Intraoperative aberrometry-assisted toric IOL exchange following unexpected surgically induced astigmatism

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A 74-year-old man with a preoperative manifest refraction of $-3.00 + 1.00 \times 25$ had cataract extraction and implantation of a toric intraocular lens (IOL). Although the IOL power was chosen according to the surgical records and accurately aligned on the target axis at the follow-up examination, the incision apparently induced enough surgically induced astigmatism (SIA) to make the cornea spherical. The patient was dissatisfied with the resulting flipped axis and 20/60 uncorrected acuity. Intraoperative aberrometry confirmed that the cornea was now spherical. An IOL exchange was performed with placement of a 22.0 diopter nontoric IOL. The second surgery was complicated by early capsule phimosis. Because it can measure true aphakic corneal astigmatism intraoperatively, intraoperative aberrometry can be useful in preventing IOL exchanges due to anomalous SIA.

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With the introduction of toric and multifocal intraocular lenses (IOLs), it has become increasingly important to achieve an emmetropic result from cataract surgery so patients can take full advantage of the spectacle independence these IOLs offer. In the 45% of eyes planned for emmetropia that do not reach this goal, the culprit is often corneal astigmatism due to astigmatism's contribution to the residual refractive error or to biometry prediction errors.1

One challenge in addressing corneal astigmatism is that most topographers and other diagnostic devices measure anterior corneal astigmatism only. Several authors have recently shown that ignoring posterior corneal astigmatism may yield inaccurate estimates of total corneal astigmatism.2,3

Surgically induced astigmatism (SIA) also plays a significant role in less-than-optimal refractive results. It is affected by several factors, some of which are difficult for the surgeon to predict or control. It is now well established that smaller incisions tend to induce less SIA, at least in comparisons with standard 2.8 mm or 3.0 mm coaxial incisions and microincisional cataract surgery (MICS) involving incisions of 2.2 mm or smaller.4–7 However, it is not only the initial incision size that matters. The incision architecture and integrity and the degree of incision stretching or manipulation during surgery can increase SIA even in MICS cases.8,9 In the best of scenarios, very experienced surgeons performing cataract surgery with advanced technology and very small (1.5 mm and 1.7 mm) incisions, 1.0 diopter (D) or more of SIA can occur.4,10

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Many surgeons have attempted to improve their refractive results by calculating a personalized SIA using a widely accepted online calculator. Of note, this site requests data for 225 eyes so more than 200 cases will remain after the exclusion of any outliers. This potential for outliers is concerning to diligent surgeons attempting to achieve high rates of emmetropia. Even with excellent biometry and personalized SIA factored into the IOL selection, the refractive result may be off target due to posterior corneal astigmatism or an outlier SIA. This can lead to dissatisfaction and even necessitate an IOL exchange, as in the case described here, exposing the patient to additional time, expense, and risk.

Intraoperative aberrometry presents an opportunity to measure astigmatism intraoperatively, thereby facilitating more accurate spherical and cylindrical power selection and IOL positioning. It has also been shown to reduce the enhancement rate for incisional correction of astigmatism after cataract surgery.

CASE REPORT
A 74-year-old man was referred to our clinic 2 months after toric IOL implantation in his right eye. The uncorrected distance visual acuity (UDVA) was 20/60, and the patient was disappointed with the refractive outcome. The primary surgeon asked that the patient be evaluated for a possible IOL exchange. This case is detailed in the accompanying video (Video 1, available at http://jcrsjournal.org).

Preoperative records indicated that at the time of the original cataract surgery, the manifest refraction was −3.00 +1.00 × 25. Both partial coherence interferometry (PCI) (IOLMaster, Carl Zeiss Meditec AG) and manual keratometry (K) were recorded as 43.37/44.50 @ 178, consistent with the manifest cylinder. Preoperative topography was not provided.

Using the toric IOL calculator, the surgeon decided to place a 24.0 D SN60AT3 Acrysof toric IOL (Alcon Laboratories, Inc.) at 166 degrees. According to all the data provided, this appeared to be the best IOL choice. Anticipated residual astigmatism with this IOL was 0.24 D at 166 degrees.

When the patient was examined 2 months after surgery, the UDVA was 20/60 and the manifest refraction was −1.75 +0.75 × 45, for a spherical equivalent (SE) of −1.25 D. The slitlamp examination showed a well-placed IOL aligned at the target axis. Early anterior capsule phimosis was present. Although there was some asymmetrical with-the-rule astigmatism present on corneal topography, the simulated Ks exhibited only 0.25 D of corneal cylinder at 90 degrees (Figure 1). Manual Ks were 44.5 D sphere and PCI Ks were also essentially spherical (44.47/44.82 @ 48).

It was decided to perform an IOL exchange assisted by intraoperative aberrometry (Ocular Response Analyzer, Wavetec Vision). Based on Holladay 1 power calculations, the tentative plan was to replace the toric IOL with a 22.5 D spherical IOL. A pseudophakic aberrometry reading was taken before the incision was made to determine whether it would be consistent with the manifest refraction. The pseudophakic aberrometric refraction was −1.89 +1.24 × 66 compared with the manifest refraction of −1.75 +0.75 × 45.

This patient had small pupils and a history of tamsulosin (Flomax) use, so Shugarcaine (a mixture of 1.5 mL preservative-free lidocaine and 2.0 mL of preservative-free 1:1000 epinephrine diluted with 4.5 mL of balanced salt solution) was used to ensure adequate mydriasis. The anterior capsulotomy had phimosed to about 4.0 mm, and there was more fibrosis and epithelial growth on the anterior

Figure 1. Topography 2 months after toric IOL implantation shows an essentially spherical cornea with the axis of the minor residual astigmatism flipped 90 degrees from its original position.
Knowing that a toric IOL loses its astigmatic effect when rotated 30 degrees off axis, a rotation of 30 degrees was attempted. However, an intraoperative aberrometry measurement following this rotation suggested the result would still yield 0.95 D of astigmatism. The IOL was then rotated an additional 60 degrees into a final position perpendicular to the original alignment. An aberrometric measurement demonstrated no reduction in the magnitude of the astigmatism so the explantation proceeded.

With a 26-gauge needle on a syringe of an ophthalmic viscosurgical device (OVD), the phimotic capsule was tented up with the needle and a flat-tip cannula with balanced salt solution was gently advanced beneath the capsule with the other hand to free the IOL (Figure 3). The capsular bag was inflated with OVD and the IOL was spun around and pulled through a 2.75 mm incision (Figure 4) without cutting it.

Immediately after the toric IOL was removed, another intraoperative aberrometric measurement was taken (Figure 5). The aphakic aberrometric refraction was +12.49 +0.45 x 10. The system selected a 22.0 D IOL as the best option, predicting a residual refractive error of −0.24 D SE compared with a predicted SE of −0.57 for the 22.5 D IOL. A 22.0 D SN60WF IOL was implanted, per the aberrometric recommendation, and the case was concluded uneventfully.

On postoperative day 1, the UDVA was 20/30 and by 3 weeks, 20/20 with a plano manifest refraction. The patient was very happy with the final refractive result.

**DISCUSSION**

This case illustrates how challenging it can be to adequately predict and account for the actual SIA in a given case. The initial surgeon's incision relaxed more than 1.0 D of astigmatism, flipping the axis and making the T3 the wrong IOL choice despite correct biometry and preoperative power calculation. Although it is difficult to know for sure, my hypothesis is that the incision architecture in this case may have contributed to a greater than expected SIA resulting in a refractive surprise. After the initial incision, the eye was quite spherical. Although a toric IOL loses its astigmatic effect when rotated 30 degrees off axis,13 the rotation attempted in this nearly spherical cornea could not negate the cylinder power completely. This was not surprising, given that the online tool also indicated that a rotation would not be successful.

Of note, there are 2 important concepts to point out in this case presentation. First, with intraoperative wavefront aberrometry, the eyes are allowed to have cyclotorsion because the astigmatism is measured in real time on the operating table. The difference in axis between the aberrometric and the manifest refractions demonstrated in this case is probably due to cyclotorsion. The second point is the method by which this single-piece IOL was explanted as described in the case. This is a common approach at our institution for removing 1-piece foldable hydrophobic acrylic IOLs and is a variation on the push-pull techniques. Although one might argue that removing an IOL in this manner could stretch the wound and induce astigmatism, it may be safer than introducing sharp instruments into the eye to cut the IOL. Moreover, since the astigmatism will be measured intraoperatively, any
resulting SIA will be taken into account in the subsequent aphakic measurement.

Without intraoperative aberrometry or evaluation of posterior corneal astigmatism, there was no way to have predicted or prevented this outcome. With intraoperative aberrometry, the surgeon may have seen that the astigmatism had been neutralized by the incision and could have opted for a nontoric IOL at that time. This may have saved the patient the cost of the toric IOL, eliminated the delay in achieving a satisfactory result, and, most important, avoided the need for an IOL exchange, which carried additional risks in this eye with intraoperative floppy-iris syndrome and early capsule phimosis.

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Figure 5. Aphakic intraoperative aberrometry identified a 22.0 D spherical IOL as the best choice for a spherical equivalent target of –0.24 D.
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