Comparison of the At.Smart Aspheric and Spherical IOLs

Patients receiving the aspheric model had slightly better visual acuity and contrast sensitivity.

BY JOSEF REITER, MD; AND BERNHARD KÖBL, MD

Our visual system integrates the refractive surfaces of the cornea and the crystalline lens; the positive spherical aberration (SA) of the cornea is partially cancelled out by the negative SA of the crystalline lens.1–2 As the eye ages, the cornea remains fairly stable, but the crystalline lens thickens at the periphery, inducing positive SA.1–3 The nucleus hardens4 and changes occur in the internal refractive index gradient,5 equivalent refractive index,6 and lens shape.6 As these changes occur, the compensation for aberration gradually declines, leading to increased total ocular aberrations and loss of optical7 and visual8 quality. Contrast sensitivity is reduced, and glare and halos become more common.9

Traditionally, cataract patients have been implanted with standard spherical IOLs. This strategy produces good visual acuity;10 however, total optical aberrations increase, affecting visual quality. Aspheric IOLs were introduced to eliminate or reduce SA, with the aim of improving functional vision.11 The optical advantages of aspheric IOLs have now been largely accepted.12 Two types of aspheric IOL are in common use: (1) negative SA and (2) aberration-free. IOLs with a small amount of negative SA, such as the Tecnis Z9000 (Abbott Medical Optics Inc., Santa Ana, California) and the AcrySof IQ (Alcon Laboratories, Inc., Fort Worth, Texas), are designed to cancel out the positive corneal SA. Aberration-free IOLs aim to leave the eye with a small amount of positive SA. Examples of this include the SofPort AO (Bausch & Lomb, Rochester, New York) and the At.Smart 46LC (Carl Zeiss Meditec, Jena, Germany).

The rationale for leaving a small amount of positive SA in the eye is that this may have beneficial effects on contrast sensitivity.13 The At.Smart 46LC has been found to produce significantly fewer higher-order aberrations over a 6-mm optical zone than conventional spherical IOLs, suggesting that it could be particularly helpful in improving visual quality in mesopic conditions.14 However, little has been published to date about the At.Smart 46LC IOL. We recently conducted a study exploring the performance of this IOL and comparing it with its sister lens, the spherical At.Smart 46S in each patient’s contralateral eye. The only difference between the two IOLs is their sphericity.

The At.Smart family of IOLs are foldable single-piece acrylic lenses (25% water content) with a four-haptic design. After hydration, the refractive index is 1.46. The 46S (power range, 16.00–27.00 D) has a conventional biconvex spherical optic and the 46LC (power range, 0.00–32.00 D) is equiconvex and aspheric aberration-free and designed for convergent rays entering the IOL.

### TABLE 1. PREOPERATIVE CHARACTERISTICS OF OPERATED EYES

<table>
<thead>
<tr>
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<th>46S</th>
<th>46LC</th>
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</thead>
<tbody>
<tr>
<td>Mean (SD) IOP [mm Hg]</td>
<td>16.31 (3.27)</td>
<td>16.16 (2.97)</td>
</tr>
<tr>
<td>Mean (SD) refraction, sphere [D]</td>
<td>0.84 (1.55)</td>
<td>0.98 (1.43)</td>
</tr>
<tr>
<td>Mean (SD) refraction, cylinder [D]</td>
<td>-0.56 (0.63)</td>
<td>-0.55 (0.44)</td>
</tr>
<tr>
<td>Mean (SD) cylinder axis [degrees]</td>
<td>52.84 (51.48)</td>
<td>73.91 (56.95)</td>
</tr>
<tr>
<td>BCVA [decimal]</td>
<td>0.36 (0.16)</td>
<td>0.38 (0.14)</td>
</tr>
<tr>
<td>Axial length [mm]</td>
<td>23.08 (0.57)</td>
<td>23.11 (0.56)</td>
</tr>
</tbody>
</table>

**TAKE-HOME MESSAGE**

- Studies to date have not always found significant differences in contrast sensitivity or quality of vision between spherical and aspheric IOLs.
- Patients in this study preferred their vision with the aspheric At.Smart 46LC IOL to its spherical sister lens.
PATIENTS AND METHODS

This prospective, randomized study included 32 patients (mean age, 76.41 years) undergoing bilateral cataract extraction with coaxial phacoemulsification through a 2.3-mm temporal incision. Cataract density ranged from grade 2 to 4. All eyes were free of any other condition that might affect the final visual outcome, and both eyes were required to be similar in terms of health. The expected visual acuity was at least 0.5 corrected (range of IOL power, 18.00–24.00 D). Second surgery followed within 8 to 10 weeks and was carried out by the same surgeon.

Capsular bag implantation of either the 46S or the 46LC into the left or right eye was strictly randomized and masked. There was no significant difference preoperatively between the eyes implanted with the 46S or the 46LC (Table 1). The mean power of the IOLs implanted was similar for both lens types: 21.02 D (range, 18.00–24.00 D) for the 46S and 21.13 D (18.00–24.00 D) for the 46LC. Following surgery, the incisions were left sutureless and were checked for leakage.

Follow-up at 2 months included BCVA; contrast sensitivity (in photopic and mesopic conditions); wavefront analysis; and subjective opinion assessed by means of a questionnaire on photic phenomena, glare, halos, and overall satisfaction. Patients with previously undetectable retinal disease were excluded at this stage. All tests were performed under strictly masked conditions. There were two cases of posterior capsular fibrosis, one for each lens type. Otherwise, there were no intraoperative complications or difficulties with implantation or lens insertion.

More eyes implanted with the 46LC (n=16) compared with the 46S (n=11) achieved 1.0 BCVA (P<.003; Figure 1). Otherwise, the distribution of BCVA achieved was similar in both groups. Wavefront analysis revealed fewer higher-order (P<.001) and spherical aberrations (P<.00001) in eyes implanted with the 46LC (Figure 2). The mean residual spherical aberration in eyes implanted with the 46LC was almost half of that in eyes with the spherical IOL, and the 46LC performed better at all spatial frequencies under photopic and mesopic conditions, achieving statistical significance at 6 cycles per degree under mesopic conditions (Figure 3).

Subjectively, patients ranked their quality of vision as better with the 46LC than the 46S, although they were not aware which eye had which lens. This confirms that improved contrast sensitivity is perceived as better quality of vision. After vision was fully corrected, 27 patients expressed preference for the 46LC, and five patients preferred the 46S. No patient in either group complained about halos or glare.

DISCUSSION

Recent studies have not always found a significant difference, either in contrast sensitivity or perceived quality of vision, between aspheric and spherical IOLs.15-19 Although
AT.SMART 46S VERSUS 36A

Contrast sensitivity and spherical aberration have also been assessed between the AT.Smart 46S and another member of the AT.Smart family, the 36A. This IOL has a small amount of negative SA to correct the residual positive SA of the cornea.

In Wolff et al.,1 the AT.Smart 36A and 46S were implanted, one in each eye, in 21 patients. After 3 months, there was marginally better visual acuity in the eyes implanted with the aspheric 36A IOL; however, the main difference was in the spherical aberration. Eyes implanted with the 36A experienced a small decrease in spherical aberration; eyes implanted with the 46S experienced a significant increase (P<.0001). This was particularly noticeable in the higher-order aberrations at 5 and 6 mm pupils, where eyes with the spherical IOL had significantly higher aberrations. This was evident in contrast sensitivity measurements, where eyes with the 36A had significantly better contrast sensitivity in myopic conditions compared with the spherical 46S.1

the reasons are still unclear, it is assumed that age, pupil size (ie, too small to benefit from aspheric correction), unrealistic expectations, and corneal SA levels before implantation play a part in these results.

Although it has been assumed that corneal aberration is fairly consistent across the population, measurements derived from higher-order aberration data have actually found a wide range of corneal SA in the population presenting for cataract surgery.20 Therefore, disappointing study results may be due to suboptimal correction of the patient’s residual SA.

The optimal target SA is still under debate. Beiko suggests that visual quality is optimized with approximately 0.1 μm of residual postoperative SA.13 and Wang and Koch suggest that myopic eyes, in particular, benefit from residual positive SA.20 They also point out that the brain is more adept at interpreting retinal images with positive SA.

In our study, although the difference in contrast sensitivity was relatively minor, most patients preferred the aberration-free AT.Smart IOL. Similar studies have found marked differences in contrast sensitivity but low subjective preferences.19, 21, 22

This initial study suggests that the 46LC provides better quality vision compared with the 46S in contrast perception. Patients reported low levels of dysphotopsia with the AT.Smart 46LC and were generally satisfied with the quality of vision they experienced.

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