Analysis of the effect of radiation doses on UV transmission of intraocular lenses using a spectrophotometer

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1. Introduction

Every year in United States, more than one million patients undergo removal of the natural lens during cataract surgery and an intraocular lens (IOL) is placed at the same time [1]. The most important function of IOL is shielding ultraviolet radiation (UV) to protect retina. Recently, there are some patients with IOL may require radiation treatment when they have head and neck cancer [2]. There was a study to determine the effect of ionizing radiation on optical properties of IOLs in 2001. In this study, the authors concluded that at clinically relevant doses used radiation therapy, radiation produced no significant alteration in the absorption spectra of PMMA and silicone IOLs [1,3]. However, the material of IOL has been changed over time and hydrophobic and hydrophilic acrylic IOLs are commonly used these days. Therefore, it is not clear whether x-ray at clinical doses affects the new-material IOL's UV blocking capability, so we analyzed the effect quantitatively using a spectrophotometer.

2. Materials and Methods

2.1 Different types of IOL

Two different types of IOL were chosen for the experiment. One is hydrophobic acrylic IOL and another is hydrophilic acrylic IOL. (Figure 1,2) In addition, there are some specific details about these two IOLs in Table 1.

Table 1. Two types of IOLs

	Hydrophobic IOL	*Hydrophilic IOL*
Manufacturer	TECNIS	Ophthalmic Innovations International
Model	ZMB00	BioVue
Optic Diameter	6.0 mm	6.0 mm
Material	Hydrophobic acrylic	Hydrophilic acrylic
Refractive Index	1.47	1.46
A-Constant	119.3	118.2
Power Ranges	+5.0 D to +34.0 D (in 0.5 D increments)	+2.0 D to +30.0 D (in 0.5 D increments)

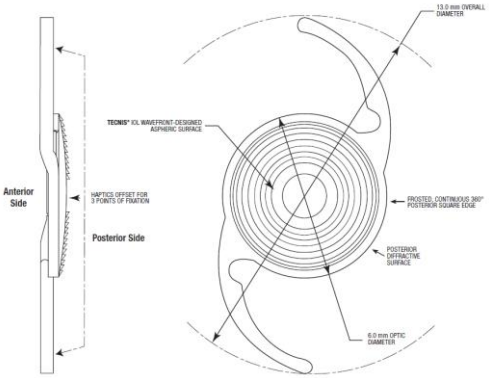

Figure 1. Hydrophobic IOL [4]

Figure 2. Hydrophilic IOL [5]

2.2 Spectrophotometer

A spectrophotometer (DU 800 UV/Visible Beckman Coulter) was used in this experiment for the measurement of UV transmission ratio after irradiation.

2.3 IOL holder

To measure the UV transmission ratio of IOL, we should manufacture the IOL holder to hold IOL in the spectrophotometer. The IOL holder consists of three acrylic blocks and screw to hold them. (Figure 3)

2.4 X-ray irradiation setup

For x-ray irradiation, we utilized 6 MV LINAC in Seoul National University hospital. We put IOL with the holder inside of a water phantom and adjusted IOL's

depth in the phantom to 6 MV beam's D_{max} which is 1.5 cm. Also, SSD was 100 cm. (Figure 3)

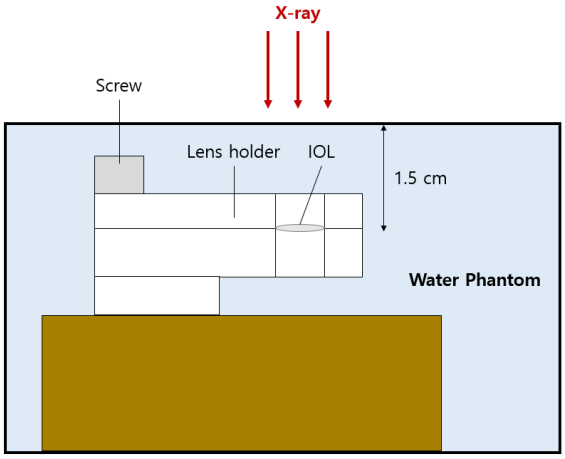

Figure 3. X-ray irradiation setup

2.5 Irradiation schedule

We irradiated x-ray to IOL following this schedule. 3 IOLs for each type were chosen and irradiated with different initial dose (2, 10, 30 Gy). Then 3 to 10 Gy were re-irradiated and total dose was accumulated up to 100 Gy.

Table 2. X-ray irradiation schedule

Irradiation	*IOL* 1	*IOL* 2	*IOL* 3
1st (Initial dose)	2 Gy	10 Gy	30 Gy
2nd	+ 3 Gy	+ 10 Gy	+ 10 Gy
3rd	+ 5 Gy	+ 10 Gy	+ 10 Gy
4th	+ 10 Gy	+ 10 Gy	+ 10 Gy
5th	+ 10 Gy	+ 10 Gy	+ 10 Gy
6th	+ 10 Gy	+ 10 Gy	+ 10 Gy
7th	+ 10 Gy	+ 10 Gy	+ 10 Gy
8th	+ 10 Gy	+ 10 Gy	+ 10 Gy
Final dose	**60 Gy**	**80 Gy**	**100 Gy**

3. Results

UV transmission ratios were measured with spectrophotometer after each irradiation every time.

3.1 Hydrophobic IOL results

Figure 4 to 6 shows the transmission ratio of each hydrophobic IOL. There is no UV transmission from 200 nm to around 380 nm and after the UV region, visible light was well transmitted (around 80 to 100%).

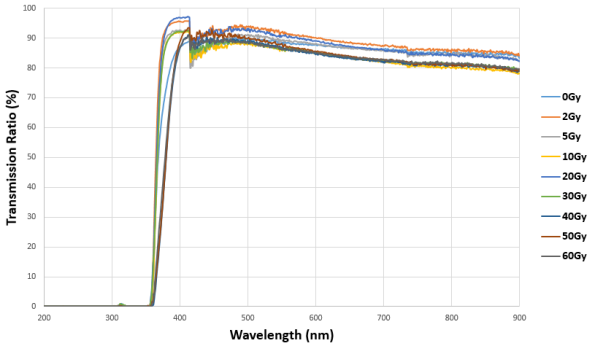

Figure 4. UV transmission ratio of hydrophobic IOL 1 (Initial dose: 2 Gy, Final dose: 60 Gy)

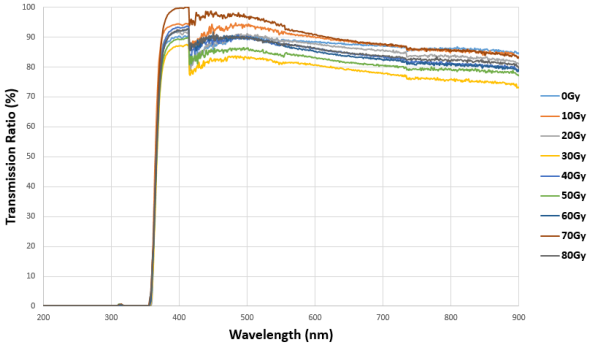

Figure 5. UV transmission ratio of hydrophobic IOL 2 (Initial dose: 10 Gy, Final dose: 80 Gy)

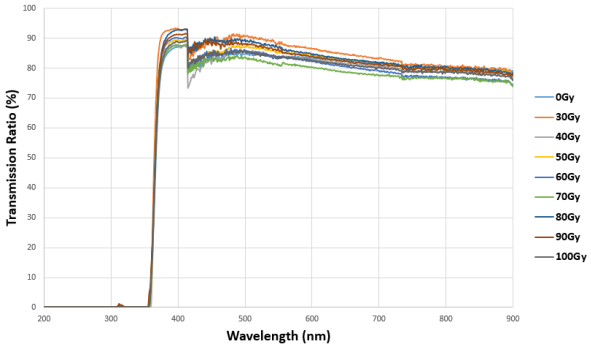

Figure 6. UV transmission ratio of hydrophobic IOL 3 (Initial dose: 30 Gy, Final dose: 100 Gy)

3.2 Hydrophilic IOL results

Figure 7 to 9 shows the transmission ratio of each hydrophilic IOL. Like hydrophobic IOL's results, there is no UV transmission from 200 nm to around 380 nm and after the UV region, visible light was well transmitted (around 80 to 95%).

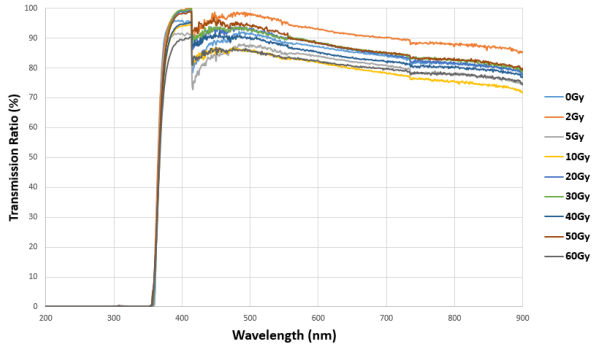

Figure 7. UV transmission ratio of hydrophilic IOL 1 (Initial dose: 2 Gy, Final dose: 60 Gy)

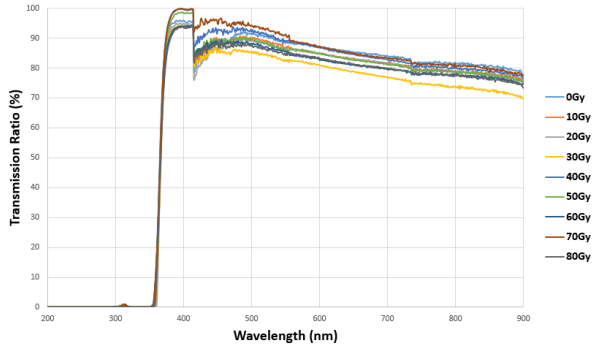

Figure 8. UV transmission ratio of hydrophilic IOL 2 (Initial dose: 10 Gy, Final dose: 80 Gy)

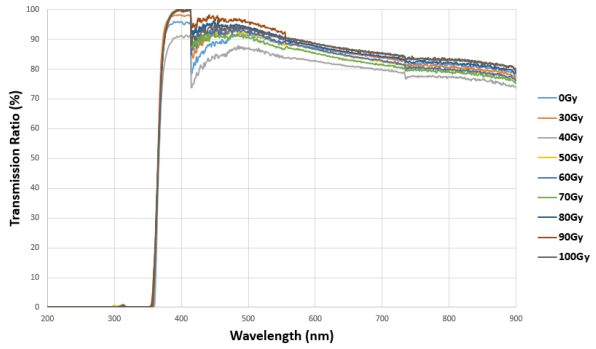

Figure 9. UV transmission ratio of hydrophilic IOL 3 (Initial dose: 30 Gy, Final dose: 100 Gy)

4. Discussion

In both types of IOLs, UV-blocking capability (200 ~ 400 nm region) remained even though 100 Gy was deposited in IOLs. However, there is a sharp rise around 370 nm wavelength, so we inquired this issue to manufacturers and got the answer that IOL was designed that light transmission ratio is continuously increased from 370 nm to 400 nm. In this result, transmission ratio at 370 nm is around 60 %, so we achieved almost reasonable measurement results compared to manufacturers' comments. Furthermore, the transmission ratio after 400 nm region is around 80 ~ 90% and it is independent of radiation dose up to 100 Gy. Therefore, radiation treatment dose to the patient (up to 100 Gy) causes no significant change in both IOLs' UV blocking capability and this result may give some guidelines for doctors and head and neck cancer patients who have IOLs and are supposed to have radiation treatment.

5. Conclusion

Through the measurement using a spectrophotometer, we could conclude that the UV blocking capability of both hydrophobic and hydrophilic acrylic (new material) IOLs was not affected by the exposure of clinical radiation doses (up to 100 Gy) during the course of radiation treatment.

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