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The effects of ultraviolet radiation (UVR) on the human eye and the importance of ocular protection – Part 2

About the author

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Chris Steele graduated from City University in 1988 and was a double prize winner in ocular disease and contact lens examinations. He qualified in July 1989 after his pre-registration year at the Royal East Sussex Hospital, Hastings. He is Consultant Optometrist, Head of Optometry at Sunderland Eye Infirmary (SEI). Over the past 28 years he has continued to develop a wide range of extended roles within his optometry team involving medical retina, cataract, glaucoma, anterior segment, emergency department and paediatric caseloads.

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Chris was a College examiner for pre-registration final exit examinations and postgraduate higher qualifications (diabetes and glaucoma) for many years. Chris was a member of the original NICE Glaucoma Guideline Development Group that produced the NICE glaucoma guidelines (CG85) published in 2009.

In the past 5 years he was a member of the College of Optometrists Medical Retina Development Group that produced the new Medical Retina Higher Qualifications for optometrists. Most recently he was involved in establishing the new Advanced Practice in Ophthalmology MSc Degree Apprenticeship at UCL and Moorfields, London. He continues in his role as a co-editor for Specsavers' CPD.

Outline

The potentially damaging effects of ultraviolet radiation (UVR) on the human eye and the surrounding tissue are wide ranging. This article, part 2 of two looks at the different methods of UVR protection including spectacle and contact lenses as well as surgical options. The article also outlines the relevant eyewear regulations and provides some general advice for protection against UVR

Learning objectives

Domain: Professionalism

Registrants will be able to provide up to date advice to patients and access to solutions to help protect and safeguard them from the potential harm casued by UVR (s.11).

Domain: Clinical practice

Registrants will be able to identify a range of different methods and resources which may help protect patient's against the potential damage caused by exposure to UVR (s.5).

Introduction

The first part of this two-part review discussed the impact of ultraviolet radiation (UVR) over exposure and the evidence in the literature regarding the impact this may have on the various parts of the eye and skin. In Part 2, methods of UVR protection will be discussed in terms of optical and surgical methods and general advice. Approximately 40% of daylight UVR lies in wavelengths not fully blocked by materials (e.g. spectacle lenses) that claim to be 100% UV protective but only block up to 380nm instead of 400nm.

There are various ways that individuals can reduce solar radiation exposure to their eyes. Optometric and surgical options include:

- UV filtering ophthalmic clear spectacle lenses
- Anti-reflective (AR) coatings
- Sunglasses with UV filtering coatings, including wrap around lenses or wide arms (to provide side protection) that have the appropriate CE Mark. This is an indication that they meet the relevant European Standard. Appropriately UV protective sunglasses, should have the "CE" Mark or nowadays the British Standard BS EN ISO 12312-1:2022, which ensures that the sunglasses offer a safe level of UV protection.
- Photochromic prescription lenses with UV filtering
- Snow skiing goggles
- UV filtering hydrogel contact lenses
- UV filtering RGP contact lenses
- Intraocular lenses with UVR filters – post cataract, or elective refractive surgery (clear lens extraction (CLE))

Spectacle lenses

Spectacles can provide significant eye and eyelid protection from UVR. Approximately 90% of UVR is incident through the front of a spectacle lens, with indirect UVR entering from the sides and rearward reflections from the back surface of the lens accounting for the rest. Some rearward UV radiation will pass straight through the lens from the back to the front surface and therefore does not reach the eye.

While regular spectacle lenses can absorb some UV light, UVR absorption can be enhanced by treating or coating ophthalmic lenses. This includes integrating a UV absorber into the clear lens substrate or applying an enhanced back surface anti-reflective coating (see below).

Eye-Sun Protection Factor (E-SPF)
It has previously been advocated that the notion "wearing sun glasses protects against UVR" is incomplete or might even be misleading and should be replaced by a message that "clear lenses and/or sunglasses with high E-SPF® worn on a regular basis from childhood onwards provide useful UVR protection". To provide reliable labelling of the protective potential of lenses, an eye-sun protection factor (E-SPF®) was introduced a few years ago. It integrates UV transmission as well as UV reflectance of lenses. The E-SPF® reportedly compared well with established skin-sun protection factors and provides clear messages to eye health care providers and to lay consumers.

Level of UV protection with spectacle lenses
Commercially available spectacle lenses that often claim to provide '100%' or 'full' UV protection refer to transmission, absorption, block, cut-off, UV400 and Eye-Sun Protection Factor (E-SPF), yet none of these terms have been consistently adopted to quantify UV protection. Consequently, this can still lead to some confusion.

For example, ISO 8980-3:2022 specifies requirements for the transmittance properties of un-cut finished spectacle lenses and mounted pairs, including attenuation of solar radiation.[1] This defines the UV spectrum as up to 380 nm, whereas the World Health Organisation (WHO) and the International Commission of Non-Ionizing Radiation Protection (ICNIRP) define UV radiation up to 400 nm which has led to the introduction of UV 400 lenses (see below).

The potential risk of UVR exposure is present either from the front, if the lens does not adequately block UVR, or from the side, if the combined lens and frame do not provide appropriate coverage of the wearer's face (which is dependent of back vertex distance). UV reflection from the back surface of a spectacle lens is maximal between 10:00 and 14:00 (see Part 1) and particularly when facing away from the sun. A recent study demonstrated that the UV reflection risk is greatest when the wearer is about 135°-150° degrees from the sun, that is, with sunlight is coming from behind the wearer, just over their shoulder.[2]

Standard 1.5 refractive index lenses

These provide UVR protection up to 355 nm, however, the wavelengths between 355 and 400 nm represent about 70% of the total amount of solar UV irradiance. Standard 1.5 refractive index lenses account for approximately 50% of the lenses sales worldwide. Even higher index materials (typically made of polyurethane resins) do not provide maximum UV protection up to 400 nm, suggesting most spectacle lens-wearers are at risk of chronic ocular UVR damage.[3]

Clear ophthalmic lenses and UVR coatings

Spectacle lens manufacturers can now incorporate UVR absorbers into clear lens materials to provide UVR protection up to 400 nm (**Figure 1**). Achieving this without introducing a significant hue or lens darkening that compromises the cosmetic appearance and visual performance of the lens has, until recently, proved quite challenging. Although these ophthalmic lenses will not reduce glare like sunglasses, these UV blocking clear spectacle lenses are effective and provide good general UVR protection. For example, some manufacturers now include full UV protection up to 400nm in all clear plastic lenses using "UVProtect technology". This gives the same standard of UV protection provided by premium sunglasses.

Figure 1: UV absorbers incorporated into clear lens materials

Spectacle lenses do not offer complete ocular protection, since obliquely incident UVR may still reach the eye, either directly or by reflection off of the back surface of the spectacle lens. To prevent reflections from the back surface of the lens into the eye, some manufacturers incorporate back surface UV protection as standard.[4] Other lens manufacturers use similar acting coatings. However, in bright outdoor environments, clear spectacle lenses with a UVR filter coating may not provide adequate comfort.[5, 6, 7, 8, 9]

Spectacle lenses incorporating a UV absorber and an enhanced back surface anti-reflective coating provide the best protection from UVR up to 400 nm.

Anti-reflection (AR) coating

An anti-reflective (AR) coating increases luminous transmission of most spectacle lenses, reducing glare, and enhancing the cosmetic appearance of the wearer. An AR coating should be applied to both lens surfaces, since it will decrease the direct and internal reflections that can occur at each surface (**Figure 2**). This will reduce glare from light sources both in front of and behind the wearer. However, it is important to remember that by the way AR coatings work, this will inherently increase reflection of non-visible wavelengths such as ultraviolet (UV) and infrared (IR).[10]

Figure 2: AR coating - back reflections

AR coatings are applied in multiple layers on each lens surface, achieved through a physical vapour deposition technique, consisting of four-layer coatings of alternating high (either titanium oxide or zirconium dioxide) and low index (silicone dioxide) dielectric materials.[11] Recently, these coatings have also had a blue light control filter included to address (controversial) concerns around over-exposure to high energy visible (HEV) light emitted from e.g. visual display units, and smart phones (see below).

Most lens manufacturers (see above) now offer lens options with enhanced back surface anti-reflective coatings, incorporating additional layers to significantly reduce UVR reflected into the eye from the back surface of the lens.

Sunglasses

Sunglasses provide a vertical protection barrier to the eyes, whose effectiveness depends highly on the sunglass lenses' radiation transmittance, sunglasses' geometry and the exposure conditions. High UVR doses can reach the eyes even when sunglasses are worn however. Sun radiation reaches the eyes from above due to direct radiation circumventing the sunglasses, from below by reflected radiation from ground surfaces and from all other directions due to diffuse radiation from scattering by clouds and particles. Protection effectiveness of sunglasses is generally categorised by systems based on the lenses only, classifying the entire sun spectrum (UVR, infrared (IR) transmission and visible (Vis)) provided, without accounting for periorbital skin zones or environmental factors. Sunglasses come in many different types with tint colours and varying levels of transmission (darkness) that also provide protection against glare. A common misconception about sunglasses is that the darker lens, the more protection they offer, which is not necessarily the case.

Polarised sunglasses, further reduce glare and are good for driving and water activities. It's important to remember that polarisation is different to UV protection. While most polarised sunglasses offer UV protection, it's important to always ensure that they will also fully protect the eyes from UVR.

As mentioned above, colour and darkness of sunglasses does not affect how well they protect eyes from UV light. The shade and colour selection of sunglasses is purely a personal preference depending on individuals' lifestyles. For example, a grey or "black" tint is good for reducing brightness and glare without affecting colour perception. Brown tints increase contrast and clarity and are a good option for increasing colour vibrancy.

Mirrored sunglasses have thin layers of a metallic coating applied to a standard sunglass lens which are available in varying colours (**Figure 3**). Although they will reduce visible light transmission, they should never be assumed to protect the eyes from UVR.

Figure 3: Mirrored sunglasses

Not all sunglasses provide 100 percent UVR protection from all UV light. For 100% UVR absorption the manufacturer's labels should state "UV absorption up to 400nm." Whilst no ophthalmic spectacle lens is completely unbreakable, plastic lenses are less likely than glass lenses to shatter following an impact. Most non-prescription sunglass lenses are made from some type of plastic.

Over time, prolonged UVR exposure may deteriorate the coating of any UVR protective coating, thus reducing the UVR protective efficacy provided by the sunglasses concerned. Studies have found that if sunglasses are worn outside for up to 2 hours a day, they will offer full UV protection for 2 years. After this time, UVR protection will gradually reduce, and new sunglasses should be considered.

Ideally, sunglasses should have the largest lenses possible, preferably with a wrap around style to prevent side entry of UVR in order to provide maximal protection from solar irradiation. Sunglasses don't have to be expensive to be safe and effective. Relatively cheap e.g. supermarket or pharmacy sourced sunglasses labelled as "100 percent UV-blocking" are a better choice than expensive designer labelled sunglasses with sometimes lesser protection.

The most sun protective sunglasses in all exposure conditions are close-fitting goggles, blocking UVR from all directions (**Figure 4**). The estimated protection from UVR doses received by periocular skin zones by middle or large-sized sunglasses differs greatly and is strongly depended on environmental conditions at any one time. For example, middle-sized sunglasses highly protect from direct UVR, but much less from ground-reflected UVR.[12]

Figure 4: Close fitting goggles offer greatest UV protection

Photochromic or reaction lenses

These lenses are clear spectacle lenses that become dark outside when they are exposed to UVR. These lenses will therefore be clear inside and darker outside. Photochromic lenses are good for use indoors whilst also providing protection when outside. While photochromic lenses provide good UVR protection, they may not reduce glare and the brightness of lights as much as tinted or polarised sunglasses.

It is important to note that whilst driving, most car windscreens provide UVA and UVB protection, which in turn prevents photochromic lenses from reacting with UV light and darkening. This is because of an inner layer of polyvinyl butyral containing UVR absorbers added to the windscreen that prevents photochromic activation when inside the vehicle. However, most side and rear windows do not contain any UV filter for either UVA or UVB radiation. As a consequence, these untreated windows can transmit up to 80 percent of UVA radiation. Even tinted windshields are not an effective means of protection, because these only filter out around 40% of UVA radiation.[13]

It's important to remember that photochromic lenses darken and lighten to varying speeds and amounts depending on the manufacturer and brand. Also, photochromic lenses can take longer to adjust in lower temperatures.

Blue light spectacle lenses

These offer some UV protection via a coating on clear spectacle lenses. Blue light filtering does not reduce glare and light sensitivity as effectively as sunglasses. However, blue light filtering coatings can be added to sunglasses to increase the wavelength range of protection. For the past two decades, the clinical application of ophthalmic lenses that attenuate the transmission of short-wavelength visible (blue) light has remained controversial.

Blue light filtering, also termed blue-blocking, lenses reduce ocular exposure to both UVR (involving wavelengths in the 100-400 nm range), and short-wavelength visible light (including violet, 400-440 nm, and blue, 440-500 nm light). The 2 principal categories of blue light-filtering lens products are:

- Spectacle lenses
- Intraocular lenses (IOLs) which contain, or are coated with chromophores that absorb a proportion of the selected incident wavelengths

Blue-light filtering spectacle lenses, which attenuate short-wavelength light, are currently being marketed to alleviate eyestrain and discomfort when using digital devices, improve sleep quality and potentially confer protection from retinal phototoxicity. Lawrenson et al (2017) found a lack of high-quality evidence to support using blue light filtering spectacle lenses for the general population to improve visual performance or sleep quality, alleviate eye fatigue or conserve macular health.[14] These findings have been supported by a more recent systematic review that concluded to date, there is a lack of consistent evidence for a larger-scale introduction of blue light filtering lenses in routine clinical practice.[15]

The blue light hazard is therefore reportedly misused as a marketing stratagem to alarm people into using spectacles and IOLs that restrict blue light. Blue light loss is permanent for pseudophakes with blue-blocking IOLs. Blue light hazard misrepresentation flourishes despite absence of proof that environmental light exposure or cataract surgery causes AMD (see part 1) or that IOL chromophores provide clinical protection. Blue-filtering chromophores suppress blue light critical for good mental and physical health and for optimal scotopic and mesopic vision.[16]

Polycarbonate lenses

Polycarbonate absorbs all UVR below 380 nm, unlike crown glass and CR-39® which have to be treated to provide UVR protection.[17] They also make a prescription lens 25% thinner and more impact resistant. The glare and brightness of light outdoors can be reduced in polycarbonate lenses by tinting or polarising them as with regular sunglasses. Photochromic lenses made from a polycarbonate material are also available.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) and numerous health organisations have defined the standard for UV protection as 400 nm (see Part 1). Due to the potential health risks associated with UV exposure, scientific and regulatory bodies and organisations researching the biomedical impact of light and radiation have clearly defined the need for UV radiation protection as 400 nm. The irradiance between 380-400 nm is much more intense and represents 40% of the total solar irradiance as measured on earth.

Relevant eyewear regulations

Protective eyewear (often manufactured from polycarbonate) is diverse and is designed to counter a variety of risks such as splatter, impact and light filtration. UV rays from the sun is one of the biggest risks to the eyes.

- **EN 166: 2001** is the European standard covering the requirements for protective eyewear. It is closely linked to EN 167:2001 and EN 168:2001 which specify the optical and non-optical test methods.[18] EN 166 specifies the minimum requirements for a range of performance tests. This standard contains a set of requirements referred to as 'basic requirements', which may be regarded as mandatory. EN 166 also requires optical assessment of the lens or face shield under EN 167. This includes tests for the field of vision, transmission and diffusion, and refractive properties (**Figure 5**).

Figure 5: Polycarbonate mirrored protective glasses to EN166 standard

The main purpose of these tests is to ensure the eyewear does not impede or distort the vision of the user. It also makes sure the eyewear allows sufficient light through to the wearer's eyes. The field of vision test is intended to ensure that nothing in the frame or the periphery of the lenses reduces vision.

Exposure to UV light can affect the transmission properties of safety glasses. These properties are measured again after the eyewear has been exposed to UV light. To meet the requirements, the transmission results must not exceed an impairing amount.

There are a number of other regulations with which the reader should be familiar, with regards to standards applied to sunglasses and other devices used to provide UVR protection.

- *Eye and face protection — Sunglasses and related eyewear — Part 1: Sunglasses for general use - ISO 12312-1:2022*[19]

This document refers to all afocal (plano power) sunglasses and clip-ons for general use, including road use and driving, intended for protection against solar radiation.

This document applies to all goggles with plano lenses, intended for eye protection against hazards including UVR and visible solar radiation, rain, snow and wind, during downhill skiing, snowboarding and other similar activities.

ISO 12312-1:2022 categorises filters for sun glare use into five groups, according to their range of luminous transmittance (Tv):

Filter category Description Range of luminous transmittance in the visible spectral range:

0. Clear or very light tint rom over 80% to 100% - ideal for fashion and indoor use.
1. Light tint from over 43% to 80% pale lenses - for overcast days
2. Medium tint from over 18% to 43% - for protection against glare (**Figure 6**)
3. Dark tint from over 8% to 18% dark lenses - for bright days (the most common category)
4. Very dark tint from over 3% to 8% - very dark lenses for intense sunshine (i.e. on mountains and glaciers)

Figure 6: Category 3 sunglasses

According to the College of Optometrists Professional Guidance (A277-279), filters suitable for road use and driving are included in categories 0, 1, 2 or 3. Also, the spectral transmittance of filters suitable for road use should not be less than 0.2 x Tv for wavelengths between 475 and 650 nm, and the relative visual attenuation coefficient Q of filters of categories 0, 1, 2 and 3 suitable for driving and road use should not be less than 0.8 for red and yellow signal lights, and not less than 0.6 for yellow, green and blue signal lights. Sunglass filters with a luminous transmittance of less than 75% are not suitable for road use in twilight or at night.

- *Eye and face protection for sports use — Part 1: Requirements for downhill skiing and snowboarding goggles - ISO 18527-1:2021*[20]

This document applies to downhill skiing and snowboarding goggles fitted with an insert to carry prescription lenses. It specifies requirements and testing for materials, performance, marking of goggles and information to be supplied by the manufacturer.

- *Eye and face protection — Sunglasses and related eyewear — Part 2: Filters for direct observation of the sun - ISO 12312-2:2015*[21]

This applies to all afocal (plano power) products intended for direct observation of the sun, such as solar eclipse viewing.

Contact lenses

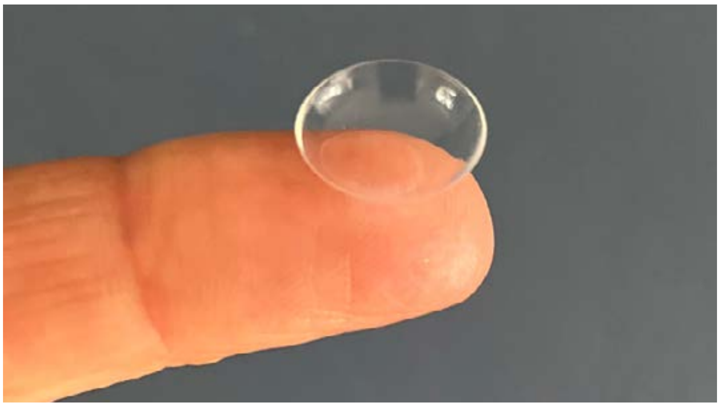

Figure 7: Not all contact lenses are UV blocking

Figure 8: RGP lenses offer less corneal coverage and therefore less UVR protection

Contact lenses can be effective UVR absorbers but contact lenses without a UVR blocker transmit 90% of the UVR spectrum (**Figure 7**). Both soft contact lens (SCL) and rigid gas permeable (RGP) contact lenses with UV filters are available. According to American National Standards Institute, UV blocking contact lens must absorb a minimum of 95% of UVB and 70% of UVA (see below). In general, SCLs offer more protection than RGPs because the former provides complete corneal and partial conjunctival coverage while the latter only covers a portion of the cornea (**Figure 8**).

One of the common standards used for UV transmission of contact lenses is the ANSI Z80.20 provided by the American National Standards Institute (ANSI) (see **Table 1**).

Table 1 *ANSI Z80.20-2010 Standards for contact lens UV absorption claims*

		Tolerance limits	
		UVB (280-315nm)	UVA (216-280nm)
Ultraviolet radiation Transmittance τ_{UV}	Class 1 absorber	$\tau_{UVB} < 0.01\,\tau_{V}$	$\tau_{UVA} < 0.10\,\tau_{V}$
	Class 2 absorber	$\tau_{UVB} < 0.05\,\tau_{V}$	$\tau_{UVA} < 0.50\,\tau_{V}$

Note - This requirement is only applicable for contact lenses with a UV absorption claim.

Source – The ACLM Contact Lens Year book 2022

Table 2 *ISO 18369-2: 2006 Standards for contact lens UV absorption claims*

Property		Tolerance limits		Relevant Method
Ultraviolet radiation Transmittance τ_{UV}	Class 1 absorber	UVB 280-315nm $\tau_{UVB} < 0.01\,\tau_{V}$	UVA 316-380nm $\tau_{UVA} < 0.10\,\tau_{V}$	ISO 18369-3 2006.4.6
	Class 2 absorber	UVB 280-315nm $\tau_{UVB} < 0.05\,\tau_{V}$	UVA 316-380nm $\tau_{UVA} < 0.50\,\tau_{V}$	ISO 18369-3 2006.4.6

Note - τ_{UVA} and τ_{UVB} are the average ultraviolet transmittance of the contact lens, summated over wavelengths shown.
This requirement is applicable only to contact lenses for which UV absorption is claimed.

Source – The ACLM Contact Lens Year book 2022

As noted by the American Optometric Association, the U.S. Food and Drug Administration (FDA) has standards for UV-blocking contact lenses based on American National Standards Institute Z80.20 standards. There are two classifications of UV-blocking lenses:[22]

- **FDA Class I blocker:** recommended for high-exposure environments such as mountains or beaches. The lenses in this classification must block more than:
  - 90% of UVA (316-380 nm wavelengths) and
  - 99% of UVB (280 – 315 nm)

- **FDA Class II blocker:** recommended for general purposes. These lenses must block more than:
  - 70% of UVA and
  - 95% of UVB

The ACLM contact lens year book is an excellent reference source to check any commercially available contact lens UVR absorbing properties and which category they each belong to. Interestingly all RGP materials appear to be all category 2 with none in category.[1] There are many SCL brands available with different levels of UVR protection.

Contact lenses with UV-blocking technology may protect the part they cover from harmful radiation, but they leave the outside of the eye – including the eyelid, conjunctiva and surrounding skin exposed. Contact lenses are no substitute for protective UV-absorbing eyewear (with 100% UV protection) and head coverings.[23]

Several scientific studies have demonstrated that after UVR exposure, the unprotected cornea is vulnerable to damage in the epithelial, stromal, and endothelial cellular layers. DNA damage, apoptosis, and altered protease expression are all examples of harmful changes that can occur within the cornea after irradiation (see Part 1). Beyond the cornea, damage associated with UVR exposure, such as decreased antioxidant levels and increased reactive oxygen species (ROS) production, has been noted in the aqueous humour and crystalline lens. UVR -blocking contact lenses provide protection against such exposure to harmful UVR. Shielding the aqueous humour and crystalline lens from irradiation with UV-absorbing SCLs also helps protect against pre-cataractous changes.[24]

In one recent study, UVR and visible light transmittance of soft contact lenses (SCLs) was measured for a range of materials. A significant difference in UVR transmittance was found between SCLs with a positive and negative back vertex power (BVP) and that thicker SCLs absorbed more UV radiation.[25]

A total of 21 SCL brands were investigated in the BVP range of -12.00 to +6.00 D. Three SCLs were measured per BVP 25 times. SCLs with a UV filter included:

- stenfilcon A
- somofilcon A
- narafilcon A
- senofilcon A
- senofilcon C
- etafilcon A
- nesofilcon A

SCLs without a UV filter included:

- delefilcon A
- lotrafilcon A
- lotrafilcon B
- comfilcon A
- balafilcon A
- samfilcon A
- asmofilcon A
- nelfilcon A
- omafilcon A
- hilafilcon B
- ocufilcon D
- hioxifilcon A
- omafilcon B73

All UV-absorbing SCLs tested met UVR protection class 2. Senofilcon A, senofilcon C, and narafilcon A met the higher UVR protection class 1 level. A statistically significant difference in UV transmittance (280 to 380 nm) was been found between SCLs with a positive BVP (+1.00 to +6.00 D) and SCLs with a negative BVP (-1.00 to -12.00 D).

UV-blocking photochromic SCLs

By incorporating a process of polymerisation of a bi-continuous nano-emulsion, these lenses have recently been reported in the literature providing a novel alternative to photochromic spectacles. Transparent nano-structured polymers are used incorporating a polymerisable surfactant and thermal initiator together with water, monomers, UV blockers and photochromic dyes. These new polymers have reportedly good oxygen permeability, water content, stiffness, strength and UV-blocking ability comparable to commercial UV-blocking soft contact lenses.[26] Approved recently by the FDA, they are commercially available as e.g. Acuvue Oasys Contact Lenses with Transitions Light Intelligent Technology.[27, 28]

"UV contact lenses"

These are heavily marketed to party goers who want to stand out from the crowd at e.g. Halloween and other similar events. UV contact lenses are not glow in the dark lenses but UV will only glow under a UV blacklight. They cannot be 'charged up' and they will not glow in darkness or at night. UV glow contacts have reportedly undergone the relevant standard safety checks and have the same certification. They have allegedly been submitted to the same rigorous testing and quality control as every natural and costume style of contact lenses.[29] UV contacts are printed with dye containing phosphors that glow when exposed to radiation emitted by ultraviolet lights/blacklights. However, the glow fades over time and eventually stops.

Surgical options – intraocular lenses (IOLs)

Cataract surgery, with intraocular lens (IOL) implantation, is the most common ocular surgical procedure worldwide. Since the late 1980s implantation of UV-blocker IOLs during cataract surgery has become an internationally accepted standard (**Figures 9** and **10**).

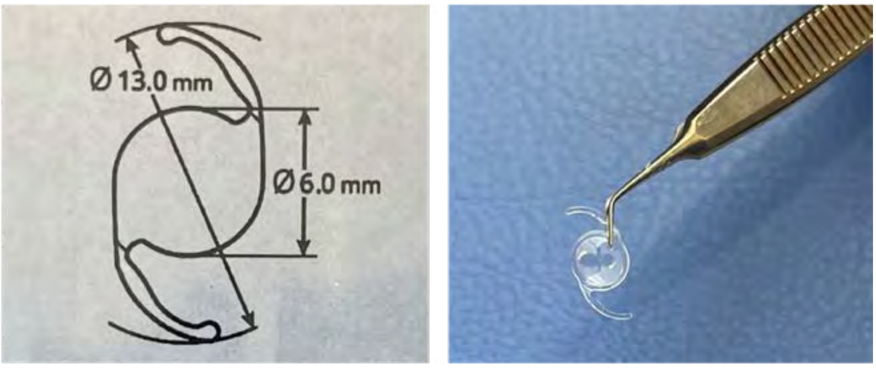

Figure 9: UV filtering IOL

Figure 10: Examples UV filtering IOL

Cornea, aqueous and vitreous absorb UV radiation below 300 nm, while the natural adult lens absorbs UV radiation between 300 and 400 nm. This protection is lost when the lens is removed by cataract surgery and thus should be restored. UV light does not contribute to vision but damages retinal structures. Therefore, UV-blocking IOLs with a 10% cut-off near 400 nm should be implanted during cataract surgery. This ensures sufficient retinal protection after surgery.[30]

It has been suggested that IOLs that also selectively attenuate short wavelength visible light (blue light-filtering IOLs) may be beneficial for macular health. Whether blue light-filtering IOLs provide retinal photoprotection is of public health relevance, particularly with regards to an aging population and the increasing global prevalence of age-related macular degeneration.

The introduction of blue-filtering intraocular lenses (BFIOLs) for implantation after cataract surgery is still the subject of active debate, with the publication of a substantial volume of literature focusing on the potential advantages and disadvantages of BFIOLs compared with ultraviolet filtering lenses (UVFIOLs). BFIOLs are also referred to as yellow or orange-tinted intraocular IOLs (**Figure 11**).[31] Theoretical disadvantages of implanting a BFIOL compared with a UVFIOL have been discussed in the literature for many years now. The main concerns are that implantation of a BFIOL will lead to:

Figure 11: Blue filtering IOL

- Altered colour perception
- Reduced colour vision
- A reduction in scotopic visual function
- Reduced contrast sensitivity in mesopic and scotopic conditions
- Disruption of circadian photo-entrainment

Interestingly, an innovative phototropic IOL has been previously reported that is clear in the absence of UVR and turns yellow in the presence of UVR. It is suggested that this lens could provide optimal protection from short-wavelength blue light during the day and then turn clear in low lighting conditions.[32]

A recent Cochrane systematic review included 51 randomized controlled trials that were performed in 17 countries. The trials involved adults undergoing cataract surgery in which a blue light-filtering IOL was compared with an equivalent non-blue light-filtering IOL. Study follow-up periods ranged from 1 month to 5 years.[33]

There is substantial evidence in the literature that implantation of a BFIOL does not impair visual acuity, photopic, scotopic, or colour vision, or disrupt the sleep–wake cycle. Also, there are some definite and theoretical benefits associated with implanting a BFIOL, including improved performance in glare. However, using blue light-filtering IOLs to protect the macula is currently not supported by the best available clinical research evidence, and it is important that clinicians are mindful of this evidence limitation when adopting these devices in clinical practice.[29]

Blue light in general

Blue light is emitted in visible light between the wavelengths of 400 to 500 nm. The main source of blue light is sunlight, but digital screens, light-emitting diodes (LEDs), and fluorescent lighting serve as additional sources. There has been prolific development of light sources emitting potentially toxic blue light (415-455nm) ranges from LED (Light Emitting Diodes) lamps for interior lighting to television screens, computers, digital tablets and smartphones using OLED (Organic Light Emitting Diode) or AMOLED (Active-Matrix Organic Light Emitting Diode) technology.

Concerns about the negative effects of blue light have rapidly increased over the past 15-20 years, and consequently there has been much interest on this topic in the literature.[34] Blue light can be both harmful and beneficial to the skin, depending on intensity and wavelength. Low-energy and low exposure times to high-energy blue light can help prevent skin diseases (see Part 1), while studies have revealed that longer exposure to high-energy blue light can increase the amount of DNA damage, cell and tissue death, eye damage, skin barrier damage, and photo-aging.

While protection from natural blue light can be achieved by wearing coloured spectacle lenses which filter out (on both front and back surfaces) the potentially toxic wavelengths, it is more challenging to ensure protection from LED lamps in internal lighting, the use of which should be restricted to "white warmth" lamps (2700K). A recent study investigated the optical radiation safety evaluations of LED flashlights to determine if they pose potential ocular hazards. In summary, these flashlights were found to present a moderate to low risk for retinal damage. However, none of the flashlights presented a UVR hazard or a retinal thermal hazard.[35]

General advice for protection against UVR

General advice regarding UV skin protection includes:

- Regular application of appropriate factor sunscreen (at least sunscreen protection factor (SPF) 15 with UVA protection). The amount of sunscreen needed for the body of an average adult to achieve the stated SPF is around 35 ml or 6 to 8 teaspoons of lotion1. There are minimum standards for UVA protection for sunscreen lotions where the label should have the letters 'UVA' in a circle logo. Preferably, the label should state that it provides good UVA protection e.g. at least '4-star UVA protection'.[1] If sunscreen is applied too thinly, the amount of protection it gives is reduced. Using SPF30 sunscreen or higher may partially overcome problems with inadequate application. But it does not necessarily mean people can spend more time in the sun without the risk of burning.[1]
- Wearing a hat with a broad brim. However, such a hat may not shield the indirect UVR, hence potentially 50% of the UVR may still enter the eyes.
- Minimising outdoor direct sunlight exposure between 10:00 and 14:00 hours. When sunny weather is expected, check Met Office UV Index Forecasts[36] and the UK Air Information resource.[37]
- The World Health Organisation and World Meteorological Organisation have continued to develop the Global Solar UV index (UVI), which provides the public with an estimate of UVR on any given day anywhere in the world.[38] The UVI has been categorised as follows:
    - Low (0–2)
    - Moderate (3–5)
    - High (6–7)
    - Very high (8–10) and
    - Extreme (11+)

- Choosing appropriate clothing as thin or wet clothing is less protective than thick clothing, and synthetic materials provide more protection from solar radiation than cotton materials.
- Limiting exposure time in high intensity UV environments. Sunburn and even a tan is a sign of over-exposure to UV – that's physical damage to your skin caused by UVR. Premature skin ageing is another sign of damage.
- Combination of above - although the most effective method is avoidance.
- While most window panes provide a certain degree of UV protection, a portion of the damaging UV light – UV-A radiation – comes through without being filtered out. You can see this in e.g. clothes that have been in a display window for a longer period of time the sunlight causes the colours to fade.

Summary

Chronic UVR effects on the eye are cumulative, so effective UV protection of the eyes is important for all age groups and should be used systematically. Protection of children's eyes (**Figure 12**) is especially important because UVR transmittance is higher at a very young age, allowing higher levels of UVR to reach the crystalline lens and even the retina. Sunglasses as well as clear lenses (plano and prescription) effectively reduce transmittance of UVR.

Figure 12: UV protection is most important for children

The second and final part of this review has discussed the importance of wearing sunglasses as well as other methods of protection from UVR over exposure.

This review has provided all the relevant peer reviewed evidence that optometrists should be fully conversant with in order to:

- Disseminate relevant healthcare information
- Discuss the varying effects (both positive and negative) of UVR exposure and
- Explain to patients the best ways to appropriately protect themselves from UVR exposure as necessary

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How to explain that a piece of CPD benefits your practice and patients

Below are examples of situations where linking CPD to your practice may be less obvious. We've shown how you might link a learning objective to your own practice and patient care where the GOC might feel it is slightly out of core scope of practice:

For a DO completing a contact lens session

This CPD has the learning objective *Practitioners will have a greater understanding of the features, benefits and contraindications of toric contact lenses*. As a dispensing optician I am frequently asked by patients about their options for vision correction, and a common question is how to manage the problem of spectacles steaming up during mask wear which may be required throughout the working day. In order to help them I need to explain the options not only for spectacles but also for dual wear of spectacles and contact lenses, and know what products may suit their prescription. It is therefore important I am up to date with toric contact lenses and the patients who are and are not suitable for this form of vision correction so I can answer patient queries accurately and provide appropriate advice and care.

For an optom completing a therapeutics session

This CPD has the learning objective *Practitioners will have a greater understanding of the therapeutic management of red eye conditions*. As an optometrist, the more understanding of therapeutic options I have the better to enable me to give patients I decide to refer rather than to manage in practice information and reassurance about what may be considered in the next steps of their care pathway, to enhance their satisfaction with their care. Also as part of my CPD plan I am working towards taking on part-time work in a hospital clinic and therefore enhancing my understanding of therapeutic treatments of ocular conditions will support my development in preparation for this new role.

For a CLO competing an optometry session

This CPD has the learning objective *Practitioners will have a greater understanding of good record keeping and referral decision-making*. The cases involved investigation and diagnosis of anterior eye conditions and best practice in documentation of the results. I am part of a multidisciplinary team which is involved in a MECS eyecare scheme so I carry out under supervision diagnostic tests and complete records relating to collecting baseline data and investigation/management of MECS patients. This session broadened my understanding of best practice in care and documentation relating to anterior eye conditions which I could come across in my MECS work.

How to log your CPD points with the GOC

In the CPD scheme the provider does NOT notify the GOC of your points.

To claim your CPD points you must enter the details on the GOC site MyGOC before the end of each calendar year.

You will be asked to provide the C-reference (see the front of this article), which will populate some of the details of this CPD unit. You will also be asked for evidence of completion. The evidence of completion you will need is the certificate which is automatically saved to your iLearn account when you complete the CPD.

More information on how to plan, access and record the CPD and download the certificate is available by clicking on the following link: CPD Information

Please send us your feedback

We would be very pleased for feedback on this or any other CPD we provide. Please give us feedback by clicking on the link provided in the confirmation email after you have submitted the quiz.

