·Letter to the Editor·

Clinical comparative analysis of the outcomes with a yellow- and a violet-tinted intraocular lens

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Dear Sir,

I am Dr. Peter Mojzis from Premium Clinic in Teplice (Czech Republic). I write to present the results of a comparative study of clinical outcomes obtained with two different types of tinted intraocular lenses (IOLs), yellow- *vs* violet-tinted IOLs.

IOLs containing a yellow chromophore that filters simultaneously ultra violet (UV) and blue light were developed several years ago in the attempt of avoiding that blue and violet visible light reached the retina in the pseudophakic eye[1]. These blue-light filtering IOLs have shown good visual and contrast sensitivity outcomes postoperatively [2-3], but some side effects in relation with the steady reduction in the transmission of short-wavelength visible light have been reported by some authors, such as alterations in colour perception[4] or a detrimental effect of the circadian rhythm[5]. For this reason, a new concept of light-filtering IOL has been recently developed that consists of introducing in the IOL material a violet absorber that allows full transmission of healthy blue light and theoretically avoiding the side effects of yellow-tinted IOLs. However, to this date, there are no studies reporting the clinical outcomes with this new modality of IOL, violet light filtering or violet-tinted IOLs.

We conducted in our clinic a prospective randomized comparative study enrolling 55 eyes of 28 patients undergoing cataract surgery and ranging in age from 61 to 84y (mean age: 71.9y). Two groups were created according to the model of IOL implanted: the yellow IOL group, including 22 eyes of 11 patients implanted with the monofocal C-loop blue-light filtering IOL (Acrysof IQ SN60WF, Alcon) that reduces the transmittance for the blue light wavelengths from 62% at 400 nm to 23% at 475 nm, and the violet IOL group, including 33 eyes of 17 patients implanted with the monofocal plate-haptic violet filtering IOL (CT Asphina 404V, Carl Zeiss Meditec) that reduces transmittance of violet light wavelengths in the range from 400 nm to 440 nm. Inclusion criteria were patients with cataract or presbyopic/pre-presbyopic patients suitable for refractive lens exchange seeking for spectacle independence. Exclusion criteria were patients with history of glaucoma or retinal detachment, corneal disease, irregular corneal astigmatism, abnormal iris, macular degeneration or retinopathy, neurophthalmic disease, history of ocular inflammation or previous ocular surgery. All patients were adequately informed and signed a consent form. The study adhered to the tenets of the Declaration of Helsinki and it was approved by the local ethics committee.

Before surgery, a complete ophthalmologic examination was performed in all cases, including manifest refraction, automated keratometry, uncorrected (UDVA) and corrected distance visual acuity (CDVA) testing (ETDRS charts), Goldmann applanation tonometry, slit-lamp examination, ocular aberrometry (OPD scan III, Nidek), corneal topography (OPD scan III, Nidek), biometry (IOL Master v.4.3, Carl Zeiss Meditec), contrast sensitivity measurements under photopic (85 cd/m^2) and mesopic conditions (3 cd/m^2, CSV 1000), and funduscopy.

All surgeries were performed by the same experienced surgeon (Mojzis P) using a standard technique of sutureless micro-coaxial 2.4-mm incision phacoemulsification in the

Table 1 Comparative table showing the 3-month postoperative visual and refractive outcomes of eyes included in the yellow and violet IOL groups.

Parameters	Yellow IOL group		Violet IOL group		*P*
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
LogMAR UDVA	0.14 (0.19)	0.10 (0.00 to 0.60)	0.10 (0.14)	0.10 (-0.10 to 0.50)	0.81[b]
LogMAR CDVA	0.00 (0.04)	0.00 (-0.10 to 0.10)	0.01 (0.06)	0.00 (-0.10 to 0.20)	0.64[b]
Sphere (D)	-0.02 (0.79)	+0.25 (-1.75 to 1.50)	-0.34 (0.61)	-0.50 (-1.75 to 1.50)	0.10[a]
Cylinder (D)	-0.31 (0.24)	-0.25 (-0.75 to 0.00)	-0.36 (0.38)	-0.25 (-1.50 to 0.00)	0.93[b]
Spherical equivalent (D)	-0.18 (0.78)	+0.06 (-2.00 to 1.13)	-0.52 (0.57)	-0.63 (-1.75 to 1.00)	0.06[a]
Corneal astigmatism (D)	0.52 (0.22)	0.52 (0.05 to 0.87)	0.50 (0.24)	0.49 (0.15 to 1.07)	0.81[a]

SD: Standard deviation; D: Diopters; UDVA: Uncorrected distance visual acuity; CDVA: Corrected distance visual acuity. [a]Student's *t*-test; [b]Mann-Whitney *U* test.

yellow IOL group and a microincision (2.0-mm) phacoemulsification technique in the violet IOL group. Patients were revised postoperatively the day after surgery, at 1mo and 3mo after surgery. The postoperative examination protocol at 3mo was identical to the preoperative protocol.

No statistically significant differences between groups were present preoperatively in sphere, spherical equivalent, mean keratometry, axial length or anterior chamber depth($P \geqslant 0.05$). Likewise, no statistically significant differences between groups were found in IOL power (P=0.46). Only a small in magnitude but statistically significant difference between groups was found in preoperative manifest cylinder (-0.48±0.27 D yellow IOL group *vs* -0.73±0.47 D violet IOL group, P=0.03).

Table 1 summarizes the 3-month postoperative visual acuity and refraction data in the two groups of eyes evaluated. No statistically significant differences between groups were found in postoperative UDVA (P=0.81) and CDVA (P=0.64). Likewise, no significant differences between groups were found in postoperative sphere (P=0.10) and spherical equivalent (P=0.06). Furthermore, no statistically significant differences between groups were found in postoperative manifest cylinder (P=0.93), which was consistent with the lack of statistical significance for the difference between groups in corneal astigmatism (P=0.81).

Significantly better photopic contrast sensitivities were observed in the yellow IOL group preoperatively compared to the violet IOL group for the spatial frequencies of 3 (P=0.03) and 6 cycles/° (P=0.04) (Figure 1). Postoperatively, only the photopic contrast sensitivity for 12 cycles/° (P=0.01) was found to be significantly better in the yellow IOL group compared to the violet IOL group (1.5 cycles/°, P=0.12; 3 cycles/°, P=0.08; 6 cycles/°, P=0.10; 12 cycles/°, P=0.82; 18 cycles/°, P=0.24) (Figure 1). Regarding mesopic contrast sensitivity, no statistically significant differences were found between groups preoperatively ($P \geqslant 0.44$) (Figure 1). In contrast, better mesopic contrast sensitivities were found postoperatively in the yellow IOL group compared to the violet IOL group for the spatial frequencies of 3 (P=0.03) and 12 cycles/° (P=0.02) (Figure 1).

Preoperatively, no statistically significant differences in any internal and ocular aberrometric term was found ($P \geqslant 0.054$), except for internal spherical aberration Zernike term (P=0.003). Postoperatively, no statistically significant differences were found in any internal and ocular aberrometric term ($P \geqslant 0.25$), except for the Zernike terms corresponding to internal and ocular spherical aberration ($P<0.001$).

Both tinted IOLs provided excellent distance visual outcomes, with mean 3-month postoperative UDVA and CDVA values around 0.10 (to 20/25) and 0.00 (to 20/20) logMAR, respectively. This confirms the ability of these two aspheric tinted IOLs of providing a good visual outcome due to a predictable correction of the spherocylindrical error. No statistically significant differences were found in the visual and refractive outcomes obtained with both IOLs, showing a similar postoperative variability. Comparing with the results reported by previous authors, our UDVA and CDVA outcomes with the two types of IOL evaluated were comparable to those obtained in previous series evaluating different yellow-tinted IOLs [2-3]. Likewise, our results were consistent with those reported for other types of aspheric IOLs without yellow tinting[6-7]. Regarding contrast sensitivity, some differences were observed preoperatively between yellow and violet IOL groups possibly due to discrepancies in the type and density of cataract in each group. Postoperatively, significantly better values of photopic contrast sensitivity were found for the spatial frequency of 12 cycles/° in those eyes implanted with the yellow IOL. Likewise, better mesopic contrast sensitivity for the spatial frequency of 3 cycles/° was found in the yellow IOL group compared to the violet IOL group. This suggests that the optical performance of the yellow IOL may be potentially better than that of the violet IOL, leading to an improved contrast sensitivity outcome. Kara-Junior *et al* [3] compared the levels of photopic and scotopic contrast sensitivity in patients implanted with a yellow-tinted IOL in one eye and

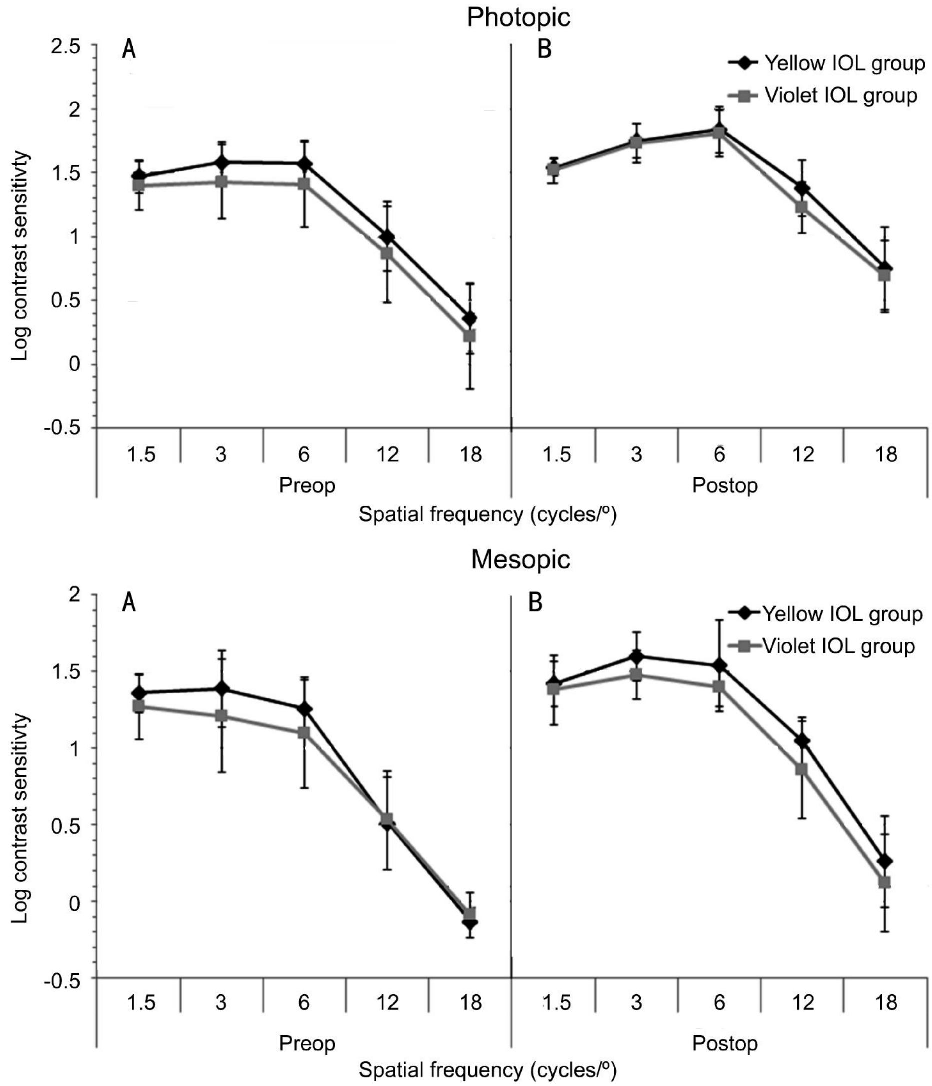

Figure 1 Mean preoperative (A) and postoperative (B) contrast sensitivity function measured under photopic (top) and mesopic (bottom) conditions in the yellow IOL (black line) and violet IOL (grey line) groups.

with a non-tinted IOL in the fellow eye and did not detect significant differences. Leibovitch *et al* [2] and Rodríguez-Galietero *et al* [8] obtained a similar outcome but comparing the contrast sensitivity outcomes in eyes implanted with yellow-tinted and clear IOLs. In contrast, Niwa *et al* [9] found in another comparative study that a yellow-tinted IOL provided an improved contrast sensitivity in the middle spatial frequencies of 6 and 12 cycles/° in photopic and mesopic conditions compared to the outcomes of non-tinted IOL.

Regarding the aberrometric outcomes, higher levels of postoperative higher order aberrations were observed in the group of eyes implanted with the violet IOL compared to the yellow IOL, although the difference was only statistical significant for primary spherical aberration. Specifically, eyes implanted with the yellow IOL showed more negative internal spherical aberration leading to an ocular level of spherical aberration of almost zero. Therefore, this IOL provided a more effective compensation for the corneal spherical aberration. This is consistent with previous studies that have confirmed the ability of this yellow IOL to compensate this type of aberration [10]. Liu *et al* [10] found in a comparative study that the aspheric yellow IOL evaluated in our series induced significantly less spherical aberration and provided better contrast sensitivity, especially under mesopic conditions, than another yellow-tinted but spherical IOL. In our study, the difference in postoperative contrast sensitivity between yellow and violet IOLs may be due to the difference in the level of residual spherical aberration.

In conclusion, the yellow- and violet-tinted IOLs evaluated in our study are able to provide an effective distance visual restoration after cataract surgery, although the yellow IOL seems to provide a better visual quality due to the optimization of the postoperative level of spherical aberration. Future studies should be performed to confirm these results in larger samples sizes and with a longer follow-up. Likewise, the potential effect of changes in chromatic aberration with these tinted IOLs should be evaluated in future series.

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