White Paper

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Exposure of the Eye to Ultraviolet Light

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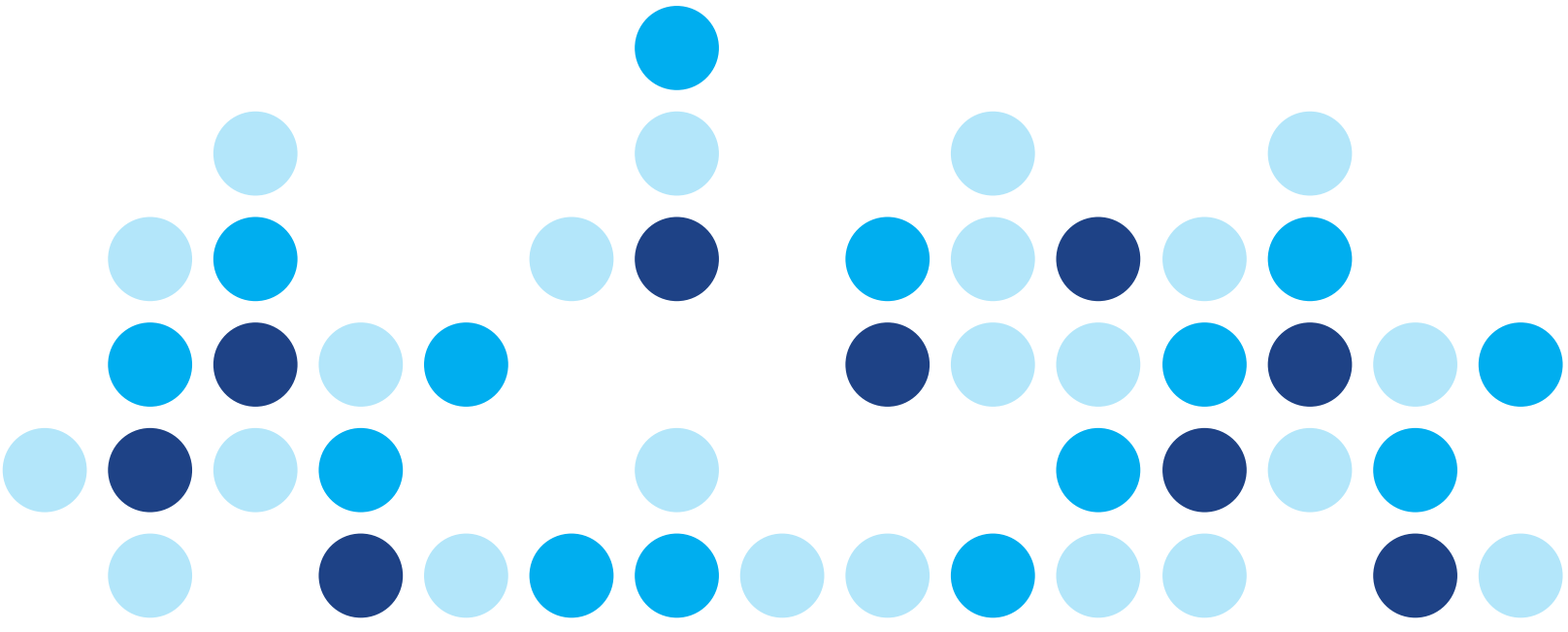

Key Highlights

- UV light comes into contact with multiple tissues in and around the eyes including the ocular surface (cornea and conjunctiva), crystalline lens, retina, skin around the eyes and lids and can cause permanent damage.
- It is important to block UV light rays from reaching the eye, using protective measures such as UV-blocking contact lenses, UV-blocking intraocular lenses, wrap-around sunglasses and hats.

What is UV light?

The sun emits a wide spectrum of visible and invisible wavelengths of light. Ultraviolet (UV) radiation includes a range of wavelengths from approximately 100–400 nm and are invisible to the human eye.[1,2]

UV light is classified into 3 categories:[1,2]

UVA (315–400 nm)

UVB (280–315 nm)

UVC (100–280 nm)

UVA and UVB rays pass easily through the atmosphere and are the most concerning as they can cause damage to the skin and the eyes. UVC rays, on the other hand, do not pose a significant risk as they are efficiently absorbed by the ozone layer and do not reach the Earth's surface (Figure 1).[1-3]

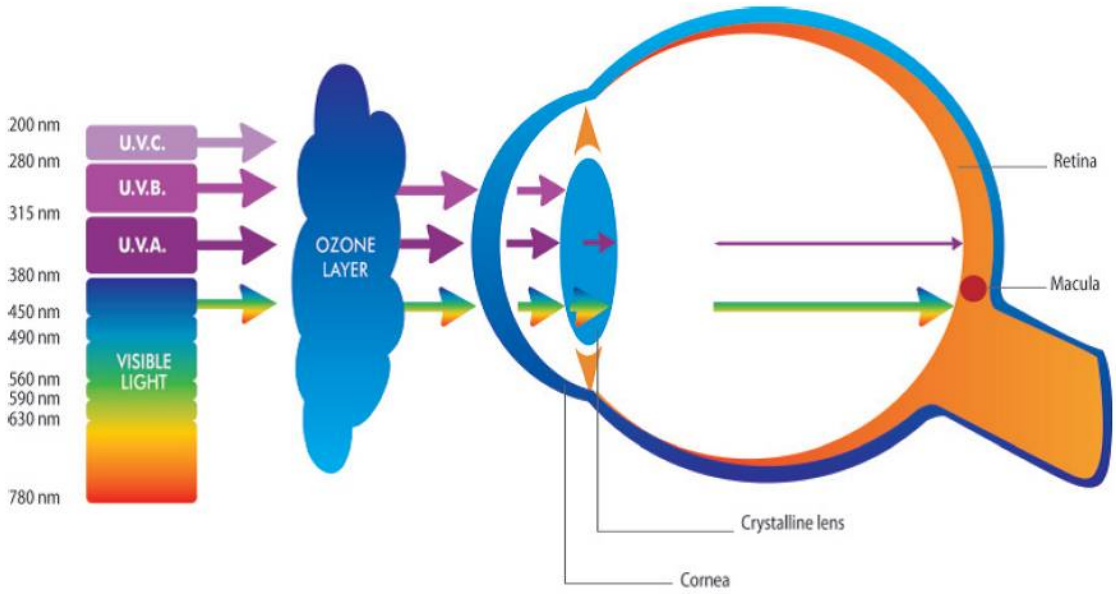

Figure 1: UV light absorption in a normal adult eye (image from the Association of Optometrists Ireland website).[4]

In general, shorter wavelength light rays have higher energy and have greater potential to cause damage to human tissues. In this regard, UVB rays are more intense and harmful than UVA (Figure 2). However, UVA rays account for approximately 95% of the total UV radiation reaching the Earth's surface and, due to the sheer amount, can be equally harmful.[1-3] Therefore, protection of the skin and the eyes from both UVA and UVB light is important.

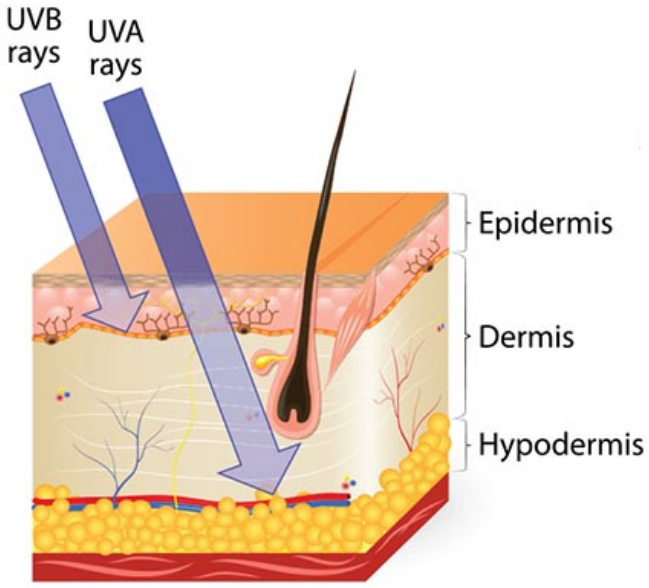

Figure 2: Penetration of UVA and UVB light into the skin. UVA light is less intense and causes damage in deeper layers of the tissue while UVB light is more intense and causes damage to more superficial layers (image from NutritionAction.com).[5]

Facts:

- Only 31% are aware that UV exposure can affect the cornea (photokeratitis).
- Only 26% are aware that cataracts can be caused by UV exposure.
- Only 21% are aware that UV light can contribute to AMD.

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Effects of UV light on ocular tissues

UV light comes into contact with multiple tissues in and around the eyes including the ocular surface (cornea and conjunctiva), crystalline lens, retina, skin around the eyes and the lids.[2] Skin and ocular UV damage are related to the total dose of UV light. Most tissues, including those of the eye, can tolerate a certain threshold dose of UV light but exposures beyond that threshold will potentially injure the tissue. Repair pathways within the tissue may be able to correct the damage, but every time the threshold is reached, it increases the probability of permanent damage.[7]

Cornea and Crystalline Lens

Fortunately, the cornea and crystalline lens naturally block most UV light from reaching the retina (Figure 1). However, this also means that these tissues are absorbing the UV light which makes them vulnerable to damage over time.[1,3,8]

Intense exposure of the cornea to UV, such as when snow skiing or when at the beach, can cause photokeratitis. These intense bouts of UV exposure go beyond the tissue's threshold and can permanently damage cells and collagen the same way UV light affects the skin.[1,9] UV light has also been associated with certain corneal degenerations, such as climactic droplet keratopathy.[3,7] There is also some evidence that suggests that UV light may be harmful to limbal stem cells which are important for lifelong corneal repair and transparency and reside in the limbal junction between cornea and the sclera.[10]

The absorption of UV light by the crystalline lens also contributes to cataract formation, likely due to oxidative changes within the tissue. The rate of these changes varies per person and depends on the cumulative amount of UV exposure that an individual endures over their lifetime.[1,3]

Conjunctiva

UV exposure is one of the confirmed risked factors in the development of pinguecula and pterygium.[1,3] These are typically vascularized growths of the conjunctiva that can eventually grow onto the cornea causing distortions in vision or blocking of vision altogether. These typically develop on the nasal conjunctiva and some have hypothesized that this is due to peripheral light focusing effect.[11,12] This means that light from extreme peripheral angles that enters the eye at the temporal cornea focuses on the opposite (nasal) side of the eye and with approximately 20 times more intensity (Figure 3).[11,12] This does not occur in the opposite direction due to the position of the nose which blocks light from entering at such extreme peripheral angles. This same phenomenon occurs in the nasal crystalline lens and is thought to be involved in the development of cortical cataracts since they most commonly occur in the nasal quadrant.[11]

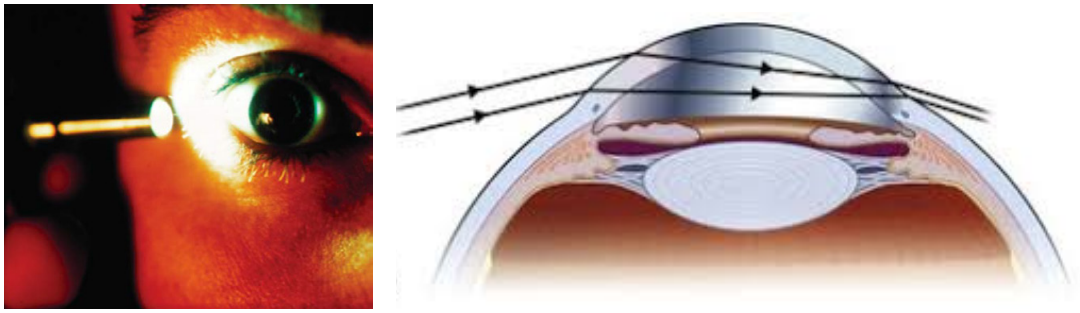

Figure 3: Light from extreme temporal peripheral angles entering the eye and focusing on the nasal side with approximately 20x concentration (images from Coroneo 2011).[11]

Retina

The effect of UV light on the retina, in general, is not well understood. However, there are studies that have shown an association between age-related macular degeneration and time spent outdoors.[13,14] Internal ocular melanoma, although rare, may have an association with UV light exposure as this is a known risk factor for other melanomas of the skin. However, the evidence for this within the eye is very low.[15] Given that little UV light actually reaches the retina, this likely only becomes relevant after cataract surgery when the crystalline lens, the eye's natural UV filter, is removed.

Since the cornea and crystalline lens absorb most of the UVA and UVB light entering the adult eye, very little makes it to the retina (Figure 1). However, there is variation in the amount of UV absorption by the crystalline lens based on age. Yellow pigment within the lens helps to filter UV light and the amount of this yellowing increases with age. This means that, while little UV light passes through to the adult retina, some UV light does reach the retina in young children.[3] In fact, estimates suggest that the majority of a person's lifetime exposure to UV light is received before the age of 18.[16]

Skin Around the Eyes & Eyelids

The skin around the eyes and the lids are susceptible to UV light damage in the same way as skin on any other part of the body. However, this is an area that is not easily protected by the use of sunscreen since it is so close to the ocular surface. Skin cancer is very common in general, and the eyelid is a common place for it to occur. The majority of skin cancers around the eyes are basal cell carcinomas (Figure 4). This type is highly curable if caught early but has the potential to grow rapidly and could cause disfigurement around the eye; however, it does not typically spread into deeper tissues or metastasize. Other types of eyelid cancers are much less common: squamous cell carcinoma and melanoma make up 5% and less than 1% of all eyelid cancer, respectively. Both are easily cured if treated early, although melanomas have the potential to be aggressive and metastasize.[17] Additionally, ocular skin exposure to UV light, just like any skin on the body, can cause a break down in the collagen, leading to unwanted cosmetic effects like wrinkles around the eyes.[3]

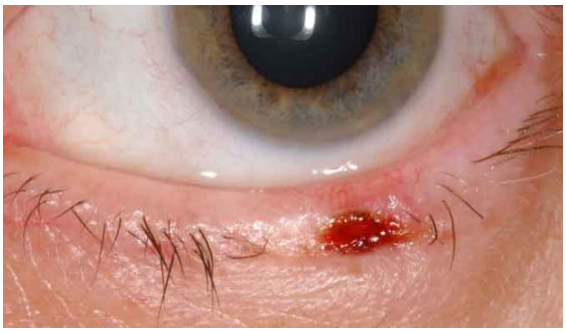

Figure 4: Basal cell carcinoma of the lower eyelid (photo from Wills Eye Hospital website).[18]

How to Protect the Eyes from UV Light

Contact lenses

UV blocking contact lenses can significantly decrease the amount of UV absorbed by the cornea and crystalline lens and, to a lesser extent, the retina. However, they do not protect the conjunctiva beyond the edge of the contact lens and do not provide any protection to the lids or the skin around the eyes. One additional benefit provided by a UV-blocking contact lens is protection of the limbal area where stem cells reside.[10]

UV protection in contact lenses can be especially useful in certain circumstances where sunglasses and/or hats are not allowed or are impractical. However, the use of UV-blocking contact lenses often gives patients a false sense of security, thinking that the lens will fully protect their eyes. Therefore, it's important to educate them that UV-blocking contact lenses do not provide complete protection and that sunglasses and/or hats should still be worn. In fact, the FDA specifies that manufacturers should list the following warning when mentioning the UV blocking capabilities offered by a contact lens: UV-absorbing contact lenses are NOT substitutes for protective UV-absorbing eyewear such as UV-absorbing goggles or sunglasses because they do not completely cover the eye and surrounding area.[19]

There are two classifications of UV blocking contact lenses defined by the current ANSI Z80.20 standard and also recognized by the FDA: Class 1 and Class 2. Class 1 provides the greatest amount of protection against UVA and UVB light, whereas Class 2 blocks less UVA and UVB and is not as protective.[20]

Class 1: must block at least 90% of UVA (315 to 380 nm) and 99% of UVB (280 to 315 nm)

Class 2: must block at least 50% of UVA (315 to 380 nm) and 95% of UVB (280 to 315 nm)

Of note is a change to the ANSI standard Class 2 definition that occurred in 2010.[21] The standard for Class 2 contact lenses previously required that the lens block at least 70% of UVA light, whereas the revised and current standard only requires at least 50% of UVA light to be blocked.

Sunglasses

Sunglasses are essential for protecting all of the ocular tissues from UV light exposure. The FDA guidance on non-prescription sunglasses points to the ANSI standard[22] for characterization of sunglasses made in the USA.[23] The ANSI standard requires sunglasses to protect against both UVA and UVB radiation and to be labeled with "lenses meet ANSI Z80.3-2018 UV blocking requirements" or something similar. It is important to note that this labeling does not have to be on the product itself but could be within the package or catalog from the manufacturer. Therefore, it may not be directly apparent to the consumer that the lenses meet these requirements. It is more likely that manufacturers will use stickers or tags on the sunglasses that state "blocks UVA and UVB" or "blocks X% UVA/UVB". The American Optometric Association recommends that sunglasses block 99-100% UVA and UVB.[24] Educating patients to look for this type of marking on sunglasses or asking to see the labeling for these details are important so they can be more confident that the lenses are providing the protection they need. Since non-prescription sunglasses are over the counter, FDA class 1 devices, the ANSI standards are voluntary guidelines that manufacturers should follow but are not required to follow. Further, there is no FDA approval process for individual sunglasses, and there is the possibility of them not providing UV protection and/or being mislabeled by non-reputable vendors. Warning patients to be watchful of this can help them to make more informed decisions.

MYTH: Darker lenses block more UV light.

FACT: UV protection has nothing to do with the darkness or color of the lens. Dark lenses without UV protection can actually be worse than no sunglasses at all because they cause the pupil to dilate, which allows more UV light to the retina.

MYTH: All sunglasses have UV protection.

FACT: Not all sunglasses have UV protection because they aren't required to. Look for a label, sticker or tag indicating UV protection before purchasing a pair of sunglasses.

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One other factor to point out to patients is that the amount of tint in the lenses does not equate to the amount of UV protection (ex. a darker lens does not mean that more UV light is being blocked).

It is also best that sunglasses are wraparound style in order to avoid peripheral light from reaching the eye through the sides of the lenses. In fact, it has been shown that non wrap-around sunglasses provide little or no protection from peripherally focused UV light. These peripheral light rays that reach the eye are at just the right extreme angles for contributing to the peripheral light focusing effect mentioned above.[25]

Hat

The anatomy of the ocular orbit naturally provides some protection from overhead UV light by way of the brow bone. However, this varies person to person and there are still angles of light from above that can reach the eye, even when wearing sunglasses or UV blocking contact lenses. Therefore, wearing a wide brim hat or cap that shades the face and directly blocks UV light from above is ideal.[3]

Intraocular Lenses

When cataracts develop and it is time for replacement with an artificial intraocular lens (IOL), UV protection is a key factor to discuss with patients. An IOL that blocks UV light can protect the retina since the natural crystalline lens is no longer there to provide that protection.[8] Most currently used IOLs include 100% UV light blocking capability; however, patients should be discussing this with their surgeon to verify that their IOL choice includes this.

Summary

Exposure of the ocular tissues (cornea, conjunctiva, crystalline lens, retina, skin around the eyes and lids) to UV light can cause permanent damage over a person's lifetime or during intense exposure. It is important to protect the eye with mechanisms for blocking UV light rays from reaching the eye which include UV-blocking contact lenses (and IOLs), wrap-around sunglasses and wide-brimmed hats. A UV-blocking contact lens or IOL alone does not fully protect the eyes and needs to be combined with the use of wrap-around sunglasses and a protective hat.

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