

# Comparison of Visual Performance with Photochromic, Yellow and Clear Intraocular Lenses

Hamid Gharaee, MD<sup>1</sup> • Mohammad Reza Sedaghat, MD<sup>1</sup> • Malihe Nikandish, MD<sup>2</sup>

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## Abstract

**Purpose:** To evaluate visual function in patients with different types of light-filtering intraocular lenses (IOLs)

**Methods:** In this prospective comparative clinical study Cataract patients with different types of IOLs in Khatam-al-Anbia Eye Hospital, Mashhad were enrolled and followed for three months postoperatively. Corrected distance visual acuity (CDVA), color discrimination under photopic (1000 lux) and mesopic (40 lux) conditions were evaluated with Roth 28 hue test. Contrast sensitivity testing was then performed with 1000E contrast sensitivity unit (CSV-1000E, vector vision) with a constant test luminance level of 85 cd/m<sup>2</sup>.

**Results:** In this study, 47 patients were evaluated with different IOLs (16 clear, 17 yellow, 14 photochromic). There were no significant differences between the three IOLs in CDVA, contrast sensitivity and mesopic and photopic color vision ( $p < .05$ ).

**Conclusion:** Contrast sensitivity as well as the mesopic and photopic color vision are not different in clear, yellow and photochromic IOLs.

**Keywords:** Visual Performance, Contrast Sensitivity, Intraocular Lens, Photochromic Lens

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## Introduction

With the general aging of the population, the overall prevalence of visual loss as a result of lenticular opacities gradually increases. Currently, surgery is the only available treatment for visually significant lenticular opacity. To replace the extracted lens after cataract Surgery, intraocular lens (IOL) implantation became a standard practice in the mid-1970s.<sup>1</sup>

Retinal phototoxicity from environmental

light exposure has been postulated to cause age related macular degeneration (AMD). This hypothesis has motivated manufacturers to attach light –absorbing chromospheres to constituent monomers in IOL optics.<sup>1</sup>

IOL can be divided into different classes based on their transmission spectra. Ultraviolet (UV) -transmitting IOLs do not have optical radiation absorbing chromophores bound to their optic monomers.<sup>1</sup>

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1. Associate Professor of Ophthalmology, Cornea Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

2. Ophthalmologist, Eye Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

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Correspondence to: Malihe Nikandish, MD

Ophthalmologist, Eye Research Center, Mashhad University of Medical Sciences, Mashhad, Iran,

Email: nikandishm1@mums.ac.ir

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Standard UV-blocking IOLs have chromophores that block UV radiation and possibly some additional violet lights. Moreover, blue blocking IOLs block some amount of violet and blue lights. UV – transmitting and UV – blocking IOLs have a clear appearance, whereas blue – blocking IOLs have a yellowish appearance. Yellow IOLs that block blue light inevitably decrease the scotopic sensitivity, which may compromise the night vision.<sup>1</sup>

Photochromic IOLs are reversible blue light filtering IOLs which are designed to block harmful blue light without compromising mesopic or scotopic vision.

In this study, we evaluated the differences in the visual performance between three IOL models: clear, yellow and photochromic, to evaluate mesopic and photopic color vision and cataract sensitivity.

## Methods

In this prospective comparative clinical study, all consecutive cases of senile cataract who met inclusion criteria of potential visual acuity of 0.5 or better without any other ocular pathology, previous ophthalmic surgery or color vision deficiency were recruited.

The exclusion criteria were as follows: intraoperative complication, abnormal pupillary reaction, retinal detachment, glaucoma, IOL power calculation less than +10.00 D or greater than +30.00 D, posterior capsular opacity (PCO), inflammatory sign and astigmatism greater than 2.00 D.

Informed consents were obtained from all patients for the study protocol.

After complete ocular examination, patients who met inclusion and exclusion criteria, were consecutively assigned to receive one of the three IOL models. Implanted IOL specifications are summarized in table 1.

The first group (clear IOL Group) received an Acrysof – SA 60AT (Alcon, INC) which is a clear UV – filtering model. The second group (yellow IOL group) was assigned to receive an Acrysof – SN 60AT (Alcon, Inc) yellow tinted blue filtering model. The third group (photochromic IOL group) had implantation of photochromic IOL (Aurium matrix, model 400, medenium, Inc). These photochromic IOLs are colorless in the absence of UV light; and when exposed to the UV light, IOLs turn

yellow within seconds and become colorless again in the absence of UV light.

Consecutively patients were enrolled for implantation of one of the three IOLs and the physician who collected the data was masked to the type of implanted IOL in the eye.

**Table 1.** Intraocular lenses characteristics

	Acrysof SA60AT	Aurium matrix	Acrysof SN60AT
Refractive index	1.55	1.56	1.55
UV filtering	YES	YES	YES
Blue light filtering	NO	YES	YES
Photochromic	NO	YES	NO
Design	1 piece	1 piece	1 piece

## Surgical technique

All operations were performed by the same surgeon (H.GH) using a standard phacoemolcification procedure (phaco chop manner) with a temporal clear corneal incision. In all patients, IOL was implanted in the capsular bag through the widened 3-mm incision. Postoperatively, each patient received topical chloramphenicol every six hours and betamethason every two hours for one week. Based on the ocular inflammation, betamethason was tapered within one month of the surgery.

## Postoperative evaluation

Postoperative visits were scheduled at one day, one week, two months and three months. Each follow-up visit included anterior and posterior segment evaluation, measurement of the corrected distance visual acuity (CDVA) and corrected near visual acuity. The contrast sensitivity test was also performed with 1000E contrast sensitivity unit (CSV-1000E, vector vision) with a constant test luminance level of 85 cd/m<sup>2</sup>.

Hue discrimination to test color vision was evaluated monocularly using Roth 28 hue test, under indoor photopic (400lux) and mesopic condition (30 lux). The objective of the hue test was to arrange 28 disks in a sequence with a gradual progression of hue between adjacent disks. Tritan errors were calculated by counting the mistake lines along the tritan axis.

## Statistical analysis

Statistical analysis was performed using SPSS software (version 11.5), one-way

ANOVA (analysis of variance) and the Kruskal-Wallis test. A  $p$  value  $< 0.05$  was considered statistically significant.

## Results

The study enrolled 60 consecutive eyes of 60 patients, only 47 patients completed the study. The mean age was  $67.87 \pm 8.22$  years. A total of 25 participants were male and 22 were female. From the above-mentioned study population, 27 right eyes and 20 left eyes were evaluated. There were no statistically differences in the demographic data between the three IOL groups. A slit-lamp examination at three month postoperative visit found no

abnormality in any eye.

Table 2 shows the best corrected visual acuity (BCVA) at the final visit; there was no statistically significant difference between the three IOL models in final visual acuity.

There was no statistically difference in contrast vision evaluated with and without glare between the three IOLs models (Figures 1, 2).

Our study showed no statistically significant difference between clear, yellow-tinted and photochromic IOLs in the total error score for color vision under photopic and mesopic conditions as measured by the hue test (Table 3).

**Table 2.** Best corrected visual acuity at the final visit

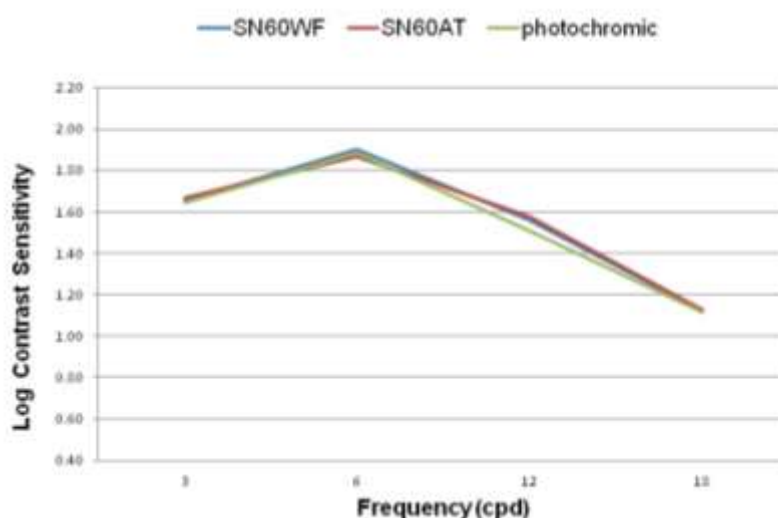
	BCVA (Mean $\pm$ SD)
SN60WF IOL (n=17)	0.92 $\pm$ 0.09
SN60AT IOL (n=16)	0.94 $\pm$ 0.08
Photochromic IOL (n= 14)	0.96 $\pm$ 0.07
p value	0.37

BCVA: Best corrected visual acuity  
IOL: Intraocular lens

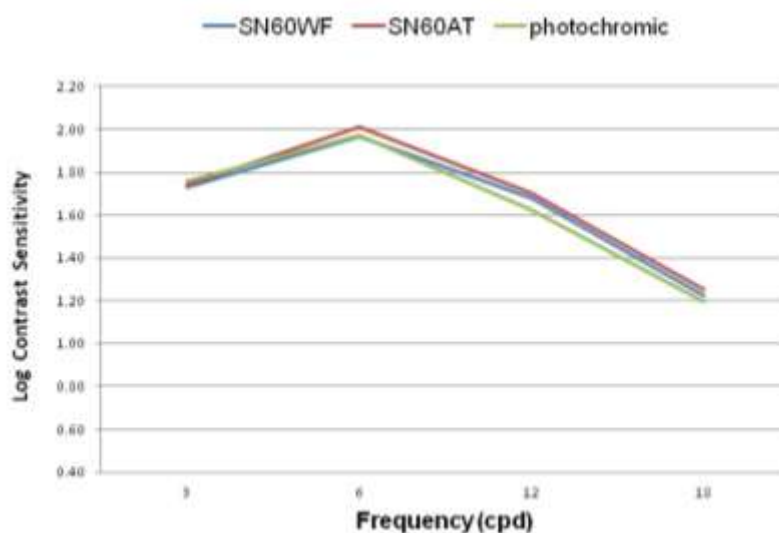
**Table 3.** Color vision under photopic and mesopic conditions with three types of intraocular lens. Data are expressed as mean $\pm$ SD

	Mesopic color vision	Photopic color vision
SN60WF IOL (n=17)	3.12 $\pm$ 2.12	2.18 $\pm$ 1.55
SN60AT IOL (n=14)	2.14 $\pm$ 1.56	1.07 $\pm$ 1.07
Photochromic IOL (n= 14)	3.21 $\pm$ 1.81	1.71 $\pm$ 1.49
p value	0.15	0.11

IOL: Intraocular lens



**Figure 1.** Mean contrast sensitivity values with glare (cpd=cycles per degree)



**Figure 2.** Mean contrast sensitivity values without glare (cpd=cycles per degree)

## Discussion

Because of the growing evidence of UV-induced retinal damage, UV light-filtering lenses have been the dominant IOLs used in the modern cataract surgery since the mid-1980s.<sup>2</sup>

Healthy human crystalline lens yellowing as a normal ageing process reduces the transmission of the blue light; thereby blocking the amount of blue light from reaching the retina.<sup>3</sup> UV light-filtering IOL has not been capable to do so.<sup>4</sup>

Moreover, several blue light-filtering IOLs with yellow tint have been introduced in recent years that replicate the spectral transmission properties of the human aged crystalline lens more closely than do the UV light-filtering IOLs.<sup>4</sup>

Spectral transmission characteristics and protective effects of clear and yellow-tinted IOLs against retinal damage by sunlight were evaluated by Tanito et al. It has been revealed that UV-blocking clear IOLs reduce the blue-light irradiance value by 60%; yellow-tinted IOLs conferred an additional 17% to 56% reduction.<sup>5</sup>

Despite these protective benefits of the blue light filtering IOL, concerns have been raised that this could negatively influences the visual performance after cataract surgery.<sup>6</sup>

They may compromise mesopic and scotopic vision. This would make performance

of many early-morning or evening activities such as night driving, more difficult.<sup>7</sup>

These concerns are basically the subject of many studies that evaluated visual performance and compared these two IOL groups, which will be mentioned in the present article.

To overcome the potential disadvantages of the blue light-filtering IOLs, the Aurium photochromic blue light-filtering IOL was developed. The entire body of the IOL contains photochromic dyes that become yellow on exposure to the UV light and become colorless again in the absence of long wavelength UV light.<sup>8</sup>

Since May 2007, the Aurium photochromic IOL (Aurium Matrix, model 400, Medennium, Inc.) product developed by Meddenium has been available in Europe. The colour change to yellow takes about 10 seconds and it becomes colourless within about 30 seconds. The current Aurium product blocks about 50% of both violet and blue lights in the activated state.

Werner et al, (2006, 2011) evaluated photochromic IOL in two studies of rabbit model. In the first study, it was revealed that the photochromic IOL turned yellow only on exposure to the UV light; otherwise it remained clear. This lens was also found to be biocompatible.<sup>8,9</sup>

In the second study of rabbit model, the long-term biocompatibility and photochromic stability were assessed by Werner et al. The rabbits were exposed to a UV light source under conditions simulating at least 20 years of UV exposure and as a result they showed these IOLs are biocompatible with up to 12 months of accelerated UV exposure simulation. In this study, photochromic changes were observed within seven seconds of UV exposure.<sup>9</sup>

Protective effect of photochromic IOL was evaluated in a study by Qian et al. They showed Photochromic IOL can abate the degree of acute photodamage of retinal pigmentary epithelium (RPE). Moreover, in comparison with other IOLs, the protective effect was the highest when using the yellow Acrysof Natural IOL, followed by photochromic IOL and colorless IOL.<sup>10</sup>

In the clinical study group, the contrast sensitivity, visual acuity and color perception in patients with yellow and clear IOLs were evaluated by Neumaier-Ammereret al (2010) and it was shown that they are equivalent under photopic conditions. However, patients with yellow-tinted IOLs made more statistically significantly mistakes in the blue range under dim light than patients with clear IOLs.<sup>11</sup>

Zhu et al, (2012) in a systematic review and a meta-analysis included 15 randomized controlled trials from 107 studies. It was demonstrated that postoperative visual performance with blue light-filtering IOLs was approximately equal to that of UV light-filtering IOLs after cataract surgery, however; color vision with blue light-filtering IOLs showed some compromise in the blue light spectrum under mesopic light conditions.<sup>12</sup>

After introduction of photochromic IOL, limited studies were performed to assess visual function with these IOLs and compared them to two other groups.

Avalos performed a prospective intraindividual comparative eye study with a photochromic IOL (Matrix Acrylic Aurium) versus a nonphotochromic counterpart (Matrix Acrylic) in human. The mean postoperative BCVA with the Aurium IOL was found to be similar to that for the control IOL. Follow-up at two years indicated that the Aurium appears to be as safe and efficacious as the control IOL.<sup>13</sup>

In a prospective comparative clinical study by Wang et al, visual function of three IOL groups including clear, yellow, and photochromic was compared and it was shown that the photochromic blue light-filtering IOL performed as well as the yellow and clear IOLs under photopic conditions. Under mesopic conditions, the yellow IOL gave poor color vision and contrast sensitivity.<sup>7</sup>

In the present study, the visual performance with clear, yellow and photochromic IOLs were also compared.

Our study showed that there is no statistically significant difference in CDVA between the three IOL groups (i.e. clear, yellow, and photochromic). This finding was in agreement with results of previous studies.<sup>11,12</sup>

There was no statistically difference in contrast vision evaluated with and without glare between three IOLs models.

It showed no statistically significant difference between clear, yellow-tinted and photochromic IOLs in the total error score for color vision under photopic and mesopic conditions as measured by the hue test.

## Conclusion

Color vision with the photochromic IOL was similar to clear and yellow IOLs under photopic and mesopic conditions.

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## References

1. Mainster MA, Turner PL. Intraocular lens spectral filtering. In: Steinert RF, ed. *Cataract Surgery*, 3rd ed, Philadelphia, PA: Saunders Elsevier; 2010:477.
2. Ham WT Jr, Mueller HA, Sliney DH. Retinal sensitivity to damage from short wavelength light. *Nature* 1976;260(5547):153-5.
3. van Norren D, van de Kraats J. Spectral transmission of intraocular lenses expressed as a virtual age. *Br J Ophthalmol* 2007;91(10):1374-5.
4. Brockmann C, Schulz M, Laube T. Transmittance characteristics of ultraviolet and blue-light-filtering intraocular lenses. *J Cataract Refract Surg* 2008;34(7):1161-6.

5. Tanito M, Okuno T, Ishiba Y, Ohira A. Transmission spectrums and retinal blue-light irradiance values of untinted and yellow-tinted intraocular lenses. *J Cataract Refract Surg* 2010;36(2):299-307.
6. Mainster MA, Sparrow JR. How much blue light should an IOL transmit? *Br J Ophthalmol* 2003;87(12):1523-9.
7. Wang H, Wang J, Fan W, Wang W. Comparison of photochromic, yellow, and clear intraocular lenses in human eyes under photopic and mesopic lighting conditions. *J Cataract Refract Surg* 2010;36(12):2080-6.
8. Werner L, Mamalis N, Romaniv N, Haymore J, Haugen B, Hunter B, et al. New photochromic foldable intraocular lens: preliminary study of feasibility and biocompatibility. *J Cataract Refract Surg* 2006;32(7):1214-21.
9. Werner L, Abdel-Aziz S, Cutler Peck C, Monson B, Espandar L, Zaugg B, et al. Accelerated 20-year sunlight exposure simulation of a photochromic foldable intraocular lens in a rabbit model. *J Cataract Refract Surg* 2011;37(2):378-85.
10. Qian JJ, Guan HJ. [The protective effect of photochromic intraocular lens on visible light-induced lesion in cultured retinal pigment epithelium]. *Zhonghua Yan Ke Za Zhi* 2013;49(5):410-5. [Article in Chinese]
11. Neumaier-Ammerer B, Felke S, Hagen S, Haas P, Zeiler F, Mauler H, et al. Comparison of visual performance with blue light-filtering and ultraviolet light-filtering intraocular lenses. *J Cataract Refract Surg* 2010;36(12):2073-9.
12. Zhu XF, Zou HD, Yu YF, Sun Q, Zhao NQ. Comparison of blue light-filtering IOLs and UV light-filtering IOLs for cataract surgery: a meta-analysis. *PLoS One* 2012;7(3):e33013. Epub 2012 Mar 7.
13. Avalos G. Two-year clinical experience with a photochromic IOL. *Cataract & Refractive Surgery Today Europe*. July 2008.