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# A comparative study of blue light filtering intraocular lens with ultraviolet filtering intraocular lens in visual functions

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**Abstract**
**Purpose:** This prospective study was conducted, to compare visual functions of blue light filtering intraocular lens (IOL) with ultraviolet filtering (UV) intraocular lens.
**Methods:** Fifty patients with senile cataract were randomly assigned to implant blue light filtering IOL or UV filtering IOL. There were 25 patients selected in each, Y group (blue light filter) and A group (UV filtering) for study. The outcome measures were visual acuity for distance (6 meter) and near (33 cm), contrast sensitivity under photopic (85 cd$^2$) conditions with Pelli Robson chart, color vision with Farnsworth-Munsell 100-hue test and patient satisfaction questionnaire.
**Results:** Six months postoperatively, there was no significant difference, between the two groups for distance vision, near vision, color vision, contrast sensitivity and patient satisfaction. As far as only visual functions are concerned both IOLs performed equally well.
**Conclusions:** In this study the blue light filtering (Yellow) IOLs and UV light filtering (Clear) IOLs gave similar outcomes for visual functions. So the blue light filtering IOL didn't provide any significant advantage over colorless UV filtering IOL, also there is no harm in using blue light filtering IOL. Although longer clinical studies are required, to confirm the Age-related macular degeneration (ARMD) prevention, as claimed by blue light filtering IOLs.

**Keywords:** blue light filter, ultraviolet filter, yellow lens

## 1. Introduction
The human lens becomes yellowish in color with aging, due to urochrome pigment deposition. It could be nature's way to protect macula from the blue short wavelength light. The harmful effect of Ultraviolet (UV) rays is established, the concept of blue light damage to retina is being evaluated. The development of intraocular lens (IOL) incorporating a blue-light filter was aimed at improving visual performance and safety of the macula.
The blue light filtering IOL reduce glare disability, (*Rayleigh's law, which states that when shorter wavelengths are blocked, scatter is reduced, thereby reducing glare*), improve the heterochromatic contrast threshold, recovery of photostress and cause less photophobia and cyanopsia in postoperative period [1]. The hypothesis that blocking blue light from reaching the retina will protect eyes from AMD has also been supported by several in studies [2, 3].
But three main concerns for blue light filtering IOL are scotopic vision, color perception and sleep disturbance (circadian rhythm). (Figure1). There are studies, both in favor and against blue-light filtering IOLs [4, 5].
The blue-light filtering IOLs of different manufacturers exhibit different blue light transmittance and therefore their performance on functional vision might differ. In this study we compared visual functions of blue-light filtering (*yellow*) IOL with colorless UV blocking (*clear*) IOL. The yellow lens filters spectrum of blue light along with ultraviolet rays, while the clear lens filters only UV rays (figure 1). Both IOLs in the study were aspheric and hydrophilic type.

## 2. Materials and Method
This prospective randomized clinical study was conducted at our eye department. The clinical investigation plan was reviewed and approved by the ethics committee. All patients gave written informed consent before enrolment in the study. Fifty patients with cataract were screened and enrolled in the study. They were divided in to Y group (blue light filtering IOL) and A group (UV light filtering IOL).
Exclusion criteria were diabetic retinopathy, corneal opacity & degeneration, pterygium, astigmatism, IOL power less than +18.0 D or greater than +24.0 D, and inability to attend follow-up appointments.
The two IOL studied were same except added blue light filtering agent in yellow IOL. The blue light filtering IOL *blocks both UV and blue light* up to 430 nm. The colorless UV light filter in IOL blocks spectrum up to 390nm only (Figure1).
Patients were assigned to implantation of either blue light filtering IOL (n = 25 eyes) or colorless UV filtering IOLs (n = 25 eyes). Detailed characteristics of the 2 IOLs are shown in Table 1. The biometric measurements were performed with A scan and the IOL power was calculated with the SRK/T formula (A constant = 118.0).

### Surgical technique
All surgeries were performed by the same surgeon using standard surgical procedures and medications. Surgical method was 2.8 mm self-sealing limbal incision in the steepest corneal axis, aka SMI (steep meridian incision) to

minimize astigmatism. A 5.5 to 6 mm continuous curvilinear capsulorhexis, slightly smaller than the IOL optic diameter to ensure an optic overlap, followed by phacoemulsification and IOL implantation in the capsular bag. The IOLs were inserted through an incision of 2.8 mm using the injector provided with IOL. All IOL were inserted in the capsular bag.

**Postoperative assessments**

Postoperative visits were scheduled at 1 month, 3 months and 6 months after surgery for refraction, slit-lamp evaluation and the measurement visual acuity for far and near with snellens chart. The distance visual acuity was evaluated using a Snellens chart at 6 meter and for near at 33 cm. The Snellen fraction was converted to log MAR (log minimum angle of resolution) for statistical analysis**.** Other visual functions were assessed at 6 months including contrast sensitivity, color vision and patient satisfaction.

Contrast sensitivity was measured with distance correction under photopic (85 $cd/m^2$) with Pelli-Robson chart. Pelli-Robson test measures contrast sensitivity using a single large letter size (20/60 optotype), with contrast varying across groups of letters. The chart uses letters (6 per line), arranged in groups whose contrast varies from high to low.

A Pelli-Robson score of 2.0 indicates normal contrast sensitivity of 100 percent. Pelli-Robson contrast sensitivity score of less than 1.5 is consistent with some visual impairment and a score of less than 1.0 represents in visual disability.

Color vision was evaluated with distance correction under room light conditions using the Farnsworth-Munsell (FM) 100-hue test. The test consists of 4 rows containing many small disks of varying hues. The person being tested must arrange the other disks within the tray to create a continuum of gradually changing hue. The test is available online. And total error score is calculated for each patient [6].

Lastly, patients were asked questions about near activities, distance activities, dependency, driving, peripheral vision and their overall satisfaction with their vision.

**Statistical Analysis**

All results were expressed as mean +- SD. The values were processed for statistical analyses using the one-way analysis of variance (ANOVA). It is used to determine whether there are any statistically significant differences between the means of two or more independent (unrelated) groups. The P value < 0.05 was considered statistically significant.

## 3. Results

**Vision**

The Snellen fraction was converted to log MAR (log minimum angle of resolution) for statistical analysis**.** With 25 patients in each group, total of 50 patients were studied for the six months follow-up for distance and near vision. (Y group, n = 25; A group, n = 25). There was no significant difference in visual acuity between two groups for near vision (p value 0.545) and distance vision (p value 0.645). (table3)

**Color vision**

Table 4 shows the total error scores at Farnsworth-Munsell 100 hue test, obtained with the blue light filtering IOL and colorless UV light filtering IOL at the 6 months follow-up. Measurements were carried out under photopic conditions. Total error score is calculated. There was no statistical significant difference between the two groups. (p value 0.146) Both types of IOL performed equally at color vision test.

**Contrast sensitivity**

In the study, the Pelli-Robson test was stopped when two letters of a triplet were incorrectly identified. It was tested in photopic and mesopic conditions. P value for photopic test was 0.116 and for mesopic test was 0.127 which is not statistically significant. So no difference in postoperative contrast sensitivity was detected between the blue light filtering group and UV light filtering group. (Table 5)

**Patient satisfaction**

After 6 months patients were asked about their satisfaction and quality of vision it consists of questions about near activities, distance activities, dependency, driving and peripheral vision.

In the Y group 18 (n = 18/25) patients were satisfied and 7 scored average with performance of blue light filtering IOL. None of the patient was unsatisfied with blue light filtering IOL.

In A group 19 (n = 19/25) patients were satisfied and 6 scored average with performance of UV light filtering IOL. Results in both groups were comparable and patients were equally satisfied in two groups.

## 4. Discussion

In old age, due to pupillary miosis and reduced crystalline lens light transmission of short wavelengths there is loss of circadian photoreception. Blue light filtering IOL may cause same by circadian disruption in some. Pseudophakia with only *UV filtering IOLs* may improve circadian rhythm which transmit blue light, optimal for non-visual photoreception.

Although the potential advantages of the yellow-tinted IOLs in reducing the risk of developing AMD has not been demonstrated clinically yet, they seem to provide similar outcomes than clear IOLs without additional risks [7, 8].

There have been some concerns that blue-light filtering IOLs might compromise mesopic and scotopic vision, blue color perception and circadian rhythms.However, literature shows, that IOLs with and without the blue light-feature performed similarly in terms of contrast sensitivity under photopic and mesopic conditions [9, 10, 11]. The results of color vision with several studies reporting no significant difference in color vision between blue light filtering and clear IOLs [12, 13, 14], Our study also confirmed it. However, we acknowledge that a larger sample size and better instruments would be required to yield clearer results.

The increasing number of patients opting for clear lens exchange, combined with the fact that patients are now living longer, makes it necessary to take the potential risk of age-related macular degeneration seriously.

Blue-light filtering *spectacle lenses* can partially filter high-energy short-wavelength light without substantially degrading visual performance and sleep quality. These optical lenses may serve as a supplementary option for protecting the retina from potential blue-light hazard. There is importance of wearing blue light filtering (amber-tinted) sunglasses for outdoors after cataract surgery for additional benefit of blue light filtering ability.

Patient preoperative characteristics were similar in both study groups. Six months postoperatively, mean subjective refraction and mean visual acuity outcomes for far, and near were comparable between the two IOL types with no statistically significant difference. Both IOL groups achieved equal best corrected visual acuity in the A group and the Y group. These data are in line with those reported in previous studies showing similar visual acuity outcomes between yellow-tinted *versus* clear IOLs [13, 16].

Unilateral examination of contrast sensitivity did not show any significant differences between the Y and A group. The visual function of patients with blue filter IOLs is not significantly different to those without blue light filter IOLs. Since blue light filter IOLs did not show any functional disadvantage, but potentially protect the macula from AMD, blue light filter IOLs may be considered as a reasonable alternative to colorless IOLs, especially in eyes with a high risk for the development of macular degeneration [17, 18].

Nonetheless, these outcomes suggest that contrast sensitivity tested here is not impaired by the blue-light filtering implantation. This result adds to literature showing that yellow-tinted IOLs do not compromise photopic and mesopic contrast vision. Higher contrast sensitivity in patients with diabetic retinopathy has even been reported in eyes implanted with the yellow-tinted AcrySof Natural *versus* the contralateral eyes implanted with the clear AcrySof SA60AT [15].

The results of the impact of blue light-filtering IOLs on color vision have not been straightforward. Depending on the study design including, and in particular, the sensitivity of the method used to test color perception and follow-up length, study conclusions have been distinct. While most studies found no significant difference in color vision between eyes with or without blue light-filter in photopic and mesopic conditions, some showed reduced vision with the yellow-tinted IOLs in the blue light spectrum, particularly, in dim light conditions.

In our study, we evaluated FM 100-hue test under photopic condition. After 6 months postoperatively, the two IOL groups performed similarly with no statistical difference in the mean total error scores. These results are in agreement with those of Wang et al.[7], showing no difference in color discrimination under photopic conditions in the green-to-blue band of the FM 100-hue test between blue light-filtering IOL, clear IOL and photo chromic IOL. Similar outcomes have been reported by others. Although, Mester et al. showed overall higher mean total error scores in the same light spectrum in eyes implanted with the yellow AF-1 (UY) IOL as compared with the fellow eyes implanted with the clear AF-1 (UV) IOL under photopic conditions, the difference was significant for the first 6 months postoperatively but not at the 1-year follow-up visit. In contrast, all studies mentioned above observed some color discrimination impairment in the blue light spectrum under mesopic conditions in eyes with the yellow-tinted IOLs. But none of them reported any significant difference in overall color discrimination or discomfort in mesopic conditions when subjective perception evaluation was carried out by a questionnaire to the patients.

Finally, when asked about their overall visual performance with IOL 72% of the Y group patients reported “satisfied” and 28% “average”. Similar results were obtained with the A group with 76% of patients being “satisfied” and 24 % rated average. None of the patients with blue light filtering IOL or UV light filtering IOLs were unsatisfied with visual functions.

Some patients asked if they have clear lens in one eye and yellow lens in other eye, will they notice any difference. We reviewed studies available on this topic and majority of patients would not find a difference in vision between two eyes.[18] In our own experience the 5 patients who had yellow lens in one eye and clear in other eye would not find any difference eyes. It shows that both blue light filtering IOL and UV light filtering IOL have similar visual performance.

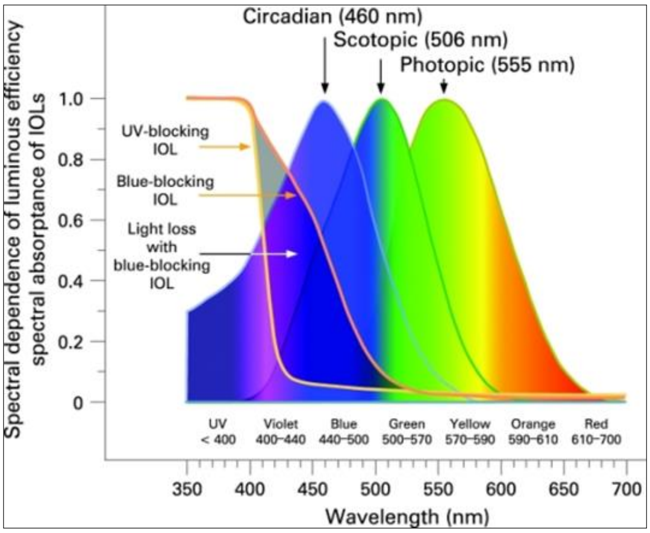


**Fig 1**

**Table 1:** Characteristics of the two types of IOLs used in this study

| | **Blue light filtering (Yellow)IOL** | **UV filtering Clear IOL** |
|---|---|---|
| IOL Design | Single piece | Single piece |
| | Aspheric optics | Aspheric optics |
| | Posterior 360° square-edge | Posterior 360° square-edge |
| Optic material | Hydrophilic Acrylic | Hydrophilic Acrylic |
| UV filter (colorless) | Yes (block 390nm) | Yes (block 390nm) |
| Blue light filter(Yellow) | Yes (block 430nm) | No (Aspheric IOL) |
| Optic shape | Biconvex | Biconvex |
| Optic diameter (mm) | 6 | 6 |
| Total diameter (mm) | 12.5 | 12.5 |
| Haptic shape | C-loop | C-loop |
| A constant | 118.0 | 118.0 |

**Table 2:** Profile of cataract patients under study

| | Blue light filtering Yellow IOL (Y group) | UV filtering Clear IOL (A group) |
|---|---|---|
| Number of eyes | 25 | 25 |
| Sex (M/F) | 13/12 | 11/14 |
| Mean age (years) | 65.4 ±4.0 | 66.1±5.0 |
| (range) | (51– 83) | (46–81) |
| Mean IOL power (D) | 22.5 ±1.5 | 22±1.9 |
| (range) | (18 – 24.0) | (18.0–24) |
| Mean axial length (mm) | 22.67 ±0.90 | 22.80±0.76 |
| (range) | (21.12 – 24.33) | (21.72–24.22) |

**Table 3:** Visual acuity after 6 months

| Mean VA (Log MAR; Snellen)* | Blue light filtering Yellow IOL (Y group) | | UV filtering Clear IOL (A group) | | *P* value* |
|---|---|---|---|---|---|
| UCVA (6 m) | 0.10 ± 0.15 | | 0.12 | ± 0.14 | 0.654 |
| BCVA (6 m) | 0.01 | ± 0.06 | 0.01 | ± 0.07 | 0.640 |
| UCVA (33 cm) | 0.55 | ± 0.14 | 0.54 | ± 0.15 | 0.866 |
| BCVA (33 cm) | 0.58 | ± 0.12 | 0.60 | ± 0.14 | 0.545 |

UCVA uncorrected visual acuity
BCVA best corrected visual acuity
*(Log MAR; log Minimum angle of resolution)

**Table 4:** Total Error scores (TES) for the Farnsworth-Munsell 100-hue test in photopic condition.

| Parameter | Blue light filtering yellow IOL | UV light filtering Clear IOL | *P* value* |
|---|---|---|---|
| Total error score (Mean ± SD) | 124.4 ± 23.1 | 132.8 ± 28.6 | 0.146 |
| Range | (92 – 215) | (84 – 220) | |
| (Mean ± SD) | | | |

**Table 5:** Contrast Sensitivity tested with Pelli - Robson chart at 6 months

| | Y group contrast sensitivity mean | A group contrast sensitivity mean | P Value |
|---|---|---|---|
| photopic | 1.59 ± 0.26 | 1.63 ± 0.25 | 0.116* |
| mesopic | 1.12 ± 0.22 | 1.15 ± 0.18 | 0.127* |

0.05 ≤ * statistically significant p

## 5. Conclusion

In this study we found that the blue light filtering IOL offer no significant advantage over UV light filtering IOL in visual functions. The parameters tested were postoperative visual acuity, contrast sensitivity, color vision and patient satisfaction. But there is no negative effect of using Blue light filtering IOL. Longer clinical studies are required to evaluate retinal protection claimed by using a blue-light filtering yellow IOL.

There is an option for those who do not using blue light filtering IOL. It is use of UV light filtering IOL along with blue-light filtering *spectacle lenses* worn during sunlight, for macular protection.

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