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ULTRAVIOLET TRANSMITTANCE OF THE VISTAKON DISPOSABLE CONTACT LENSES

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Abstract — *With increasing scientific evidence demonstrating the harmful effects of ultraviolet (UV) radiation on different ocular tissues, contact lens manufacturers are incorporating UV blocking monomers into their contact lenses. This study evaluated the transmittance spectra of Vistakon's disposable soft contact lenses (1 Day Acuvue, Acuvue, Surevue, and Vistavue). All except Vistavue contain a UV blocking agent. Transmittance for each lens was recorded from 200 to 400 nm on a Shimadzu UV 160U Dual Beam Recording Spectrophotometer. The results indicate that lenses which incorporate the UV blocking monomer significantly reduced the transmission of UV radiation while untreated lenses did not. Our findings indicate that 1 Day Acuvue, Surevue, and Acuvue meet the American National Standards Institution (ANSI) Standard Z80.20 for Class 2 UV blockers: a maximum of 30% transmittance of UVA wavelengths and 5% transmittance of UVB wavelengths. In contrast, the Vistavue lens demonstrated negligible UV blockage. Our technique, in which contact lenses were placed directly in front of a measuring beam, was accurate and simpler than previously reported methods and may be useful in future studies. We found that UV blocking soft contact lenses can be a viable alternative for spectacles in protecting internal ocular structures from UV radiation. However, the external structures of the eye remain at risk and would continue to benefit from the use of UV blocking sunglasses or spectacle lenses.* Contact Lens and Anterior Eye *(2000)* **23,** *10-15.*

KEY WORDS: ultraviolet (UV) transmittance, disposable contact lenses, spectrophotometer

Introduction

The adverse effects of ultraviolet light on ocular tissues have been well documented.[1,2] The UV spectrum is divided into three bands: UVA (320 to 400 nm), UVB (280 to 320 nm), and UVC (100 to 280 nm). Each UV band has shown to be absorbed differently by ocular tissues. UVA, the closest band to the visible spectrum, is preferentially absorbed by the cornea and retina. UVB is mainly absorbed by the crystalline lens and partially by the retina. UVC is typically filtered out by the ozone in the atmosphere.[3] Cataracts, pinguecula, pterygium, photokeratitis, age-related macular degeneration, as well as damage to the epithelial limbal stem cell population, thought to be important in the healing properties of the cornea and conjunctiva, are believed to be caused by exposure to damaging amounts of ultraviolet radiation.[3-10] Previous studies have found that contact lenses manufactured with ultraviolet absorbing monomers reduce UV transmittance[11-14] which translates to protection to the cornea.[15] Until recently, the majority of soft contact lenses were manufactured with negligible UV absorbing capabilities. Since UV absorbing spectacle lenses decrease the amount of ocular exposure to ultraviolet radiation versus non-UV absorbing contact lenses,[16] wearers of non-UV absorbing soft contact lenses who do not use secondary UV protection could be at increased risk for developing ocular conditions linked to ultraviolet radiation when compared to patients wearing spectacles with UV-absorbent properties.

A number of soft contact lens manufacturers have begun incorporating UV absorbing monomers into their lenses. The reported UV protection levels from a number of studies of various UV absorbing contact lenses show transmittance spectra[12-14] that are consistent with, or better than, the protection offered by spectacle lenses, when comparing the transmittance spectra of various ophthalmic material (e.g. glass, plastic) and considering the effects of the atmosphere on UVC transmittance. Furthermore, the limbal coverage offered by soft contact lenses could yield increased protection of the internal structure of the eye from oblique and scattered UV rays that are not blocked by spectacle lenses resting some distance (e.g. 15 mm) from the cornea.[16] The distance from the spectacle plane to the corneal plane increases in importance as a factor in UV protection as the UV intensity increases secondary to changes in altitude (e.g. mountain dwelling populations) and the atmosphere (e.g. ozone depletion).[1,10] As the depletion of the ozone layer continues, it is predicted that there will be increases in the amount of short wavelength UV light reaching the earth's surface, and, consequently, an increase in associated health problems.[10] Coupled with an increased amount of leisure time spent outdoors as well the rising popularity of the disposable mode of soft contact lens wear, UV protection could be a significant consideration in the fitting of soft contact lenses.[1]

Previous studies evaluating the efficacy of UV absorbing soft contact lenses in reducing UV transmittance have found attenuation ranging from 1 to 95.5% in the UVA wavelengths, with UVB attenuation ranging from 0 to 30%, depending on lens type.[11-14] These studies incorporated either a single or dual beam spectrophotometer and involved cutting the contact lens to fit into a cuvette.

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With these facts in mind, our study was designed to evaluate the UVA, UVB, and UVC transmittance spectra of Vistakon's soft disposable contact lenses: 1 Day Acuvue, Acuvue, Surevue, and Vistavue. We also employed a simplified procedure by which to evaluate UV transmittance of a contact lens.

Methods

We evaluated 15 lenses each of 1 Day Acuvue, Surevue, Acuvue, and Vistavue. Lenses from each line were obtained from two different lots to minimize sampling error. Back optic zone radius and back vertex power parameters were chosen to maintain consistency between the lenses and to compare with the manufacturer's data. All lenses evaluated had the same power. It has been shown previously that lens power does not have a statistically significant effect on transmittance of soft lenses.[17] *Table 1* lists the parameters of the lenses evaluated. The centre thickness of each lens was measured with a Rehder Development Corporation Electronic Thickness Gauge Model ET-3 according to the manufacturer's recommendations (David Rehder, personal communication, University of California, Berkeley School of Optometry).

A Shimadzu UV 160U Dual Beam Recording Spectrophotometer (Shimadzu Scientific Instruments, Inc., 7102 Riverwood Drive, Columbia, Maryland 21046, USA) was used to measure the UV transmittance of the lens. This spectrophotometer has six standard measuring modes to analyse absorptive and/or transmissive characteristics. We utilized the spectrum mode which allowed absorption or transmission measurements to be made continuously as the wavelength varied. In the spectrum mode, the instrument plotted the transmittance of each sample as it scanned across the pre-set wavelength range. We eliminated possible UV absorption by any material other than the lens itself by using an open-air lens holder design rather than the standard quartz lens holder. The open-air lens holder consisted of two rectangular pieces of clear plastic measuring 12.0 × 30.0 mm. A smaller central area of plastic measuring 8.0 × 23.0 mm was then removed from each lens holder.

The spectrophotometer tray contained two slots. One slot housed the contact lens sample (S) within its lens holder and the other slot was the reference (R). Since the UV beam only passed through the contact lens itself and no other material or medium, the R slot was left empty. Prior to the placement of each contact lens in the S slot, the transmittance was confirmed to be 100% to eliminate minor drift errors. Each contact lens was removed from its original sealed blister pack with clean tweezers and quickly positioned between the two lens holders with the convex side facing the scanning beam. The spectral mode was then initiated and the spectrophotometer recorded the per cent transmittance at every 10 nm interval for each individual contact lens.

Each contact lens was placed between the two lens holders and inserted into the S slot of the spectrophotometer tray. *Figure 1* illustrates the placement of the contact lens between the lens holder. While the UV beam was on, we placed a white background behind the S slot and determined visually that the UV beam did not come in contact with any portion of the lens holder. A baseline scan without any contact lens was also done to ensure that the transmittance in air was 100% across the preset wavelength range of 200 to 800 nm.

Results

Our results are summarized in *Table 2* and *Figure 2*. In *Table 2*, for each lens type, the transmittance values obtained for each wavelength were averaged, and the highest and lowest of those averaged values over a particular spectrum (e.g. 320 to 400 nm) were then

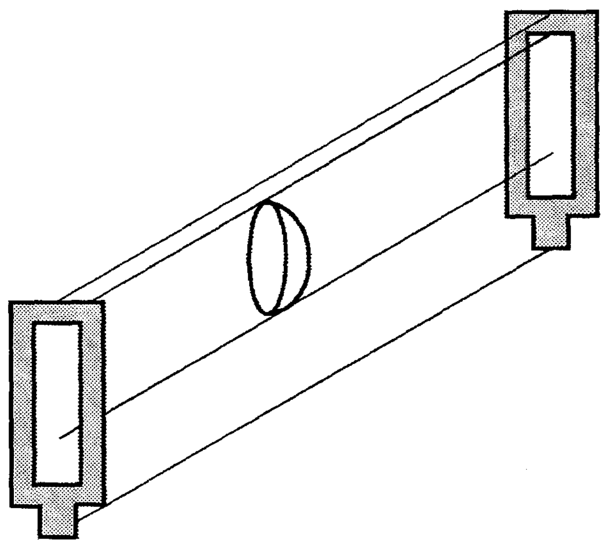

Figure 1. *A schematic diagram illustrating the orientation and configuration of the sample contact lens in relation to the lens holder. The lens holders are sandwiched in contact with the contact lens prior to insertion into the specrophotometer.*

Table 1. *The contact lenses evaluated in this study*

Lens name	*Material*	*Back vertex power*	*Back optic zone radius (mm)*	*Mean centre thickness (mm)*	*Total diameter (mm)*	*Handling tint*	*UV blocker*
1 Day Acuvue	etafilcon A	–3.00 DS	9.00	0.066 ± 0.007	14.20	no	yes
Surevue	etafilcon A	–3.00 DS	8.80	0.100 ± 0.006	14.00	yes	yes
2 Week Acuvue	etafilcon A	–3.00 DS	8.80	0.075 ± 0.007	14.00	yes	yes
Vistavue	genfilcon A	–3.0 DS	8.60	0.071 ± 0.005	14.00	yes	no

listed to give a general measure as to the amount of UV radiation transmitted by a specific lens type over a specific spectrum. From *Figure 2*, for all four lens types at wavelengths longer than 400 nm, there was a high, relatively uniform range of transmittance of approximately 83 to 90% for wavelengths longer than 400 nm among all four lens type. For the 1 Day Acuvue, Surevue, and Acuvue lenses which contain a UV blocker, the spectrum showed a sharp drop off beginning at 380 nm with an 83 to 90% transmittance and ending at 290 nm with a 1 to 3% transmittance. The spectrum for these three lens types then showed a sharp spike beginning at 280 nm and ending at 240 nm with a peak of 25 to 40% transmittance at 270 nm. Below 240 nm, there was less than 1% transmittance for these three lens types.

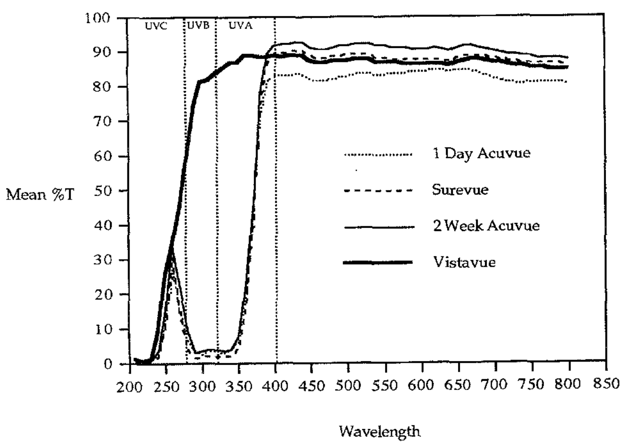

Figure 2. *Mean per cent transmittance of wavelengths from 200 to 800 nm of 1 Day Acuvue, Surevue, Acuvue, and Vistavue.*

In contrast, the transmittance spectrum for the non-UV blocking Vistavue lens did not show a sharp drop until 300 nm. Above 300 nm, there was approximately an 80 to 88% transmittance for the Vistavue lens. Beginning at 300 nm with an 80% transmittance, the spectrum decreases rapidly until it began to plateau at 230 nm with less than 1% transmittance at 230 nm and below.

In the statistical analysis of our data, we used a number of techniques to summarize them. For each of the contact lens types, the data from the 15 lenses were collapsed to a single line using the Lowess function in S-plus.[18] (For each wavelength analysed, surrounding data points are taken into consideration to estimate an 'average' UV transmittance for that wavelength. By doing so, this analysis created a smooth curve of transmittance across wavelengths).

To get a representation of the amount of variation of our estimates, we used a Monte Carlo simulation.[18] (We

Table 2. *UV Transmittance of the lenses evaluated in this study*

	1 Day Acuvue	*Surevue*	*2 Week Acuvue*	*Vistavue*
UVA Transmittance 320 to 400 nm	2.8 to 82.8%	1.5 to 89.0%	3.2 to 91.3%	83.2 to 88.4%
UVB Transmittance 280 to 320 nm	2.4 to 5.9%	1.3 to 3.7%	2.9 to 9.0%	60.2 to 83.2%
UVC Transmittance 200 to 280 nm	0.4 to 26.8%	0.3 to 30.4%	0.4 to 33.7%	0.4 to 60.2%

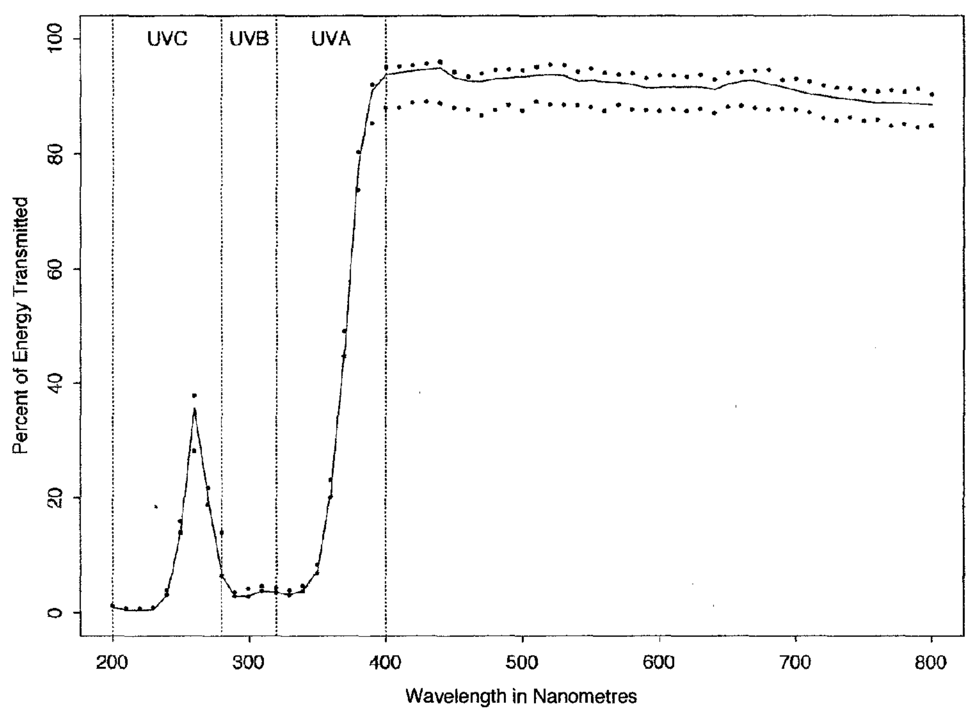

Figure 3. *UV transmittance spectrum of Acuvue lenses generated by the Lowess function in S-plus using a 5% nearest neighbour setting. Black dots represent variation inherent in the Monte Carlo estimation scheme.*[18]

generated 200 Lowess curves by statistical sampling with replacement of the data. We then eliminated the top and bottom 2.5% of these curves to give the cut offs marked as black dots in *Figures 3–6*. The cut offs in *Figures 3–6* give us a measure of the variation inherent in the estimation scheme.

A comparison of means was made to determine if all four lens types can be considered statistically identical with respect to UV blocking characteristics. Six different comparisons were made between the four lens types with the following results: when the 1 Day Acuvue, Surevue, and Acuvue lenses were individually compared

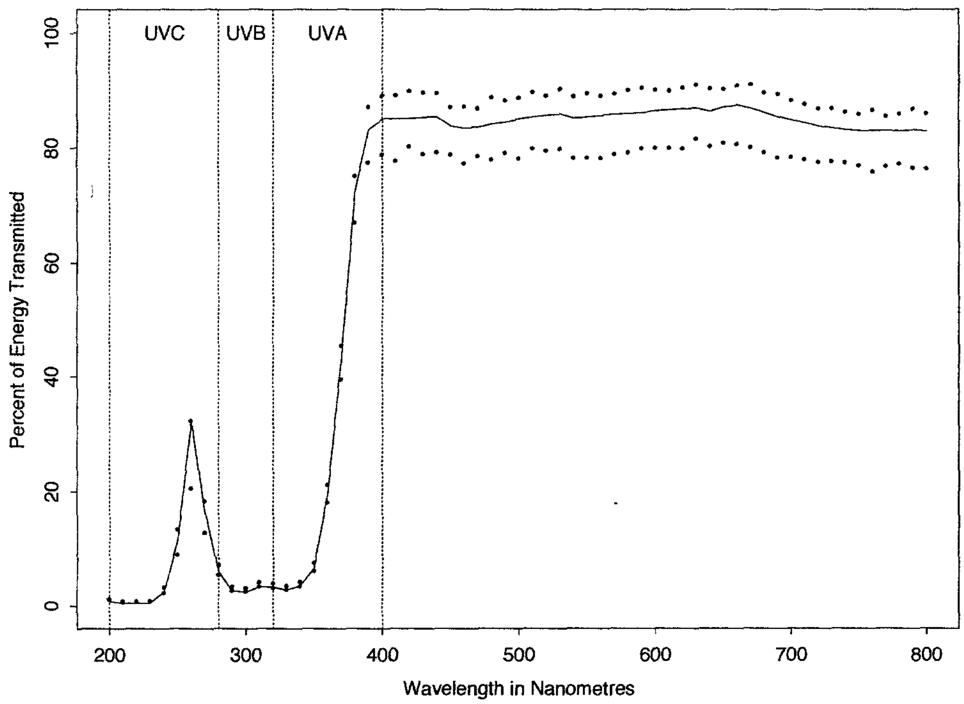

Figure 4. *UV transmittance spectrum of 1-Day Acuvue lenses generated by the Lowess function in S-plus using a 5% nearest neighbour setting. Black dots represent variation inherent in the Monte Carlo estimation scheme.*[18]

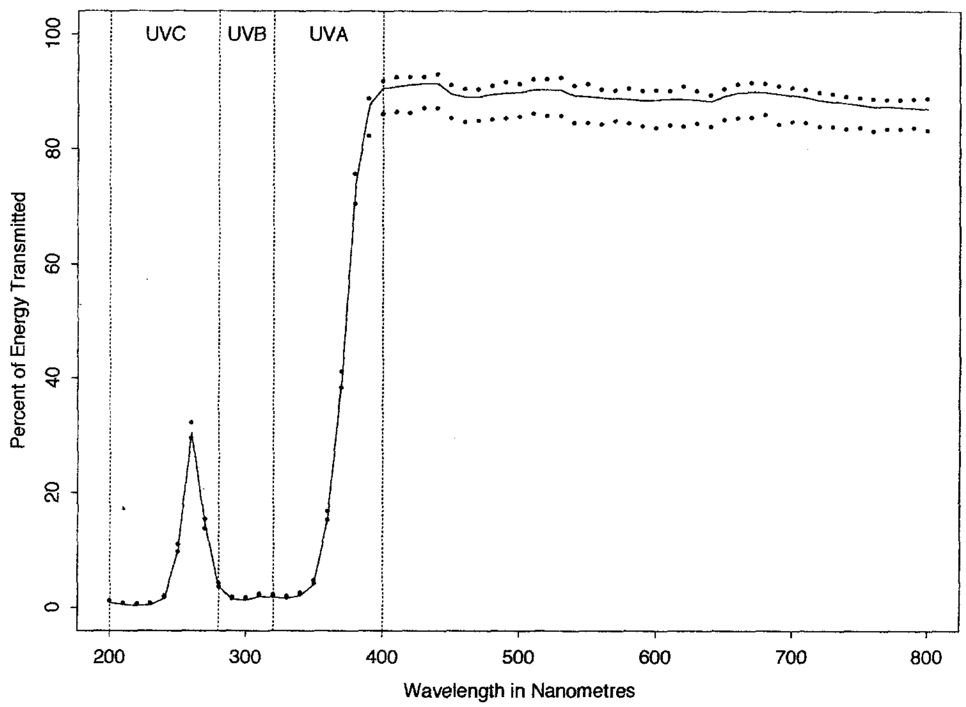

Figure 5. *UV transmittance spectrum of Surevue lenses generated by the Lowess function in S-plus using a 5% nearest neighbour setting. Black dots represent variation inherent in the Monte Carlo estimation scheme.*[18]

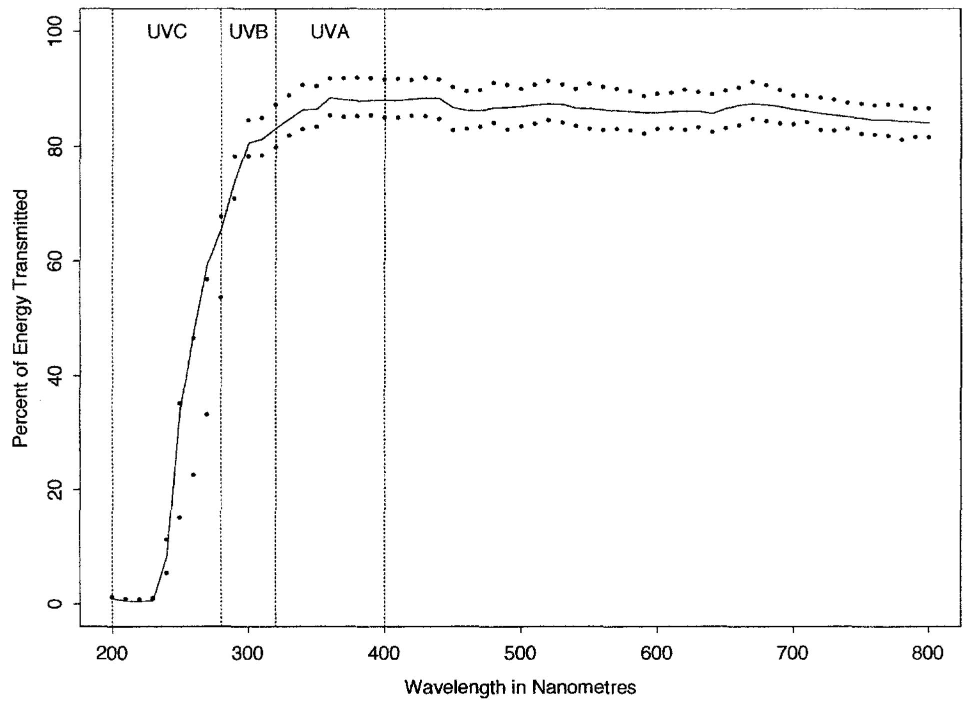

Figure 6. *UV transmittance spectrum of Vistavue lenses generated by the Lowess function in S-plus using a 5% nearest neighbour setting. Black dots represent variation inherent in the Monte Carlo estimation scheme.*[18]

to the Vistavue lens, there was a statistically significant difference for the range from 320 to 370 nm, which encompasses most of the UVA spectrum $(P<0.0002)$. Above 380 nm, there was no statistically significant difference between the Vistavue and the Surevue or the 1 Day Acuvue $(P>0.05)$, or between the Vistavue and the Acuvue $(P>0.30)$.

There was a statistically significant difference between the UV absorbing lenses and the Vistavue lens in the UVB spectrum from 280 to 320 nm $(P<0.0001)$. In the UVC range (200 to 270 nm), statistically significant differences were also found between Vistavue and the UV blocking lenses $(P<0.05)$, except at 260 nm $(P>0.4)$. Thus, it is highly unlikely that the UV transmittance of the Vistavue is similar to the other three lens types.

We found an average transmittance of roughly 75% for Vistavue versus 2.0 to 4.4% for UV absorbing lenses transmittance in the 280 to 320 nm spectrum. For the 200 to 280 nm spectrum, Vistavue had a mean transmittance of 19% versus 6.9 to 9.1% for UV absorbing lenses. For the 320 to 380 nm range, we found 19.6 to 23.2% transmittance for UV absorbing lenses versus 86.5% transmittance for Vistavue. These differences were clinically significant.

In comparing the UV absorbing lenses with each other, there were wavelengths where there were statistically significant differences between the lenses $(P<0.05)$. Since the mean transmittance values differed by less than 4% at the most, these differences were not clinically significant.

Discussion

Our method used a procedure that proved to be simpler than others previously used. The elimination of (1) media effects on transmission, (2) the need to cut lenses, and (3) the use of quartz cuvettes did not appear to reduce the accuracy or validity of the UV measurements, as our results are similar to previous studies that used more complex methods.[11,18,19]

Our results indicate that the 1 Day Acuvue, Surevue, and Acuvue lenses significantly reduce UV transmittance while the Vistavue lens does not, and also indicate that 1 Day Acuvue, Surevue, and Acuvue meet the American National Standards Institution (ANSI) Standard Z80.20 for Class 2 UV blockers: a maximum of 30% transmittance of UVA wavelengths and 5% transmittance of UVB wavelengths.[20] The lenses with the UV blocking monomer demonstrated significant UV blocking characteristics of UV radiation in the UVA and UVB range. The UVA and UVB transmittance values found for the UV blocking lenses correspond well with values found by Hickson-Curran *et al*[11] on the Acuvue lens. Other studies found similar results for other UV blocking contact lenses.[3,12–14,18] In contrast, we found that the Vistavue lens transmits a large percentage of the UV radiation in both the UVA and UVB range.

Interestingly, all four lens types transmitted up to 40% of ultraviolet radiation at certain peak wavelengths in the UVC range. The peaks found in the UVC range coincide with the results of other studies involving UV blocking lenses.[11,12,14] However, this peak was not found in a recent study of tinted and UV blocking disposable lenses.[19] Currently, the UVC transmittance is not considered an ocular health concern as only small amounts of radiation in the UVC range actually reach the earth's surface due to the filtering effects of the ozone layer.[1] Depletion of the ozone layer is actually thought to increase the transmittance of wavelengths in the UVA and UVB ranges.[21] However, as scientists continue to map the ever expanding hole in the ozone layer, there may be new ocular entities adding to the growing list of conditions believed to be associated with exposure to damaging amounts of UV radiation.

Along with environmental changes, a shift toward spending more leisure time outdoors increases the importance of UV protection in both spectacles and contact lenses.[1] Soft contact lenses with UV blocking characteristics can therefore be a viable alternative for spectacles in protecting internal ocular structures from UV radiation. However, the external structures of the eye, such as the conjunctiva and the eyelids, remain at risk and would continue to benefit from the use of UV blocking sunglasses or spectacle lenses.

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