Original Article

Comparative Evaluation of Ultraviolet and Visible Light Transmittance through Prescriptive Ophthalmic Minus Lenses

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Abstract

Background: Wearing spectacles is the most common approach in correcting the refractive errors worldwide. Due to harmful effects of overexposure to solar ultraviolet radiations, the usage of multi-layer coatings in ophthalmic lenses has recently been increased. These lenses can reduce the reflections and hence increase the transmission of visible light; they can also decrease the transmission of ultraviolet rays. This study aims to compare the transmission of ultraviolet (A and B) and visible rays through coated and uncoated prescriptive ophthalmic plastic lenses.

Materials and Methods: In this study, 39 minus non-photochromic multi-coated white plastic single-vision lenses; 9 similar lenses but without any coatings were assessed by spectral transmittancemeter for evaluation of the transmission of visible and ultraviolet rays.

Results: The transmission of visible light was 97.9%±1.07% for coated lenses and 93.5%±0.54% for lenses without coating. Ultraviolet-A transmission was 12.15%±8.02% for coated lenses compared to 66.27%±23.92% in lenses without coating. The transmission of ultraviolet-B rays was 1.21%±0.4% and 23.0%±15.97% for lenses with and without coatings, respectively.

Conclusion: The transmission of visible light was significantly higher in multi-coated lenses compared to uncoated samples; whereas the transmissions of ultraviolet rays in multi-coated lenses were significantly lower than uncoated ones. Therefore, it is recommended that, except for particular cases, prescribed lenses be equipped with this multi-layer coating.

Keywords: Plastic lens, visible light, ultraviolet radiation

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Introduction

Refractive errors are the most common ocular disorders worldwide[1], and wearing spectacle is the most common and safest way to correct refractive errors[2], in addition spectacles can be used for protection against harmful solar radiations.

Solar light is an electromagnetic radiation which lays within the infrared (IR), visible, and ultraviolet (UV) wavelength spectrums. Electromagnetic radiation with a wavelength between 400-760 nm is perceived as visible light, while UV-B ranges from 290-315 nm and UV-A ranges from 315-400 nm[3]. Exposure to UV radiations can be potentially damaging if absorbed by certain parts of eye in considerable amounts or within prolonged time[4]. The role of UV radiation has been understood in the development of some ocular conditions including pterygium, pinguecula, cataract [5] & retinopathy[6].

Currently, many brands of plastic lenses are widely used in both developed and developing countries, and we have some of them in our country. Now usage of glass is decreasing rapidly because of its disadvantages, therefore

we intended to study on plastic lenses[7].

The ophthalmic lenses are made in two ways; with and without coatings. There are two kinds of coating to apply on ophthalmic lenses; mono-layer & multi-layer[8]. Nowadays, because of better performance of multi-layer coating, it is more common than mono-layer coating. Of course we know use of any kind of coatings on ophthalmic lenses has some advantages and disadvantages. One of disadvantages is that they can decrease impact resistance of the lenses [9], but about their benefits; as we know currently a wide variety manufactures produce spectacle lenses and claim that the usage of multi-layer coatings can increase visible light transmission and prevent the transmission of harmful UV radiations to the eyes. Hence, in this study for first time in Iran and for understanding efficacy of multi-layer coating experimentally, we decided to compare spectral transmittance of available coated and uncoated plastic ophthalmic minus lenses.

Methods

In this cross sectional study, 48 non-photochromic white plastic (refractive index: 1.56) single vision lenses were assessed for factors contributing to the transmission of ultraviolet and visible light rays. As compared to non-coated lenses, more types of multi-layer coated lenses are used; therefore 39 multi-layer coated lenses were selected, whereas 9 lenses did not have any kind of coating. Samples were randomly provided from different famous manufactures such as zeiss, essilor, indo. All samples were minus lenses, since they are more commonly used in refractive ocular errors.

Data was gathered through direct in-vitro observation. In order to measure UV transmission as well as visible light wavelength transmission through sample lenses, we used a spectral transmittance-meter (Humphrey, Zeiss Company). The transmission was evaluated for UV-B (290-315 nm) & UV-A (315-380), also for 380-760 nm as visible light. The Spectral resolution and transmission resolution of the instrument was 5 nm and 1%, respectively. The instrument can provide both graph and numerical data for each reading. After removing the lenses from their packets, we put them into the instrument and testing was conducted. The instrument shows transmittance values: for example; If a given lens allowed 5% UV transmittance, it was considered to afford 95% protection against UV, it means: 95% protection=100–5% transmittance. After receiving data, using statistical software SPSS (versions 16) ANOVA testing was performed to prove whether a statistically significant difference is existed ($p< 0.05$).

Results

The transmission of visible rays was 97.9%±1.07% and 93.5%±0.54% for coated lenses and uncoated lenses, respectively. The transmission of UV-A was 12.15%±8.02% for coated lenses compared to 66.27%±23.92% in lenses without coating. The transmission of UV-B rays was 1.21%±0.4% and 23.0%±15.97% for coated lenses and uncoated lenses, respectively (Figure 1 & 2).

The mean transmission of visible rays in coated lenses was significantly higher than those of uncoated lenses ($p\leq0.0001$). The mean transmission of UV-A rays was significantly lower in coated lenses compared to uncoated samples ($p\leq0.002$). Also, the mean transmission of UV-B rays was significantly lower in coated lenses compared to uncoated samples ($p\leq0.021$).

Discussion

Plastic lenses such as other materials normally decrease transmission of both visible and UV rays. By applying antireflection coatings on the lens surface, it is possible to increase transmission of visible light to the eye. So, the original purpose of applying coatings is enhancement of transmission of visible light to the eye & result in improvement of visual performance[10]. In addition, the coatings can decrease transmission of UV rays to the eye.

Using prescribed spectacle lenses regardless of their material and coatings can be a protection for reducing the harmful effects of solar radiations to the eyes; the results of the current study is also supporting the results of studies of Velpandian et al.[11], Wojno et al.[12]. The mentionable question here is the role of lens coatings in the elimination of hazardous rays.

As our results expectedly show, the mean transmission of visible lights through coated lenses is 4.4% higher than

that of uncoated lenses. The mean transmission of UV-A rays through coated lenses is 54.12% lower compared to uncoated lenses and the mean transmission of UV-B rays through coated lenses is 21.8% lower compared to uncoated samples.

The result of this study confirms result of Citek K. study[13] in elimination harmful rays; however his work originally is about measurement of UV reflection from surface of coated lenses and we specially focused on transmission of visible light and UV harmful rays.

Since there is similarity between role of sunglasses and multi coated lenses in blocking harmful rays, it is possible to compare effectiveness of these lenses with sun lenses. In this way, according to ANSI Z80.3-2001 (American National Standards Institute) that determine allowable values transmission of UV rays through sun lenses, it seems the multicoated lenses generally can pass the requirements of sunglasses standards[14]. To compare, you can suppose white plastic lenses are as category 4 of ANSI Z80.3-2001 Table. According to this standard, UV allowable transmission are related to visible transmission; since mean transmission of coated lenses is 97%, thus for UV-B, they can transmit 0.125 of maximum visible transmission and for UV-A, they can transmit equal value of maximum visible transmission. (For normal use)

Regardless of decreasing visible light, we can say there is priority for use of coated lenses rather than sunglasses because they don't change color of objects, therefore color vision of patients will be intact.

CONCLUSION

We found ophthalmic lenses that are equipped with multi-layer coatings are really useful against sun's harmful rays. So, we recommend except for particular cases, ophthalmologists and optometrists prescribe multi-layer

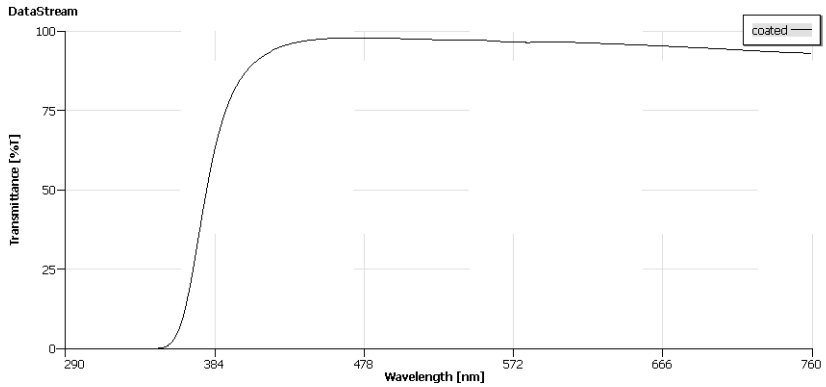

Figure 1. Spectral transmittance curve of a plastic lens with multi-layer coating.

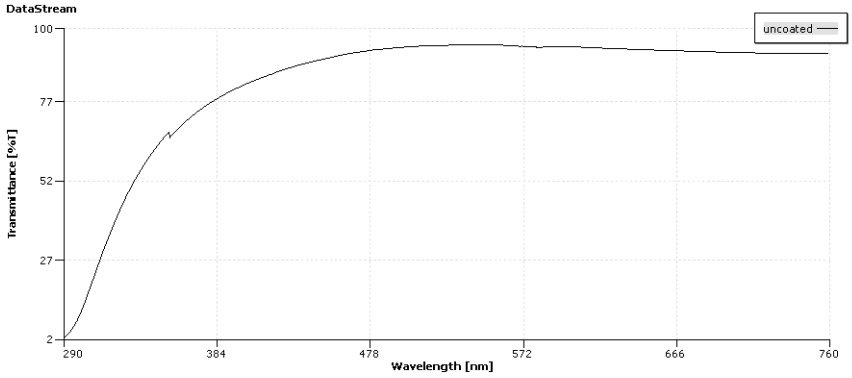

Figure 2. Spectral transmittance curve of a plastic lens without multi layer coating.

coated ophthalmic lenses for correction of ocular refractive errors and they can be good choices in cases a person cannot use plano sunglasses because of his refractive error. Finally, further studies on effectiveness of different coatings (mono and multi-layer) are recommended.

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