Effect of Yellow-Tinted Intraocular Lens on Standard Automated Perimetry and Short Wavelength Automated Perimetry in Patients with Glaucoma

Naveed Nilforushan, Mohammad Parsamanesh, Fei Yu, Nariman Nassiri, Arezoo Miraftabi, Anne L. Coleman

ABSTRACT

Purpose: To investigate the effect of cataract surgery and yellow-tinted intraocular lens (IOLs) implantation on perimetry indices of short-wavelength automated perimetry (SWAP) and standard automated perimetry (SAP) testing in patients with coexisting cataract and glaucoma.

Materials and Methods: In this prospective comparative case series, phacoemulsification with implantation of yellow-tinted Acrysof Natural IOL was performed in 16 eyes of 16 patients with visually significant cataract (best-corrected visual acuity (VA) better than 20/120) and mild to moderate glaucoma. Pre- and postoperative values for VA and for perimetry indices including mean deviation (MD), pattern standard deviation (PSD), and foveal threshold (FT) from both SAP and SWAP testing were compared.

Results: Postoperative VA improved significantly after cataract surgery and yellow-tinted IOL implantation (P < 0.001). After cataract extraction and IOL implantation, MD and FT on SWAP testing improved significantly (P = 0.001); however, there was no statistically significant change with SAP testing between the pre- and postoperative perimetry indices. There was no statistically significant change in PSD with either SAP or SWAP testing postoperatively. The differences between pre- and postoperative values for all perimetry indices under study were not significant when comparing SAP with SWAP tests, except for MD which had improved statistically significantly in SWAP testing (P = 0.03).

Conclusions: In mild to moderate glaucoma patients with cataracts, the perimetry indices of SWAP testing improved after phacoemulsification and yellow-tinted IOL implantation. This suggests that the yellow-tinted IOLs have less effect on SWAP testing than visually significant cataracts.

Key words: Glaucoma, Standard Automated Perimetry, Short-Wavelength Automated Perimetry, Yellow-Tinted Intraocular Lens

INTRODUCTION

Short-wavelength automated perimetry (SWAP) can detect functional changes due to glaucoma in individuals with the early stages of disease and without visually significant cataracts. Cataracts have been reported to cause a generalized reduction in sensitivity for standard automated perimetry (SAP) and SWAP tests in normal subjects, and this generalized reduction is more prominent on SWAP testing compared with SAP testing.\(^1\) SWAP testing uses a blue stimulus of 440 nm on a bright yellow background of 100 candela/m\(^2\). However, yellow-tinted intraocular lens (IOLs) contains a yellow chromophore with the ability to absorb the high-energetic visible blue light between 380 and 500 nm and may act like nuclear
sclerotic cataracts and affect the quality of SWAP visual field testing. This effect can be even more important in glaucoma patients undergoing cataract surgery with yellow-tinted IOL implantation, as the koniocellular pathway which uses this spectrum for blue-yellow light processing has been reported to be damaged in early glaucoma.  

As early diagnosis of glaucoma is highly dependent on visual field results, it is important to evaluate the effect of yellow-tinted IOLs on SWAP testing in patients with mild to moderate glaucoma. In addition to claims of the manufacturer, the spectral transmittance curve of these yellow-tinted IOLs with the ability to filter the blue light has been previously evaluated by Artigas et al.  

In this study, we investigate the effect of the yellow-tinted AcrySof Natural IOL (SN60AT, Alcon Laboratories, Inc., Fort Worth, TX, USA) on SAP and SWAP testing in patients with glaucoma. To our knowledge, the effect of cataract extraction and implantation of yellow-tinted IOLs on the results of SAP and SWAP tests in glaucoma patients has not been documented.

**MATERIALS AND METHODS**

**Study population**

This prospective case series was performed from May 2008 to November 2009 at the Rassoul Akram Hospital, Tehran, Iran. The Ethics Committee of the Rassoul Akram Hospital approved the study protocol. All patients provided written informed consent and this study was followed the tenets of the Declaration of Helsinki. A total of 16 eyes of 16 patients with cataract and mild to moderate glaucoma (11 primary open-angle glaucoma, 5 pseudoexfoliative glaucoma) were enrolled. Inclusion criteria were visually significant cataract up to grade 2 in all segments of the lens based on the Lens Opacities Classification System classification; best-corrected visual acuity (BCVA) better than 20/120; spherical refractive error within ± 5 D and cylinder correction within ± 3 D; intraocular pressure (IOP) less than 18 mm Hg during the previous 6 months with no more than two IOP-lowering medications; open angle on gonioscopy; and no history of previous intraocular surgeries, diabetes, neurologic disease, or use of medications known to affect visual fields or color vision. In addition, patients had characteristic repeatable signs of mild to moderate glaucomatous damage on SAP based on Hodapp’s visual field classification, with corresponding clinical signs of retinal nerve fiber layer or optic disc changes. Glaucomatous eyes were defined as those with vertical cup-to-disc asymmetry between eyes of ≥0.2, a cup-disc ratio ≥0.6, neuroretinal rim narrowing, notches, or retinal nerve fiber layer defects with glaucomatous visual field loss in the corresponding hemifield. Glaucomatous field defects were defined as a consecutive abnormal result in a glaucoma hemifield test in addition to one of the following three parameters: ≥2 contiguous points with a pattern deviation sensitivity loss of  P < 0.01, ≥3 contiguous points with a sensitivity loss of  P < 0.05 in the superior or inferior arcuate area, or a 10-dB difference across the nasal horizontal midline at two or more adjacent locations. Subjects in this study had at least one of the above visual field findings; however, none of the following findings was detected in the pattern deviation plot of our patients: Depression of greater than 50% of points with P < 5% or more than 25% of points with P < 1% level or both hemifields in the central 5° with sensitivity of <15 decibel or any point in the central 5° with sensitivity of 0 decibel. Diagnosis of glaucomatous field defect was based on SAP testing findings, which is considered as the gold standard functional test.

**Preoperative assessments**

Preoperatively, in addition to visual field perimetry, each participant underwent a comprehensive ophthalmic evaluation including a review of the medical and ocular history, slit-lamp biomicroscopy (SLE), dilated fundoscopy with a 78-D lens, BCVA, IOP with a calibrated Goldmann applanation tonometer, and gonioscopy.

Both SAP (24-2 SITA-standard strategy) and SWAP (24-2 full threshold strategy) were performed with the Humphrey Field Analyzer 750 (Humphrey-Zeiss Instruments, Dublin, California, USA). Participants were required to have at least two consecutive reliable SAP and SWAP tests (fixation loss < 20%, false negative < 15%, and false positive < 10%) within 30 days prior to surgery. The last visual fields were within 5 days preoperatively. For decreasing the possible effect of test-retest variability and long-term fluctuation on the result of the study, each test was repeated if the values of mean deviation (MD) or pattern standard deviation (PSD) were ≥1.5 decibels from the previous test. Patients with no previous experience of visual field testing were instructed before each test. All patients performed the SAP and then the SWAP test. The patients rested for 30 min between the visual field tests to minimize fatigue. For all SWAP tests and for adaptation to yellow light, patients were exposed to yellow light from the Humphrey perimeter for 5 min before starting the test.

**Surgical procedure and postoperative management**

All surgeries were performed under topical anesthesia in an outpatient setting by a single surgeon (N.Nil). Phacoemulsification was performed through a 3.2-mm clear temporal corneal incision. The AcrySof Natural IOL (SN60AT, Alcon Laboratories, Inc.) was placed in the capsular bag after aspirating the lens cortex. The corneal wound was sealed by injecting a balanced salt solution into the corneal stroma, which causes local corneal edema. Postoperative follow up was performed on days 1, 7, 14, and 30. SLE, VA, and IOP measurements were performed at all follow-up visits. Medical treatment consisted of a combination of topical antibiotic for 5 days and steroid eye drops. Steroids were tapered over the course of 4 weeks. IOP-lowering medications
were continued depending on the postoperative IOP and clinical status of the eye. Visual field tests with the same preoperative parameters were performed two times 4-6 weeks after cataract surgery.

Statistical analysis
The average of MD, PSD, and foveal threshold (FT) measurements from two consecutive and reliable tests on both SAP and SWAP were used for statistical analysis. Demographic data as well as pre- and postoperative visual field measures were recorded on standardized data sheets and later transferred to SPSS software file for analysis (version 15; SPSS Inc., Chicago, IL, USA). Normality of the distribution of all variable scores was tested by Kolmogorov-Smirnov statistical analysis. Preoperative and postoperative measures were compared using the paired t-test. The sample size calculation was based on standard deviation of 2 dB, difference of 2 dB in MD between pre- and postoperative SWAP and statistical power of 0.8. A P value less than 0.05 was considered statistically significant.

RESULTS
Table 1 depicts the baseline characteristics for the study population. Pre- and postoperative measures of both SAP and SWAP testing are presented in Table 2. There was a statistically significant improved in BCVA postoperatively (P < 0.001). MD and FT improved for both SAP and SWAP postoperatively and were statistically significant on SWAP (P = 0.001) but not on SAP (P = 0.3 and 0.2, respectively).

The mean difference between preoperative and postoperative values of the visual field indices were not statistically significant between SAP and SWAP, except for MD (P = 0.03), which showed greater improvement on SWAP testing compared with SAP testing [Table 3].

DISCUSSION
Although yellow-tinted IOLs decrease the amount of light transmission to the retina, cataracts appear to interfere with SWAP testing more than do yellow-tinted IOLs in glaucoma patients because yellow-tinted IOLs were associated with an improvement in the MD and FT on SWAP testing in mild to moderate glaucoma patients.

There have been three comparative studies regarding the effect of yellow-tinted and clear IOLs on SAP and SWAP in subjects without glaucoma. Castro et al., stated a reduction of MD and FT on SWAP testing, but not with SAP testing when a blue-light-spectrum filter was placed in front of the eyes of 20 young patients without cataracts. These filters mimicked the Acrysof Natural IOL with regard to light spectrum transmittance. Kara-Júnior et al. compared the effect of clear and yellow-tinted IOLs on SWAP indices in 46 normal subjects (mean age: 68.5 years old) and did not detect any statistically significant differences between these two IOLs in postoperative values although the MD, was better on SAP, which is similar to the outcome from our study. Jang et al., reported that there was no statistically significant difference between the yellow-tinted and non-tinted IOLs on SAP indices (MD and PSD) in 22 patients. However, on SWAP testing, there was a statistically significant difference in MD and PSD values between yellow-tinted and non-tinted IOLs. However Jang et al., did not evaluate the preoperative SAP and SWAP indices in the

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age±SD, year</td>
<td>64.3±7.0</td>
<td>64.3±7.0</td>
<td>&lt;-0.001</td>
</tr>
<tr>
<td>Male/female, (male %)</td>
<td>8/8 (50)</td>
<td>8/8 (50)</td>
<td>0.11±0.18</td>
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<tr>
<td>Right/left, n</td>
<td>11/5</td>
<td>11/5</td>
<td>2.94±1.9</td>
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<tr>
<td>Mean IOP±SD, mm Hg</td>
<td>16.0±1.2</td>
<td>16.0±1.2</td>
<td>33.31±2.5</td>
</tr>
<tr>
<td>Mean number of glaucoma medications±SD</td>
<td>1.6±0.5</td>
<td>1.6±0.5</td>
<td>3.9±5.4</td>
</tr>
<tr>
<td>Mean BCVA±SD, logMAR</td>
<td>0.62±0.24</td>
<td>0.62±0.24</td>
<td>4.15±1.1</td>
</tr>
</tbody>
</table>

BCVA: Best corrected visual acuity, IOP: Intraocular pressure, SD: Standard deviation, log MAR: Logarithm minimum angle of resolution

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<th>Postoperative</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean BCVA±SD, (logMAR)</td>
<td>0.62±0.24</td>
<td>0.11±0.18</td>
<td>&lt;-0.001</td>
</tr>
<tr>
<td>Mean deviation</td>
<td>-5.4±3.4</td>
<td>-4.5±3.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Pattern standard deviation</td>
<td>4.3±3.7</td>
<td>2.9±1.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Foveal threshold</td>
<td>32.2±3.5</td>
<td>33.3±1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Mean deviation</td>
<td>-9.2±4.7</td>
<td>-5.4±3.6</td>
<td>0.001</td>
</tr>
<tr>
<td>Pattern standard deviation</td>
<td>4.1±1.1</td>
<td>4.4±1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Foveal threshold</td>
<td>16.4±4.7</td>
<td>20.3±5.4</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Results are presented as means ± standard deviation. BCVA: Best corrected visual acuity, log MAR: Logarithm minimum angle of resolution, SAP: Standard automated perimetry, SD: Standard deviation, SWAP: Short-wavelength automated perimetry, *: Paired t test, P<0.05 was statistically significant

<table>
<thead>
<tr>
<th>Variables</th>
<th>SAP</th>
<th>SWAP</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference MD</td>
<td>0.87±3.5</td>
<td>3.8±3.7</td>
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<td>Difference PSD</td>
<td>-1.33±4.3</td>
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<tr>
<td>Difference FT</td>
<td>1.1±3.3</td>
<td>3.9±5.4</td>
<td>0.08</td>
</tr>
</tbody>
</table>

FT: Foveal threshold, MD: Mean deviation, PSD: Pattern standard deviation, SAP: Standard automated perimetry, SWAP: Short-wavelength automated perimeter, *: Paired t test, P<0.05 was statistically significant; Difference: postoperative measure-preoperative measure
same eye. Both of the latter two studies13,14 compared the effect of clear IOLs and yellow-tinted IOLs in two eyes of the same subject yet they did not control for the correlation between two eyes of a subject.

We observed a 0.8-dB improvement in MD on SAP testing after cataract extraction. This observation may indicate that the cataracts in our patients had slight greater absorption of white light compared with yellow-tinted IOLs. This mild improvement in MD after phacoemulsification could be attributed to a lower grade of cataract in our study subjects; thus, the observed visual field depression was probably related to glaucoma rather than cataract.

A limitation of our study is that lens opacity based on standard photographs was not recorded. Another limitation of our study is that we did not have a control group that underwent cataract extraction with the implantation of nonyellow tinted IOLs. Previous studies have reported similar performance and result with full threshold and SITA strategies for SWAP testing.15,16 However, using a full threshold strategy for SWAP instead of a newer version of SITA is another limitation of our study. The SITA SWAP program was not available in our Humphrey perimeter in the initial stages of patient testing. Last, the sample size of our study was small. Therefore, further studies with control groups, larger sample size including patients with different severity of glaucoma, and standardized assessment of cataract density are required.

In conclusion, yellow-tinted IOLs do not appear to adversely affect the MD and FT indices of SWAP testing and may be associated with improvement of these indices postoperatively in mild to moderate glaucoma patients with cataract. Hence, it appears that implantation of a yellow-tinted IOLs is not a contraindication in patients with mild to moderate glaucoma and visually significant cataracts.

REFERENCES


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