Introduction

Approximately 15–20% of patients with cataracts have more than 1.5 diopters (D) of pre-existing astigmatism. Reducing this preoperative astigmatism can improve visual outcomes after cataract surgery. The astigmatism can be reduced with the phacoemulsification incisions, with corneal or limbal relaxing incisions and with excimer laser keratectomy. Another alternative for astigmatism correction in the cataract surgery is to implant a toric intraocular lens (IOL). Several reports have shown good outcomes in terms of safety, predictability, and efficacy after implantation of toric lenses.

Methods

Fifty-eight eyes of 46 patients participated in this prospective randomized study. After phacoemulsification the eyes received the AcrySof toric or AcrySof IQ IOLs depending on their preoperative corneal astigmatism. Three month after surgery, all patients underwent complete ophthalmological examination including corneal topography, best corrected visual acuity, wavefront analysis for 6 mm pupil diameter and CS measurements with the CSV-1000HGT test under photopic (85 cd/m²) and mesopic conditions (5 cd/m²).

Results

BCVA in toric group was 0.054±0.043 logMAR and 0.030±0.037 logMAR in aspheric group (all patients achieved a BCVA of 20/25 or better). The mean postoperative SA was higher in the AcrySof toric group than the AcrySof IQ group (0.540±0.887 vs. 0.216±0.047 μm) and this difference was statistically significant (p<0.001). CS results showed no statistically significant differences between the values post-implantation at any lighting condition and spatial frequency (p>0.01). The AcrySof toric lens provided excellent rotational stability in the capsular bag with an average lens rotation of less than 3.3±2.5 degrees.

Conclusions

The AcrySof toric IOL and aspheric AcrySof IQ yield similar and good visual outcomes. However, the AcrySof IQ IOL reduced significantly the SA for large pupils in relation to toric IOL. Surgeons should consider that patients may benefit from aspheric designs. Future studies, should consider direct comparison between spherical and aspheric toric IOLs to analyze properly the benefit in visual performance.

Keywords: Visual acuity, Contrast Sensitivity and Spherical Aberration with AcrySof Natural IQ and Toric IOLs.

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The best optical quality of the whole eye is achieved by the combination of corneal and lens aberrations. Combination of both surfaces is important to achieve the best optical quality of the whole eye. However, low-order optical aberrations should be corrected efficiently also to provide the best optical quality, and thus visual quality, for cataract patients.

The purpose of this study is to assess and compare the visual performance in patients implanted after cataract surgery with two IOLs, a spherical toric IOL, the AcrySof toric SN60Tx and an aspheric IOL, the AcrySof IQ SN60WF.

PATIENTS AND METHODS

Study Design

Fifty-eight eyes of 46 patients who underwent cataract extraction by uncomplicated phacoemulsification and implantation of the AcrySof toric SN60Tx or AcrySof IQ SN60WF, depending on their preoperative corneal astigmatism, were included. If it was larger than 1.50 D, the IOL implanted was the AcrySof toric IOL. If it was smaller than 1.50 D the IOL was the AcrySof IQ IOL. The study was performed in the Fundación Oftalmológica del Mediterráneo, Valencia, Spain, between February 2008 and July 2008. Inclusion criteria included cataract, age between 45 and 85 years, and preoperative regular corneal astigmatism smaller than 5.00 D. Exclusion criteria included cataract, age between 45 and 85 years, and preoperative regular corneal astigmatism smaller than 5.00 D. Exclusion criteria included preoperative astigmatism larger than 5.00 D, history of glaucoma or retinal detachment, corneal disease, previous corneal or intraocular surgery, macular degeneration or retinopathy, and history of ocular inflammation.

The AcrySof Natural IQ SN60WF (Alcon Laboratories Inc, Ft Worth, TX) is an aspheric IOL with negative SA (-0.20 µm with a 6.0 mm pupil) designed with prolate posterior surface to reduce the total amount of ocular SA when implanted after cataract or clear lens extraction.

The AcrySof toric IOL SN60Tx (Alcon Laboratories Inc, Ft Worth, TX) is an open-loop, modified single piece, acrylic polymer IOL with L-shaped haptics. The IOL’s toricity, located on the posterior surface, extends across the entire surface of the spherical optic. The IOL is available in 3 models: SN60T3, SN60T4, and SN60T5. The U.S. Food and Drug Administration (FDA) approved the AcrySof toric IOL in September 2005 for 3 cylindrical powers: 1.50 D, 2.25 D, and 3.00 D at the IOL plane. (Available at: http://www.fda.gov/cdrh/pdf/p930014s015.html. Accessed January 9, 2008).

Before cataract surgery, patients had a complete ophthalmologic examination including manifest refractions, keratometry, topography (Pentacam system), slit lamp examination, applanation tonometry, and ocular fundus examination. Axial length and keratometry were measured with IOL Master (Carl Zeiss Meditec, Jena, Germany). The SRK/T formula was used for IOL power calculation. The targeted refraction was emmetropia. In the case of the Acrysof toric IOL was implanted the IOL model and axis placement was using a program available from the IOL manufacturer (www.acrysoftoriccalculator.com). Preoperative keratometry and biometry, data, incision location, and the surgeon’s estimated surgically induced corneal astigmatism were used to determine the appropriate AcrySof toric IOL model, spherical equivalent lens power and axis of placement in the eye.

Surgical Technique

Two experienced surgeons (A.L., F.P.) performed all surgeries using peribulbar anesthesia. With the patient seated at the slitlamp and with a coaxial thin slit turned to the 0- to 180-degree axis, the corneal limbus was marked at the 0-degree and 180-degree positions with a sterile marker after vertical alignment of the patient’s head. Next, with the patient lying on the surgical table, the steep corneal meridian was identified and marked using a Marquez gauge with the aid of the preplaced reference points. Phacoemulsification was performed through a 2.75 mm temporal corneal incision. In all cases, the target capsulorhexis diameter was 5.50 mm to ensure overlap of the IOL border. After phacoemulsification, a foldable AcrySof toric IOL was inserted in the capsular bag using the Monarch II injector (Alcon Laboratories Inc, Ft Worth, TX). The IOL was rotated to align the cylinder axis with the marked steep corneal meridian. There were no complications in any of the cases. The tenets of the Declaration of Helsinki were followed in this research. Informed consent was obtained from all patients after the nature and possible consequences of the study were explained. Institutional Review Board approval was obtained.

Visual Performance Measurements

Best spectacle-corrected visual acuity (BCVA) measurement was performed by means of the logarithm of the minimum angle of resolution (logMAR) acuity
charts under photopic conditions (85 cd/m²). Ocular wavefront aberrations were measured with the LADARWave Hartmann-Shack aberrometer (Alcon Laboratories Inc, Ft Worth, TX) for 6 mm pupil. Monocular photopic and mesopic contrast sensitivity (CS) was measured with best distance correction using CSV-1000HGT (VectorVision, Dayton, Ohio) in both groups at 3 month after implantation. Absolute values of log₁₀CS were obtained for each combination of patient, spatial frequency, and luminance; means and standard deviations were calculated. The CS measurements were taken under 2 illumination conditions: photopic at 85 cd/m² (luminance recommended in manufacturer’s guidelines) and mesopic at 5 cd/m². IOL rotation was measured at the slitlamp in 1-degree steps using an eyepiece for angle measurement through pupils dilated with tropicamide. A thin coaxial slit was projected in front of the eye and rotated until the thin slit projection overlapped the axis marks of the IOL.

Data Analysis

All examinations were performed at 3 month after implantation by one ophthalmic technician who was unaware of the objective of the study. To explore any correlation between the BCVA, CS at 2 lighting conditions and SA measured between the two IOLs t-test was carried out. Differences were considered to be statistically significant when the p-value was <0.01 (i.e., at the 1% level).

RESULTS

The mean ages of the AcrySof toric and AcrySof IQ groups were 65.1±7.78 and 63.7±4.78 years, respectively. Mean IOL power was 18.97±4.30 D in the AcrySof toric group and 21.61±2.28 D in the AcrySof IQ group. Patient demographics are shown in Table 1. No statistically significant differences were found between both groups in relation to age, IOL power, and pre- and post- sphere (p>0.01). We found statistically significant differences between both groups for pre- and post-cylinder (p=4.48x10⁻¹³ and p=1.77x10⁻³, respectively). After the surgery and IOL implantation, the pupils of all patients were round, without iris trauma, and showed a good responsiveness to light.

Visual Acuity

In the toric group the BCVA was 0.054±0.043 logMAR and in the aspheric group was 0.030±0.037 logMAR (in both groups, all the patients achieved a BCVA of 20/25 or better). No statistically significant differences were found between both groups for BCVA (p=0.015).

Contrast Sensitivity

The mean values of log₁₀CS after implantation with the AcrySof toric and the Acrysof IQ IOLs were plotted as a series of CS Functions (CSF) in Figure 1. Left and right images shows distance CSFs at the different luminance levels (85 and 5 cd/m²). To explore the statistical significance of differences between lenses, t-tests were performed on the comparable data of the two

Table 1: Demographic Characteristics of Participants

<table>
<thead>
<tr>
<th></th>
<th>AcrySof Toric IOL (SN60Tx)</th>
<th>AcrySof IQ IOL (SN60WF)</th>
<th>P value</th>
</tr>
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<tbody>
<tr>
<td>Number of eyes</td>
<td>31</td>
<td>27</td>
<td>–</td>
</tr>
<tr>
<td>Age (years)</td>
<td>65.1±7.78</td>
<td>63.7±4.78</td>
<td>0.08</td>
</tr>
<tr>
<td>Gender (Male/Female)</td>
<td>20/11</td>
<td>13/14</td>
<td>–</td>
</tr>
<tr>
<td>IOL Power (D)</td>
<td>18.97±4.30</td>
<td>21.61±2.28</td>
<td>0.09</td>
</tr>
<tr>
<td>Preoperative Sphere (D)</td>
<td>-1.70±4.03</td>
<td>-0.10±2.12</td>
<td>0.03</td>
</tr>
<tr>
<td>Preoperative Cylinder (D)</td>
<td>-2.61±0.99</td>
<td>-0.73±0.44</td>
<td>4.48x10⁻¹³</td>
</tr>
<tr>
<td>Postoperative Sphere (D)</td>
<td>0.34±0.73</td>
<td>0.33±0.48</td>
<td>0.38</td>
</tr>
<tr>
<td>Postoperative Cylinder (D)</td>
<td>-0.82±0.51</td>
<td>-0.44±0.41</td>
<td>1.77x10⁻³</td>
</tr>
</tbody>
</table>

IOL = intraocular lens; D = diopters; means ± standard deviation.
groups (absolute log_{10}CS values) at each spatial frequency and illumination level. The results showed no statistically significant differences between the values post-implantation at any lighting condition and spatial frequency (p>0.01).

### Spherical Aberration

The mean SA for each group before and after surgery is summarized in Table 2. The mean postoperative SA for a 6mm pupil was higher in the AcrySof toric group than the AcrySof IQ (0.540±0.887 versus 0.216±0.047 µm). This difference was statistically significant (p<0.001; Table 2).

### Rotational Stability

The AcrySof toric lens provided good rotational stability in the capsular bag with an average lens rotation of less than 3.3±2.5 degrees, verifying the placement with photographs.

### DISCUSSION

Previous clinical trials evaluated clinical, optical and functional outcomes after spherical and aspheric IOLs\(^{21-31}\), however this is the first study that compares toric IOLs with aspheric IOLs.

Toric IOLs are a predictable and stable alternative for correcting astigmatism in patients with cataracts and preexisting corneal astigmatism\(^{2-20}\). Success in achieving favourable postoperative visual function depends on several factors. First, patients with regular bowtie astigmatism may be benefit with toric IOL implantation. The second factor is to obtain accurate corneal astigmatism measurements to determine the actual amount of cylinder requiring correction and the spherical IOL power. The AcrySof toric IOL calculator program has been proved efficient for determining the toric IOL to be implanted and calculation of the implantation axis\(^{3,16,18-20}\). The stability of the toric IOL is highly important to reduce the pre-existing cylindrical power. In our study the toric lens provided rotational stability in the capsular bag with an average lens rotation of less than 3.3±2.5 degrees from the lens initial placement at 3 months after surgery. This study did not evaluate the incidence of later postoperative rotation because previous trials found good long-term rotational stability of toric IOLs\(^{7,15-17}\).

Our results revealed that both IOLs provided good BCVA (about 20/20). Mendicute et al.\(^{3}\) using the AcrySof toric reported similar values and percentages of binocular BCVA in 30 eyes at 3 month post-surgery (mean BCVA of 0.02±0.05 logMAR; 100% of the patients with 20/25 or better). Zuberbuhler et al.\(^{16}\) on a sample of 44 eyes implanted with the same IOL at 3 months found a mean BCVA of 0.01±0.11 logMAR (about 20/20); and recently, Chang\(^{19}\) reported that the 94% of a sample of 50 patients achieved a BCVA of 20/40 or better. Cadarso et al.\(^{29}\) at 6 months and Mester et al.\(^{30}\) at 6 weeks in 30 and 52 eyes implanted with the AcrySof IQ aspheric IOL, respectively, reported that 100% of the patients achieved BCVA of 20/25 or better (logMAR 0.1 and -0.03±0.15, respectively). Different authors\(^{21-24,26-30}\) compared the results of BCVA in patients implanted with the AcrySof IQ aspheric IOL with those implanted with the AcrySof Natural spherical IOL and none found differences statistically significant between both IOLs. Probably the visual performance metrics used were not accurate enough to detect subtle visual changes resulting from spherical aberration reduction by asphericity.

In relation to the CS our results revealed photopic CSFs in both groups within the normal range (see Figure 1). Comparing both lenses we found similar photopic CS for the toric and aspheric IOLs at 3 month post-surgery without statistically significant differences at any spatial frequency analysed (p>0.01).

From seven studies reporting photopic CS (85 cd/m\(^2\)) with the AcrySof IQ IOL, 3 didn’t find statistically significant differences at any spatial frequency compared with the SN60AT IOL\(^{21,24,25}\) and 4 revealed differences\(^{23,26,27,30}\) at 3 cpd\(^{30}\), 6 cpd\(^{23,30}\), 12 cpd\(^{23}\), and 18 cpd\(^{23,26,27}\). Six studies evaluated the AcrySof IQ compared with SN60AT under mesopic conditions\(^{21,23,26-28}\). All found significant differences specially at 1.5 cpd\(^{23,26,27,30}\), 3 cpd\(^{21,23,26-28}\), 6 cpd\(^{23,29}\), 12 cpd\(^{23,26,28}\), and 18 cpd\(^{21,23,26,29}\). Our CS results with AcrySof IQ were similar to the others but the differences in conditions and measure systems between studies may play a role in the differences found. No comparison with previous studies about the CS of the

<table>
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<th>Table 2: Ocular spherical aberration values Z(4.0) with AcrySof toric (SN60'Tx) and AcrySof IQ (SN60WF) IOLs for 6 mm of pupil</th>
<th>AcrySof Toric IOL (SN60'Tx)</th>
<th>AcrySof IQ IOL (SN60WF)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative Spherical aberration Z(4.0)</td>
<td>0.243 ± 0.225</td>
<td>0.301 ± 0.114</td>
<td>0.041</td>
</tr>
<tr>
<td>Postoperative Spherical aberration Z(4.0)</td>
<td>0.540 ± 0.887</td>
<td>0.216 ± 0.047</td>
<td>3.021 x 10^-5</td>
</tr>
</tbody>
</table>

IOL = intraocular lens; means (µm) ± standard deviation.
AcrySof toric IOL is possible because this is the first study that evaluates it.

The ocular SA for a 6 mm pupil found was 0.216±0.047 µm for the AcrySof IQ group and 0.540±0.887 µm for the AcrySof Toric group (p=3.021 x 10^{-5}). Rocha et al.\textsuperscript{21} showed a mean value of SA of 0.24 ±0.04 µm for a 5 mm pupil at 3 months with the AcrySof IQ. Cadarso et al.\textsuperscript{29} found an ocular SA of 0.114±0.147 µm in 20 eyes for a 6 mm pupil at 6 months implanted with the AcrySof IQ. No comparison with previous studies about the SA of the AcrySof toric IOL is possible because this is the first study that evaluates it. We have found that the SA was significantly lower in those eyes implanted with the AcrySof Natural IQ IOL.

Marcos et al.\textsuperscript{31} found that the tolerance to defocus was significantly higher with spherical IOls than with aspherical IOls; it was necessary to add 1.5 D with the spherical IOL and 1.1 D with the aspherical IOL to make the 20/20 line illegible on simulation. Recently, Rocha et al.\textsuperscript{22} concluded that the reduction in SA after aspherical IOL implantation may degrade distance-corrected near visual acuity and intermediate visual acuity. They point out that residual SA can improve depth of focus and that the tolerance to defocus seems to be higher in eyes with a spherical IOL than in eyes with an aspherical IOL. However, it must be kept in mind that this refers to a monofocal IOL that was not designed to provide a large depth of focus, as are pseudoaccommodating IOls.

From a theoretical point of view, an aspheric IOL design improves the optical quality and therefore, the visual performance in a patient. However, in our study, the SA reduction achieved in those eyes implanted with the aspheric IOL does not correlate with an improvement in the mesopic CSF. We have to note that we didn’t control the real pupil size of our patients and then differences among eyes may overlap the role of the aspheric design for large pupils. SA was measured for a 6 mm pupil but we cannot be sure that the real pupil size of those patients would be of 6 mm under mesopic conditions. Alfonso et al.\textsuperscript{32} measured the pupil size in 650 eyes (61.2±9.3 years old) under the same lighting conditions (5 cd/m\textsuperscript{2}) reporting a mean value of 5.4±0.7 mm. 0.6 mm of difference from this mean value and the pupil size used to compute the SA in our study may be responsible to not report differences in the mesopic CSF between both lenses.

In conclusion, both AcrySof spherical toric IOL and AcrySof aspheric IOL provided good visual acuity results. Lower SA was found in those eyes implanted with the aspheric IOL in relation to the spherical model, although, no differences were achieved in visual acuity, and photopic and mesopic CS between lenses. Surgeons should consider that patients may benefit from aspheric designs (i.e. reduction of the central thickness of the lens). Custom selection of the asphericity of the lens for coupling with the corneal SA may reduce highly the ocular SA and then expect a visual performance improvement in those patients implanted with aspheric IOls. Future studies, should consider direct comparison between spherical and aspheric toric IOls to analyze properly the benefit in visual performance.

SYNOPSIS

Acrysof IQ IOL reduces the spherical aberration more than Acrysof Toric IOL but no differences were achieved in Visual Acuity, photopic and mesopic contrast sensitivity between lenses.

REFERENCES


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