Pseudophakic Residual Astigmatism

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We investigated pseudophakic residual astigmatism in order to minimize postoperative refractive astigmatism. We examined 110 eyes of 87 patients who had undergone phacoemulsification with small incision and posterior chamber intraocular lens (IOL) implantation. Corneal astigmatism was measured using an autokeratometer (RK-5, canon), refractive astigmatism by manifest refraction, and residual astigmatism by vector analysis. Mean pseudophakic residual astigmatism was +0.47 × 176°, predominantly against-the-rule. Variations of pseudophakic residual astigmatism according to sex, age and IOL type were not statistically significant. When performing cataract surgery as refractive surgery, we may consider that pseudophakic residual astigmatism is approximately 0.50D against-the-rule.

Key words: refractive cataract surgery, pseudophakic residual astigmatism, corneal astigmatism, refractive astigmatism, against-the-rule

INTRODUCTION

Residual astigmatism is the component of total ocular astigmatism that is not attributed to the anterior corneal surface.1,2 Dunne and Elawad3 reported that phakic eye possesses approximately 0.5D of residual astigmatism and that it was predominantly against-the-rule (83% of right eyes and 66% of left eyes). Furthermore, residual astigmatism was not significantly affected by gender or race. They applied the principle of astigmatic decomposition. 4,5

In 1890, Emile Javal proposed the following rule for predicting the subjective correction for astigmatism on the basis of keratometric astigmatism: Refractive (total) astigmatism = 1.25 × corneal astigmatism + (-0.50 × 90). The modification suggested by Grosvenor et al6 is: Refractive (total) astigmatism = 1.00 × corneal astigmatism + (-0.50 × 90). 0.5D of against-the-rule was suggested to account for residual astigmatism. Other authors reported similar results.7-10 When performing cataract surgery as refractive surgery, pseudophakic residual astigmatism may be considered to minimize postoperative refractive astigmatism.

MATERIALS AND METHODS

We examined 110 eyes of 87 patients who had undergone phacoemulsification and posterior chamber intraocular lens (IOL) implantation between January 2000 and September 2003. Exclusion criteria was a history of ocular disease or intraocular surgery, glaucoma, or significant posterior segment pathology that could preclude the postoperative visual outcome and any surgical complication such as continuous curvilinear capsulorhexis (CCC) rim tear, zonular dehiscence, failure to place the IOL in
the capsular bag, posterior capsular rupture, or vitreous loss.

All operations were performed by one surgeon (YI Choi) using a standard phacoemulsification technique. Topical anesthesia was used in all cases. Before surgery, the pupils were dilated by topical instillation of phenylephrine hydrochloride 2.5% and tropicamide 1.0%. A 3.0 mm limbal incision or clear cornea incision was made on the steep corneal meridian and the anterior chamber was reformed with viscoelastic material. CCC was performed with an approximately 5.0-mm diameter incision made using a bent 26-gage needle and CCC forceps. Following hydrodissection and hydrodelineation, phacoemulsification of the nucleus and cortical aspiration were performed. After the lens capsule was inflated with viscoelastic material, the main incision was extended a little, but not more than 3.2 mm. IOL was inserted in the capsular bag with injector mode. Foldable silicone IOL (SILENS 6, Bausch & Lomb) was injected for 61 eyes and foldable acrylic IOL (SENSAR AR40e, AMO) for 41 eyes.

Corneal astigmatism was measured using an autokeratometer (RK-5, canon), with the mean value from three repeat values being selected. Refractive astigmatism was measured by manifest refraction using retinoscopy and Jackson cross-cylinder ± 0.25D after at least 2 weeks postoperatively. Residual astigmatism was calculated by vector analysis and then analyzed. With-the-rule corneal astigmatism included flattest corneal meridian (minus cylinder) along 180° ± 30°, while against-the-rule astigmatism included flattest corneal meridian (minus cylinder) along 90° ± 30°.

For statistical analysis, independent T-test, ANOVA and multivariate analysis were done using SPSS program. P-value < 0.05 was considered significant.

RESULTS

Forty patients were male and 49 eyes were the right eye. The mean age at the time of the surgery was 65.6 ± 12.8 (range, 34-85) years. Power of preoperative corneal astigmatism was predominantly less than 1.0D (Fig. 1), and 46 eyes were against-the-rule (Fig. 2). Mean postoperative corneal astigmatism was +0.29 D × 96°, mean postoperative refractive astigmatism was +0.20 D × 165°, and mean pseudophakic residual astigmatism was +0.47 × 176°. Axis distribution of pseudophakic residual astigmatism was predominantly against-the-rule (Fig. 2). Power of pseudophakic residual astigmatism was predominantly less than 1.0D (Fig. 1). Variations of pseudophakic residual astigmatism according to sex, age and IOL type were not statisti-
cally significant (Tables 1-3). To determine the relation between refractive and corneal astigmatism of pseudophakia, we performed linear regression analysis for 81 eyes, after excluding 29 eyes of oblique astigmatism.

The linear regression equation had the form:

\[
\text{Refractive (total) astigmatism} = 0.81 \times \text{corneal astigmatism} + (-0.43 \times 90), \quad R = 0.75, \quad P < 0.001
\]

(Fig. 3).

**DISCUSSION**

Recently, refractive cataract surgery has become widely used in ophthalmology. The term implies a coordinated and encompassing attention to both spherical and astigmatic components of refraction.\textsuperscript{17}

The refractive cataract surgeon knows the astigmatic effects of various approaches and selects a surgical plan that optimizes the refractive outcome for an individual patient.\textsuperscript{17} In addition to the cataract incision, whose size, location and configuration help determine the astigmatic effects of surgery, the cataract surgeon now has two additional options for correcting astigmatism: corneal relaxing incisions (CRIs) and toric IOLs. CRIs can be characterized as those made in the corneal midperiphery, co-called astigmatic keratotomy (AK), and those made peripherally, so-called peripheral or limbal corneal relaxing incisions (PCRIs).\textsuperscript{17} However, cataract

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**Table 1.** Pseudophakic residual astigmatism according to sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Eyes</th>
<th>Mean Cylinder Absolute value(D)</th>
<th>C_0</th>
<th>C_{45}</th>
<th>Mean Cylinder Vector(D)</th>
<th>Axis (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>40</td>
<td>0.68</td>
<td>0.550</td>
<td>0.040</td>
<td>0.551</td>
<td>177.9</td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
<td>0.65</td>
<td>0.391</td>
<td>0.045</td>
<td>0.394</td>
<td>176.7</td>
</tr>
</tbody>
</table>

* P value P = 0.77***

**Table 2.** Pseudophakic residual astigmatism according to age

<table>
<thead>
<tr>
<th>Age</th>
<th>Eyes</th>
<th>Mean Cylinder absolute value(D)</th>
<th>C_0</th>
<th>C_{45}</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 50</td>
<td>16</td>
<td>0.52</td>
<td>0.39</td>
<td>0.10</td>
</tr>
<tr>
<td>51-60</td>
<td>15</td>
<td>0.66</td>
<td>0.59</td>
<td>-0.01</td>
</tr>
<tr>
<td>61-70</td>
<td>37</td>
<td>0.72</td>
<td>0.54</td>
<td>-0.04</td>
</tr>
<tr>
<td>71-80</td>
<td>23</td>
<td>0.68</td>
<td>0.36</td>
<td>-0.18</td>
</tr>
<tr>
<td>≥ 81</td>
<td>17</td>
<td>0.63</td>
<td>0.29</td>
<td>-0.31</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>0.66</td>
<td>0.49</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

* P value P = 0.71*

**Table 3.** Pseudophakic residual astigmatism according to IOL type

<table>
<thead>
<tr>
<th>IOL</th>
<th>Eyes</th>
<th>Mean Cylinder absolute value(D)</th>
<th>C_0</th>
<th>C_{45}</th>
<th>Mean Cylinder Vector(D)</th>
<th>Axis (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SILENS 6</td>
<td>61</td>
<td>0.68</td>
<td>0.416</td>
<td>-0.072</td>
<td>0.422</td>
<td>175.0</td>
</tr>
<tr>
<td>SENSAR AR 40</td>
<td>49</td>
<td>0.64</td>
<td>0.490</td>
<td>-0.007</td>
<td>0.490</td>
<td>179.6</td>
</tr>
</tbody>
</table>

* P value P = 0.66*

***: ANOVA, ***: Multivariate analysis

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surgery may be performed based on preoperative corneal astigmatism because the preoperative refractive astigmatism is usually not known. Pseudophakic residual astigmatism in which the lens is eliminated as one of the many reasons of residual astigmatism was not considered.

Mean pseudophakic residual astigmatism was +0.47 × 176°, predominantly against-the-rule (72%), and was similar to known phakic residual astigmatism. In addition, the simplified Javal’s rule by Grosvenor et al. was similar to the relation between corneal astigmatism and refractive astigmatism of pseudophakia.

These results indicated that residual astigmatism was not changed, even if the lens which was known as one of several causes of residual astigmatism was removed. Therefore, we conclude reason that crystalline lens does not contribute greatly to residual astigmatism, or that left posterior capsule or inserted IOL may take the place of the lens part of residual astigmatism.

When performing cataract surgery as refractive cataract surgery, we may consider that pseudophakic residual astigmatism is approximately 0.50D against-the-rule in order to minimize postoperative refractive astigmatism.

**REFERENCES**

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17. Lindstrom RL, Koch DD, Osher RH, Wang L. Control of astigmatism in the cataract patient. In: