not harmless. What we know is that while UVB can cause immediate damage, UVA causes chronic or long term damage. And it causes that damage deeper into the skin, down into the dermis. It causes deeper damage because it is a longer wavelength and so scatters less in the skin. This allows it to penetrate deeply and damage the collagen substructure of the skin. UVA seems more the driving force for long term chronic sun damage to the skin such as wrinkles.

Unfortunately, there is no easy way to measure UVA exposure to the skin. This is because there is no short term skin response to UVA. The amount of UVA that reaches the skin can be measured, what is difficult is measuring how much damage that UVA is causing. This makes it very difficult to measure how well various sunscreens protect from UVA. Unlike SPF and UVB, all measurements of UVA protection are only estimates.

UVA behaves differently from UVB in the atmosphere. UVB is not scattered and and is well absorbed by the atmosphere, therefore it only reaches the surface of the earth during specific periods. UVA, on the other hand, is not well absorbed and scatters very easily, similar to blue light. It is the scatter of blue light that makes the sky look blue, and UVA scatters the same. What this means is that if one can see blue sky, then one is also being bathed in UVA. But unlike blue light, UVA is not as absorbed by clouds, so even during overcast conditions, unless the clouds are quite thick, there is UVA reaching the surface, and coming from every direction.

In addition, because it scatters, UVA levels are constant year round. In other words, at normal latitudes in the US, UVA levels are constant summer and winter, rising quickly at dawn and dropping at dusk. Unlike UVB where protection is predominantly a summer issue, protection from UVA must be a year round process (see Figure 1 for a comparison of UVA levels during summer and winter). Finally, whereas UVB is completely absorbed by a normal layer of glass, UVA easily travels through glass. So even inside a house or car, one can be bathed in UVA.

Table 3 Provides a summary of the differences between UVA and UVB. These differences form the basis for the strategy that one must use to protect from both UVA and UVB. The next article will delve into those strategies and into a further understanding of the types of sunscreens available.

This marks the end of the second in the series. The next article will look at the strategies for protecting from UVA and UVB, particularly with sunscreens. The final article will look at practical considerations for using sunscreens.

Table 3. Compare and contrast UVA and UVB

	UVB	*UVA*
Wavelength	280 nm to 320 nm	320 nm to 400 nm
Scatter/Depth of penetration	High scatter/little penetration	Low scatter/deeper penetration
Major effect on skin	Sunburn, malignant changes	Long term chronic sun damage. Loose skin, wrinkles, collagen damage, malignant changes?
Seasonal variation in ultraviolet levels	Predominantly Summer; Spring and Fall farther South	Year round
Daily variation in ultraviolet levels	Rises mid-morning to noon peak and drops mid-afternoon	Constant throughout the day
Ability to measure skin protection	Easy to measure, SPF	Difficult to measure, no agreed standard

Sun, Skin, and Sunscreen

The following is the third in a series of articles discussing the issues surrounding sun, skin, and sunscreens, as they relate to laser hair removal.

In the previous two articles we discussed the characteristics of ultraviolet (UV) light and its effect on skin. An important point was that unlike visible light, UV light is ionizing radiation and will cause damage in the form of photodamage. In addition, ultraviolet B (UVB) and ultraviolet A (UVA) are different. Table 3 summarizes these differences. We will explore how these differences impact the use of sunscreens. But first we need to understand the important characteristics of sunscreens.

Table 3. Compare and contrast UVA and UVB

	UVB	*UVA*
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Understanding Sunscreens

Active Ingredient versus Filler

Modern sunscreens are really composed of two different types of compounds. First, there are the active ingredients. This are the products that actually provides the sun protection. In modern sunscreens there is rarely only one active ingredients rather there are a number of products that provide a range of protection. These are the products that are normally listed on the package.

In addition to the active ingredient are filler materials which provide a number of critical functions. They hold the active ingredient within the emulsion (cream) and keep it from clumping together. The filler also provides moisturizer and maintenance to the skin. And the filler is what gives the sunscreen its substantivity, i.e., the thickness and abillity of the sunscreen to stay on the skin. Generally it is the filler material that determines how the sunscreen feels. Some sunscreens feel very light on the skin (cosmetically elegant) while others feel oily and thick.

Physical versus Chemical

There are two basic ways that sunscreens can protect from UV radiation. The first is to act as a physical block. This type of sunscreen literally blocks the UV light from reaching your skin. These products actually reflect away the UV light before it reaches your skin. The two main physical agents are zinc oxide and titanium dioxide. The biggest problem with physical agents is that in the past these products were opaque and not cosmetically elegant. For example, zinc oxide is the white paste that lifeguards famously put on their noses for sun protection. But in the last ten years, a revolution in manufacturing has developed product with microscopic sizes that actually blend into the skin while still maintaining the ability to reflect UV radiation. Table 4 lists the physical agents.

Table 4. Common Sunscreen Agents

Physical agents
Titanium Dioxide
Zinc Oxide

Chemical agents

P-Amino-benzoic acid (PABA)	Octyl methooxycinnamate (Octinoxate)
Avobenzone	Octyl salicylate (Octisalate)
Cinoxate	Padimate O
Dioxybenzone	Phenlybenzimidazole sulfonic acid
Homosalate	Sulisobenzone
Methyl anthranilate	Trolamine salicylate
Octocrylene	Ecamsole (Mexorly®)

The other way that sunscreens work is to absorb the UV radiation and convert it to infrared, which is non-ionizing and hence safe. Unlike the physical blocks which are passive, this types of sunscreen require an active absorption of the radiation. The majority of active ingredients listed on sunscreens are chemical agents. They usually must be absorbed into the skin to provide their protection. These products tend to work best with the more energetic radiation which is better absorbed, hence they tend to be better for UVB than UVA. In addition, with the absorption of UV radiation there is the possibility that the product can break down and lose its effectiveness. This requires that the product be reapplied on a periodic basis. Finally, unlike the physical agents which tend to be inert, these products are usually more allergic producing. Table 2 lists some of the more common chemical agents.

UVA versus UVB

All sunscreens ingredients provide protection over some part of the UV spectrum. In some cases, this protection includes both the UVA and the UVB spectrum. These types of products are said to protect for both UVA and UVB. Other products protect only over the UVB part of the spectrum and these products afford no UVA protection.

Because UVB radiation is higher energy and doesn't penetrate as deeply, it is better absorbed than UVA. For this reason, the chemical products are able to easily absorb UVB and convert it to harmless radiation. UVA because it is longer wavelength is not as easily absorbed by the chemical agents. Except for Avobenzone, only the physical agents have a real impact on UVA. Figure 2 shows the UV characteristics of various agents.

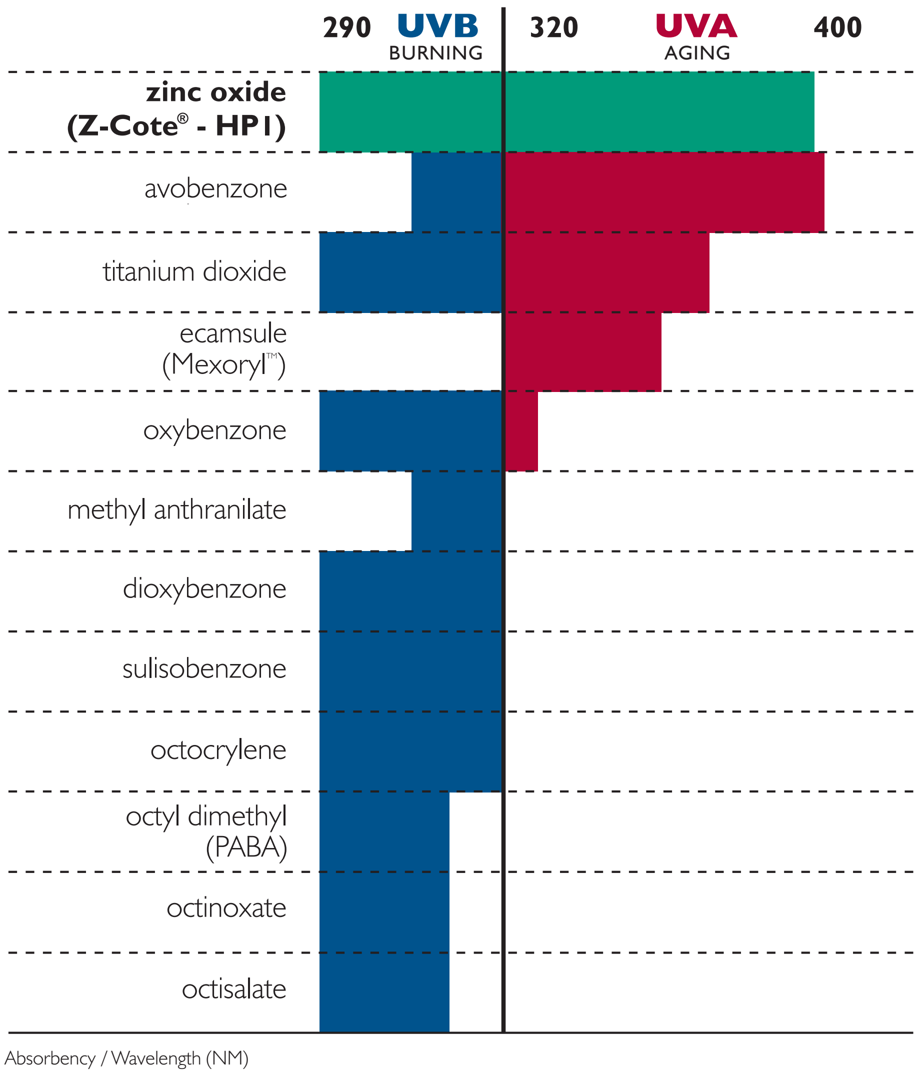
Waterproof versus non-waterproof (Substantive)

Sunscreens can be classified as being either waterproof (water resistant) or not. This is actually an arbitrary standard based on the product's ability to withstand at least 40 or 80 minutes of immersion in water without losing its ability to provide protection. In the US, sunscreens that meet the 40 minute standard can be labeled as water resistant. The products that can meet the 80 minute standard can be labeled as waterproof. The filler material in a sunscreen is what determines whether a product is waterproof or not.

Though not completely related to waterproofness, the term substantive describes how well a product stays on the skin. The more substantive a product is, the longer it will remain on the skin, and the more likely it is to be waterproof. Finally it must be remembered that there is a tradeoff between cosmetic elegance (how the product feels on the skin) and how substantive (waterproof) it is. The greater the degree of substantivity, the less likely it is that the product will feel light and elegant on the skin. In other words, to make a product stay on the skin in the water requires a product that will generally be thick and oily on the skin.

Figure 2. UV Protection of Common Agents.

Graphic courtesy of Elta.



This marks the end of the third in the series. The next article will pull together all the previous information to outline practical considerations for using sunscreens. It will provide a reasonable approach to sunscreen use.

Sun, Skin, and Sunscreen

The following is the fourth in a series of articles discussing the issues surrounding sun, skin, and sunscreens, as they relate to laser hair removal.

In the previous articles we discussed the characteristics of ultraviolet (UV) light, its effect on skin, and the characteristics of sunscreens. In this article, we will pull all of this together to provide a reasonable approach to sun protection.

UVA and UVB Protection

UVB Protection

UVB protection is straight forward. Sunscreen ingredients can be classified and compared based on their SPF numbers, as long as one remembers that the chemical agents must be reapplied as they break down under sun exposure. The only serious issue is allergic sensitivity and the newer sunscreens are much less allergenic. All one needs is an SPF of 15, except that sunscreens wear off or break down during the day; therefore a higher SPF (30+) will provide longer protection.

UVA Protection

UVA protection is much more problematic. The two best protective ingredients are zinc oxide and avobenzone (Parsol 1789), which provide fairly equal UVA protection though zinc oxide provides better UVB protection. Zinc oxide, being a physical block does not break down in the sun. Whereas avobenzone, a chemical block does break down fairly quickly. A sun stable version of avobenzone called Helioplex™ has recently reached the market. This version is much more stable in the sun. Because there is no equivalent to SPF for UVA, products are difficult to compare. It is possible to compare two products based on their percent of zinc oxide or titanium dioxide and have a relative indication as to how well they protect. The higher the percentage the better the protection. There have been no studies comparing Helioplex™ to zinx oxide. Therefore at this point in time, it is impossible to know how well the new products using Helioplex™ perform compared to the physical sunscreens.

Using sunscreens

What are we protecting?

If every part of our body received the same exposure to UV radiation, then one type of sunscreen would be all we need. The reality is not that simple. Fashion dictates that various parts are covered while others are not. Furthermore, the face is much more important than other parts of out bodies. Therefore an easy way to understand how to best use sunscreens is to divide the body into three different zones. Each zone being protected in a different manner.

Sun, Skin, and Sunscreen

Before we begin, it is important to understand that even though we are focusing on sunscreens, the single most important protection is non-exposure to ultraviolet. Either through the avoidance of exposure or in the use of clothing and hats.

The Face and Neck (and hands)

The first and most important zone is the face and neck, and to a lesser extent, the hands. With today's fashions this can also include a woman's chest. These are the areas most exposed to UV radiation, both UVA and UVB. They remain uncovered year round and the face, especially, defines who we are and most shows the effects of UVA exposure. We gage a person's age on how their face looks, and to a lessor extent, their hands and chest. Therefore the goal is to protect these areas not only from UVB but from UVA as much as possible.

To protect from year round exposure to UVA requires the daily use of a high quality sunscreen maximizing UVA protection, regardless of weather conditions. I believe that currently this is best done with a sunscreen with at least 5-7% zinc oxide and preferably more. Very elegant sunscreens of this concentration exist in a variety of lines. There are moisturizer and oil free sunscreens of this caliber such that any client can find a daily sunscreen that works for them. The zinc oxide must be miconized so as to blend into the skin and the sunscreens will generally include a chemical block to provide enhanced UVB protection. These sunscreens will all have good SPF levels due the the effect of the zinc oxide and will provide substantial UVB protection.

For daily wear, a non-waterproof sunscreen will feel lighter on the skin and be easily tolerated. During the winter, one application a day is enough. While during the summer, refreshing the sunscreen at mid-day gives the best protection. If the day is going to include physical activity, the possibility of water exposure, or perspiration, then the use of a water proof sunscreen is necessary. These sunscreen can cost in the $20 to $30 range as the zinc oxide is not inexpensive, but one's face is not the place to skimp. There is no reason to use these sunscreens on any other site of the body. It is only a waste of money.

Titanium dioxide can also be found in these products but it tends to provide less UVA protection, is more "flaky" on the skin and is often used to replace some zinc oxide to reduce manufacturing costs. The use of titanium dioxide should not invalidate a sunscreen for the face as long as the zinc oxide is high. Not enough study has yet been done to determine whether a product such as Helioplex™ provides the same level of protection as zinc oxide. Until enough research has been done it is best to avoid their use on the face.

The Arms (and maybe shoulders, lower legs and feet)

The next zone are those areas of the body that get significant exposure during the summer but get little exposure as the temperatures drop in the winter. In men, this is predominantly the arms with short sleeved shirts. While with woman, it can also include the shoulders, lower legs and feet, depending on their summer fashion tastes. The goal is to protect these areas from the strong UVB of summer while providing some UVA protection because of the chronic summer exposure. But because UVA exposure is not year round, there is less of a need to focus on strong UVA protection.

This means that sunscreens with less zinc oxide and more UVB protection can be used. These sunscreens tend to be less expensive which is good because the area being protected can be quite large. In addition, sunscreens with titanium dioxide or Helioplex™ may be good. What is important is to use a good SPF (30 or more) for longer UVB protection and to use a product that feels good on the skin. And like the face, a water proof sunscreen should be used when appropriate.

The Rest

The final zone are those parts of the body that get only sporadic exposure to the sun. These are the areas that are almost always covered up except when we are out wearing swim suits, tanning, or otherwise exposing ourselves to the sun. Depending on one's fashion sense this can be the trunk, bikini, and thighs. In other clients, especially men, this can be everything except the arms and face.

Because these areas do not get constant exposure, they receive little chronic UVA. These are areas, such as a man's back, that may be heavily tanned from short term exposure such as being outdoors on a weekend without a shirt. But their total year round exposure is minimal. Therefore the goal is to protect from UVB exposure and not worry about UVA protection. There is no need for zinc oxide, titanium dioxide, or any other specific UVA protective ingredient. Rather a high SPF UVB sunscreen should be used. These sunscreens are relatively inexpensive and are made up of a combination of chemical sunscreens.

The sunscreen should be used from mid-morning to late afternoon from Spring to Fall. The farther South one is the earlier in the Spring and the later in the Fall they should be used. They should also be refreshed often during the day and/or a waterproof version should be used with physical activity or water exposure.

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