

Intraindividual comparison of color perception and contrast sensitivity with and without a blue light-filtering intraocular lens

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PURPOSE. *To investigate color perception and contrast sensitivity with and without additional glare in pseudophakic patients with a conventional intraocular lens (IOL) in one eye and a blue light-filtering IOL in the fellow eye.*

METHODS. *Twenty-three bilaterally pseudophakic patients with a conventional IOL (AcrySof SA60AT) and a blue light-filtering IOL (AcrySof Natural SN60AT) were tested for intraindividual comparison of visual acuity (ETDRS chart), color perception (Farnsworth-Munsell 100-Hue test), and contrast sensitivity with and without glare (Contrast Sensitivity Pattern Generator). Information about subjective perception was gathered through a questionnaire.*

RESULTS. *Four patients (17.4%) observed some difference in monocular color perception. Color testing did not show significantly different results for the two IOL types expressed as total error score and segmental error subscores for protan, deutan, and tritan ranges. Regarding contrast sensitivity, 5 patients (21.7%) indicated noticeable difference between the two eyes. Contrast sensitivity testing, however, showed similar curves for the two IOL types with and without additional glare.*

CONCLUSIONS. *Despite some subjective difference in color and contrast perception in a minority of patients, the study did not show significantly different results for the two IOL types. (Eur J Ophthalmol 2009; 19: 235-9)*

KEY WORDS. *AcrySof Natural, Blue-blocking, Color vision, Contrast sensitivity, SA60AT, SN60AT*

Accepted: September 4, 2008

INTRODUCTION

Since the introduction of intraocular lenses (IOLs) by Ridley 60 years ago to correct for aphakia after cataract extraction, major modifications have been implemented during decades of further development. Many different types of haptics were investigated and important improvements of optical properties were achieved. Regarding light transmission, filtering of ultraviolet rays was incorporated in the 1980s because of growing evidence of ultraviolet light causing photic retinopathy and cystoid macular edema (1-3). However, these so-called conventional IOLs allow the passage of the entire visible spectrum (4). A number

of studies indicate that prolonged exposure of the aging retina to blue light in the range of 400–500 nm can result in photoreceptor damage (5-13). Therefore, several blue light-filtering IOLs have been introduced in recent years. Their yellow tint more closely replicates the spectral transmission properties of the human crystalline lens than conventional IOLs (4). In particular, blue light-filtering IOLs are being implanted in patients at risk of developing age-related maculopathy. Their growing use raises questions regarding color perception and contrast sensitivity. This study was designed to compare visual function in pseudophakic patients with a conventional IOL in one eye and a blue light-filtering IOL in the fellow eye.

METHODS

With the introduction of a blue light-filtering IOL for standard cataract surgery at our clinic, patients who had previously had a conventional IOL (SA60AT; Alcon, Fort Worth, TX, USA) implanted into one eye received a blue light-filtering AcrySof Natural (SN60AT; Alcon) for the fellow eye. These patients were reviewed retrospectively. Patients were excluded from the study if they had a history of any other intraocular surgery or if any pathology impairing visual function was present. Of 42 patients reviewed, 23 met these inclusion criteria and were accepted to participate in the study. The study was approved by the local ethical board and all patients signed an informed consent.

Study examinations were not performed until 3 months after cataract surgery. Evaluation of subjective visual quality was carried out by means of a questionnaire. Subjects were asked whether they could observe any difference in color or contrast perception. If the answer was positive, they had to specify whether it was perceived monocularly or binocularly and they were asked to quantify visual quality on a scale ranging from 1 (poor) to 10 (excellent). Furthermore, in the case of noticeable difference in color perception, they were asked to indicate the affected color range (red, green, blue). Visual acuity testing was performed using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart. After assessment of color vision and contrast sensitivity (see below), the examination was completed with Goldmann applanation tonometry, thorough slit lamp biomicroscopy, as well as dilated fundus examination.

Color vision was assessed for each eye with the Farnsworth-Munsell 100-Hue test under standard illumination protocol. Total error scores were calculated. For further differentiation, segmental error subscores were determined for the color cap ranges of protan (14–24, 62–70), deutan (12–20, 56–61), and tritan (2–6, 46–52) (14).

Contrast sensitivity testing was performed with the NeuroScientific Contrast Sensitivity Pattern Generator (v3.85, NeuroScientific Corporation, Farmingdale, NY, USA) using an IKEGAMI PM580 Monitor (12.3 cm, IKEGAMI Tsushinki Co. Ltd., Utsunomiya, Japan) at a 1-meter testing distance with best refractive correction. Sinusoidal gratings at six spatial frequencies from 0.38 to 11.39 c/deg (octave steps) were presented on a split screen in a two-alternative forced-choice manner (sinusoidal stimulus versus uniform gray, mean luminance: 100 cd/m², initial contrast settings: 10 dB below normal CSF, correct contrast

change: 9 dB before/4 dB after data collection, number of errors before data collected: 2, number of consecutive correct answers before contrast decreases: 2, number of reversals per special frequency: 8). The measurements were performed for each eye separately with and without additional glare. Glare simulation was carried out by means of three white light emitting diodes (luminance: 8,000 mcd) mounted on top and on both sides of the stimulus presenting monitor.

Statistical analysis was performed with the Wilcoxon signed-rank test.

RESULTS

Thirteen subjects were female, 10 were male. The average age at the time of surgery was 72.9±7.5 years. All patients were operated by the same surgeon (P.C.).

Nine blue light-filtering IOLs were implanted on the right side, 14 on the left side. Mean BCVA was 58.3±5.6 with the SA60AT and 59.3±5.0 with the SN60AT (difference of the mean between the two groups 2.7±2.6, $p=0.110$). Four subjects (17.4%) reported monocularly perceivable color difference between the two eyes. In two of them it affected the green spectrum; the other two indicated all three color ranges (red, green, and blue). None of the subjects reported binocularly apparent color difference. Subjective grading of color vision quality revealed 9.5±1.0 points for the SA60AT and 7.3±2.1 for the SN60AT on a scale from 1–10. Analysis of the Farnsworth-Munsell 100-Hue test results showed a mean total error score of 276.2±48.6 with the SA60AT and 275.8±48.5 with the SN60AT (difference of the mean 25.2±21.9, $p=0.638$). Segmental error subscores for protan, deutan, and tritan ranges showed similar results for the two IOLs (protan: 58.1±10.0 vs 56.0±9.7; $p=0.298$ /deutan: 41.0±8.6 vs 41.0±9.2; $p=0.876$ /tritan: 43.4±9.5 vs 46.6±11.1; $p=0.237$). Regarding contrast sensitivity, 4 subjects (17.4%) reported monocularly perceivable differences between the two eyes. In one patient (4.3%), some difference was apparent binocularly but without complaints. Subjective scoring showed 8.6±1.7 points with the SA60AT and 6.8±2.9 with the SN60AT. Measurement of contrast sensitivity without additional glare revealed slightly higher sensitivity thresholds with the SA60AT (Fig. 1) for middle spatial frequencies of 1.52 c/deg ($p=0.170$) and 2.85 c/deg ($p=0.412$). Measurement with additional glare showed comparable curves for both types of IOL (Fig. 2).

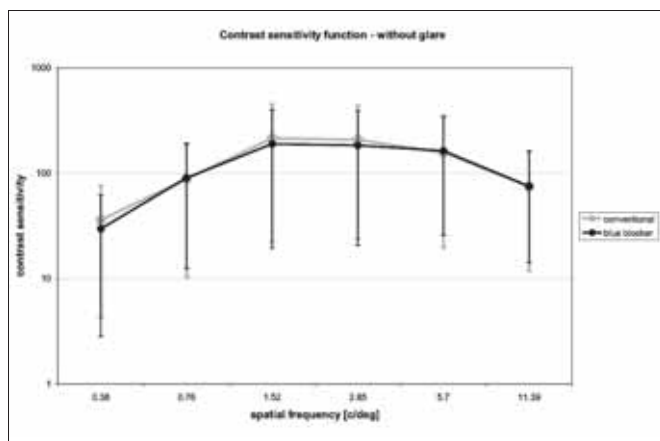


Fig. 1 - Contrast sensitivity function without glare at spatial frequencies from 0.38 to 11.39 cycles per degree (octave steps). Note the lower contrast sensitivity with blue light-filtering intraocular lenses at middle range spatial frequencies (statistically not significant).

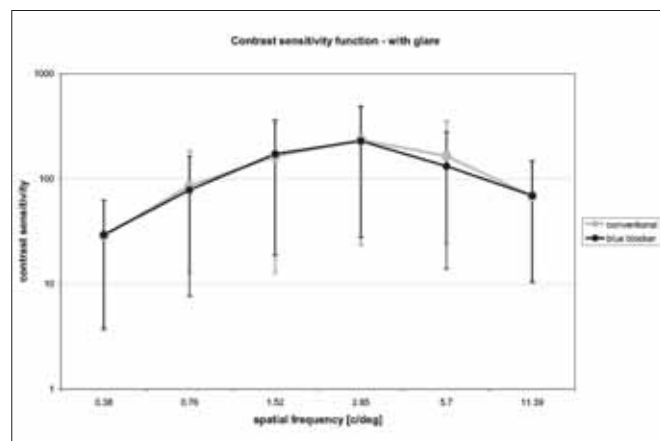


Fig. 2 - Contrast sensitivity function with additional glare. Similar curves for conventional and blue light-filtering intraocular lenses.

DISCUSSION

Conventional IOLs incorporate an ultraviolet filter, but they still allow the passage of the entire visible light spectrum (4). In comparison, the transmission properties of a human crystalline lens shows marked filtering at the blue end of the visible spectrum between 400 and 500 nm (15). This can be appreciated clinically as increasing yellow appearance with age. Some evidence exists about the protective nature of this natural filtering effect with regard to the aging macula (5-13). Hence several blue light-filtering IOLs have been introduced recently with growing use in cataract surgery, notably in the presence of age-related maculopathy. The associated change in transmission properties poses questions with regard to color perception and contrast sensitivity. In particular, influence within the tritan range of the color spectrum might be expected. Furthermore, enhanced contrast sensitivity with blue light-filtering IOLs is conceivable due to reduced longitudinal chromatic aberration (16, 17). The aim of this study was to investigate color perception and contrast sensitivity in 23 pseudophakic patients with a conventional IOL in one eye and a blue light-filtering IOL in the fellow eye.

Analysis of the Farnsworth-Munsell 100-Hue test showed comparable results for the two different IOLs, both expressed as mean total error score as well as segmental subscores for protan, deutan, and tritan ranges. Determination of contrast sensitivity for six spatial frequencies up to 11.39 c/deg with and without additional glare showed

similar curves for the two IOL types. These observations are consistent with other studies which investigated the influence of blue light-filtering lenses on visual function (18-26). Notably, the study by Landers et al (21) with a similar study design could not show any significant difference in 93 subjects with both IOL types implanted. The presumed influence on color perception within the tritan range, which could be shown by some authors (27), could not be confirmed in our study. Furthermore, no significant difference in contrast sensitivity with the blue light-filtering IOL could be shown as opposed to some other studies (17, 28, 27). This result is of particular interest as the contrast sensitivity monitor test used in this study provides better sensitivity than most of the conventional contrast sensitivity tests used in comparable studies (18, 21-25, 27). Furthermore, no effect created by frontal glare was found in this study. It cannot be excluded, however, that some difference in contrast sensitivity would be detected if tested at spatial frequencies higher than 11.39 c/deg.

With regard to subjective visual quality in pseudophakic patients with either IOL type in each eye, controversial information can be found in the literature. One retrospective case series of five patients, in whom the two different IOL types were matched unintentionally, revealed subjectively perceivable color difference upon information about the mismatch, although no color imbalance could be noted binocularly (29). One single case report even gives an account of a patient in whom an exchange of the blue light-filtering IOL for a conventional one was performed be-

cause of disturbing color imbalance (30). A reply to this report, however, states that no subjective color disturbance was induced in about 500 patients, for whom implantation of a blue light-filtering IOL contralateral to a conventional IOL was performed, though no formal testing was carried out to detect potential color imbalances (31). It therefore appears that a relevant subjective problem with color imbalance is unlikely to occur, as could be demonstrated in this study using a Farnsworth-Munsell 100-Hue test.

In summary, this study could not demonstrate a significant difference in contrast sensitivity with or without glare in patients receiving a standard IOL (Alcon SA60AT) in one eye and a blue light-filtering IOL (Alcon SN60AT) in the fellow eye. The subjective results have to be treated with caution as patients might have been biased, knowing the kind of IOL implanted in their eyes. The results on contrast sensitivity, however, are of particular interest as the test applied provides a high sensitivity and determines

contrast sensitivity thresholds at different spatial frequencies from 0.38 to 11.39 c/deg in this study. In conclusion, although the number of patients is relatively small, these results suggest that there is no relevant difference in daily life color perception or contrast sensitivity with or without glare between IOLs with or without blue light-filtering effect.

The authors do not have any proprietary interests. No grants or funds supported the study.

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