Surgical Management of Astigmatism for Cataract Patients: Pre, Intra, and Post-Operative Protocols for Success

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Preoperative Tools and Diagnostics:
Improved Treatment Planning for Toric IOL Patients
Fine-tuning preoperative assessments can help advance toric IOL outcomes.

BÉATRICE COCHENER, MD, PHD

“Practice Pearl: One-third of the overall population has more than 1.0 D of astigmatism that impacts visual performance. Only corneal astigmatism can be corrected by toric IOLs, requiring the use of video topography when performing preoperative measurements. Successful calculation requires a good correlation among the K reading, K topography, and K biometry in terms of cylinder value and axis.”

To optimise outcomes from toric intraocular lens (IOL) implantation, surgeons need to improve each element of their preoperative assessment—examining how they measure astigmatism, the tools they use, and how they perform their diagnostic examination.

MEASURING ASTIGMATISM
An estimated 47% of the population between 8 and 70 years of age have been reported to have astigmatism of at least 0.75 D, with more than 24% having bilateral astigmatism. More than one-third have astigmatism greater than 1.0 D, and two-thirds have high spherical ametropia when cataracts are diagnosed.1

To measure astigmatism, surgeons focus principally on the cornea, determining the anterior and posterior curvature, thickness, and corneal refractive indices.

The anterior curvature is measured with keratometers and computerized video keratographers, which compensate for the posterior corneal surface using a modified refractive index. The measurement of the anterior curvature is converted to the refractive...
power of the entire cornea by empirical estimation of the thickness and posterior curvature.

Refractive astigmatism, measured with automated refraction as a subjective refraction, determines the total ocular astigmatism.

Keratometry can be measured manually and digitally. Manual keratometry measures corneal power between two points, however, it does not measure the central part of the cornea, so this is extrapolated as regular. This is a simple way to detect irregular astigmatism.

Automated keratometry is similar to manual methods in terms of principles and limits. Axial specular (Placido) topography qualifies astigmatism (regularity, symmetry, orientation) and confirms the corneal origin (Figure 1). Surgeons must compare this with the refraction because only corneal astigmatism can be corrected with toric IOLs. It has a blind zone in the central area (approximately 1.6 mm), and the sim-K measurement is calculated on the central 3-mm zone.

Elevation topography is based on the slit scanning (rotation) on the cornea. There is no central blind zone. The peripheral camera measures the central keratometry without extrapolation. It also provides access to the posterior surface.

Researchers have reported that disregarding the posterior surface can lead to inaccurate calculation of the overall corneal astigmatism. Posterior corneal curvature can be estimated with the Purkinje images, scanning slit imaging, Scheimpflug imaging and optical coherence tomography, or reflection topography. These technologies measure the total corneal refractive power (anterior, posterior curvature, thickness).

Astigmatism is just one optical aberration. Aberrometry enables surgeons to define and analyze higher-order aberrations.

IMPROVING CALCULATIONS
A variety of topographers extrapolate corneal aberrometry (Figure 2). Based on mathematics, they can recalculate and estimate the aberrometry of the cornea. They can be linked to IOL calculation software, integrating topography and adjusting the IOL asphericity. This will be a new option in the future.

Meanwhile, we can combine Placido measurements, elevation with Scheimpflug, and biometry, which can be transferred to calculation software based on ray tracing that can predict wavefront errors, avoiding errors from empirical formulas in difficult cases. However, reduction of total higher-order aberrations is limited even if aspheric IOLs are well positioned. Regardless of the IOL model used, online calculator software is used for calculations.

POSSIBLE PITFALLS
When implanting toric IOLs, the primary pitfall is treating the wrong astigmatism. If surgeons treat lenticular astigmatism with a toric IOL, they will induce astigmatism. Removing the crystalline lens corrects lenticular astigmatism without a toric IOL.

Corneal warpage and irregular asymmetrical astigmatism are contraindications to toric multifocal IOLs. It is also critical to assess and treat the ocular surface before performing preoperative measurements because an unstable tear film can lead to incorrect calculations.

CONCLUSION
To achieve improved outcomes from toric IOLs, surgeons need to take a close look at their preoperative assessments. Because we need to treat corneal astigmatism, topography is necessary, and we also need to measure posterior corneal astigmatism.

REFERENCES

Professor Cochener is head of the Ophthalmology Department at Brest University Hospital, France, president of the French Academy of Ophthalmology, secretary of EuCornea, and president-elect of ESCR. She may be reached at beatrice.cochener-lamard@chu-brest.fr. She is a clinical investigator for Alcon, Santen, TearScience, PhysIOL, Thea, Allergan, Cutting Edge, and Abbott Medical Optics.
Surgical Management of Astigmatism for Cataract Patients: Pre, Intra, and Post-Operative Protocols for Success

THOMAS KOHNEN, MD

Residual astigmatism significantly impacts patients’ visual acuity after implantation of intraocular lenses (IOLs). To make the most of toric intraocular lenses (IOLs), we need to recognize and manage the factors that contribute to postoperative astigmatism.

UNDERSTANDING THE INFLUENCES

As part of this process, surgeons need to optimize their lens constants because patients will not achieve the true benefit of the IOL if the sphere is not correct. Surgically induced astigmatism also should be calculated, which is most likely minimal with a 2.2- to 2.4-mm incision. To analyze astigmatism, we need to understand double-angle plots, which were described by Holladay et al.

During preoperative testing, we need to take into account least three data points: power calculation, topography for alignment, and the patient’s glasses to determine whether there is less with-the-rule (WTR) or more against-the-rule (ATR) astigmatism. If there are discrepancies in the first two, the surgeon must remeasure.

POSTERIOR CORNEAL ASTIGMATISM

Research has shown that the mean magnitude of posterior corneal astigmatism is approximately -0.3. If not identified, posterior astigmatism contributes to ATR astigmatism and leads to incorrect measurements. Figures 1 and 2 show the effect of the posterior corneal curvature on the magnitude of WTR and ATR astigmatism.

Posterior corneal astigmatism can be measured with a combined placido disk and dual Scheimpflug corneal analyzer. When Koch et al. studied outcomes in 42 eyes in which IOLs were implanted, they used a double angle plot calculation and the IOLMaster (Carl Zeiss Meditec) postoperative prediction error. When corneal astigmatism was calculated based only on the anterior corneal surface, the WTR group frequently was overcorrected by 0.5 D and in the ATR group it was often undercorrected by 0.3 D.

Although it is important to measure the posterior and anterior curvature, we still cannot obtain actual measurements and measurements vary by system.

ADDITIONAL FACTORS

When implanting toric IOLs, we need to keep in mind that a small amount of ATR astigmatism (average of 3/8 D) occurs during a 10-year period. Therefore, we may need to compensate for this with a small amount of WTR astigmatism.

Furthermore, IOL power and anterior chamber depth determine effective toricity. With a deeper chamber and lower IOL power, there is less toric effect, and with a shallower chamber and higher power there is greater toricity. At the extremes of each, as much as 0.5 D of variation can occur in each direction.

TORIC IOL SELECTION

The correct formula guides selection of the best toric IOL for an individual patient. Formulas need to take into consideration the effect of posterior corneal astigmatism, IOL power and anterior chamber depth on effective toricity.

Using the Baylor Toric Nomogram, surgeons can adjust for WTR and ATR astigmatism, however, it does not include anterior chamber depth and IOL power. Other formulas are available, but some do not take into consideration factors such as the posterior cornea. Surgeons should always aim for undercorrection with toric IOL implantation.

CONCLUSION

To obtain optimal results with toric IOLs, we will need to have the correct formula, including the posterior corneal surface, and we need to target a slight undercorrection.

REFERENCES


Dr. Kohnen is professor and chair, Department of Ophthalmology, Goethe-University, Frankfurt, Germany. He may be reached at kohnen@em.uni-frankfurt.de. Dr. Kohnen is a consultant for Abbott Medical Optics, Alcon, Carl Zeiss Meditec, Geuder AG, Oculus Optikgerate GmbH, Schwind Eye-Tech Solutions, Staar Surgical, and Ziemer, and has received funding from Abbott Medical Optics, Alcon, Carl Zeiss Meditec, Oculus, And Schwind Eye-Tech Solutions.
Although toric intraocular lenses (IOLs) can effectively treat astigmatism, outcomes may be hampered if residual astigmatism is present. This may result from improper placement of the IOL, using the incorrect lens, poor measurements or calculations, surgically induced astigmatism, cyclorotation, IOL rotation, and other factors (Figure 1).1,3

A number of manual and digital techniques can help surgeons improve IOL orientation, which is critical to success when implanting a toric IOL (Figure 2).

### INCREASING PRECISION

Manual marking has been the standard technique to mark orientation and the steep axis. Research has shown that the pendulum marker and marking at the slitlamp using a needle, two of the most popular manual techniques, produced similar results, with approximately 3 degrees of alignment error.4

We were involved with the development of the digital system Callisto Eye (Carl Zeiss Meditec AG, Germany) for several years. It allows not only precise positioning of the toric IOL at the end of surgery, but also improves the flow of these patients in the surgical setting. Meanwhile, there are also similar systems from other manufacturers.

Comparing digital and manual methods, Elhofi et al. found less postoperative deviation from targeted induced astigmatism and misalignment of the toric IOL with a digital vs. manual technique.5 However, Montes de Oca et al. reported that alignment results when using a manual technique to guide femtosecond laser marks compared with a three-dimensional computer-guided visualization system were similar in patients receiving toric IOLs.6

Total cataract refractive suites with image-guided systems have been developed to increase accuracy and efficiency. Data are captured before surgery in the clinical area and transferred automatically to the surgical stations to potentially reduce errors. Systems use these data to size the capsulorrhexis, locate the incisions, and orient the IOL.

### SURGICAL PEARLS

To ensure optimal postoperative results with toric IOLs, it is important to remove all viscoelastic from the capsular bag and from behind the IOL.

Intraoperative aberrometry has been used to guide implantation. The pseudophakic calculation is used for alignment and residual error. However, to date, there is little peer-reviewed literature about this technique. Factors such as pressure from the lid speculum, hydration of the incisions during surgery as well as an unphysiological tear film during surgery may result in errors of these measurements.

Huelle et al. reported that refraction with intraoperative aberrometry in aphakic eyes seems to be reliable when the anterior chamber is stable and pressurized.7 In addition, Woodcock et al. stated that more eyes had refractive astigmatism within 0.50 D after surgery.8

### CONCLUSION

Ophthalmologists need to improve the way they approach toric IOL implantation. An array of improved manual and automated tools can help surgeons optimize refractive outcomes from toric IOLs.

### REFERENCES


Dr. Findl is chief of the Department of Ophthalmology, Vienna Hanusch Hospital, and founder of the Vienna Institute for Research in Ocular Surgery (VIROS), Austria. He may be reached at oliver@findl.at. Dr. Findl is a scientific advisor for Carl Zeiss Meditec AG.

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**Figure 1.** The importance of stability of toric IOLs and effect of rotation on vision

**Figure 2.** Low-tech vs high-tech marking tools

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**OLIVER FINDL, MD, MBA**
Managing Postoperative Error With Toric IOLs: Pearls for Success

Treating residual astigmatism is a critical part of achieving patient satisfaction.

RUDY M.M.A. NUIJTS, MD, PHD, AND NIENKE VISser, MD

To achieve success with toric intraocular lenses (IOLs), surgeons not only need to understand the sources of residual astigmatism, but know how to manage residual astigmatism.

SOURCES OF RESIDUAL ASTIGMATISM

Residual astigmatism results from a number of factors, such as preoperative morbidity, errors in preoperative measurements, surgically induced astigmatism, calculation inaccuracies, and marking errors and misalignment.1-3

In our research, we found that 70% of patients receiving toric intraocular lenses (IOLs) had an uncorrected visual acuity of 20/25 or better and 84% were spectacle independent.

However, 26% of eyes still had more than 1.0 D and 54% more than 0.5 D of residual astigmatism. In an overview that we published, 63% of eyes had at least 0.5 D of residual astigmatism.5

Examining with-the-rule astigmatism in our toric IOL database of more than 300 eyes, we found that the higher the power implanted, the more overcorrection occurred. However, with against-the-rule astigmatism, we saw less undercorrection.

MANAGING RESIDUAL ASTIGMATISM

When we looked at misalignment in our database, approximately 92% of eyes were within 5 degrees and 4% within 5 and 10 degrees. Four percent had more than 10 degrees of misalignment. Only 2% were realigned; a lens exchange was performed in 1% and a laser enhancement in 1%.

If realignment of the toric IOL is necessary to treat residual astigmatism, surgeons can use software programs, such as the Berdahl and Hardten calculator (http://astigmatismfx.com), to provide the ideal toric IOL position.

A 21-year-old patient who had juvenile cataract had a good outcome after implantation of a toric IOL in her right eye. However, in her left eye an alignment axis of 90 degrees was planned, but the lens was misaligned 10 degrees at 80 degrees, resulting in residual astigmatism. Her uncorrected visual acuity (UDVA) was 20/60 (0.40) and corrected distance visual acuity (CDVA) was 0.25/-1.75 x 65 degrees: 20/22 (0.9-) (Figure 1). We entered the patient’s results into the Berdahl and Hardten calculator; when we placed the IOL in the suggested position, the patient had a good outcome (UDVA: 20/26 [0.75]; CDVA [S -0.50]: 20/20).

IOL exchange is another option. In a case of stellate cataract in a 38-year-old patient with 1.8 D of with-the-rule astigmatism, a 22.5-D IOL was advised for an expected residual cylinder of -0.02 D. Postoperatively, residual refraction was S +1.25 D, with little residual refractive astigmatism, and the axis was in a good position.

When we exchanged the IOL for a higher sphere power lens, the patient achieved UDVA of 20/13 (1.5) (Figure 2). Laser enhancements also can correct residual astigmatism.

Overcorrection can be a significant problem with toric IOLs. To prevent this, surgeons need to know their surgically induced astigmatism, use a second-generation IOL calculator that includes posterior astigmatism and effective lens position, and recognize that surgically induced astigmatism and posterior astigmatism depend on the amount of anterior astigmatism.

When managing residual astigmatism, surgeons need to identify the origin. If the IOL is misaligned, one should determine whether rotation would be beneficial. For errors greater than 1.25 D, an IOL exchange is usually preferred.

REFERENCES


Dr. Nuijts is professor of cornea and refractive surgery at the University Eye Clinic, Maastricht University Medical Center, Maastricht, The Netherlands. He may be reached at rudy.nuijts@mumc.nl. Dr. Visser is a cornea fellow at the University Eye Clinic, Maastricht University Medical Center. She may be reached at nienke.visser@mumc.nl.
his evidence-based information can help surgeons refine their preoperative, intraoperative, and postoperative cataract surgery protocols to manage astigmatism more precisely.

Astigmatism is a common condition. An estimated 47% of the population between the ages of 8 and 70 have astigmatism of 0.75 D or greater and 24% of cases are bilateral. In addition, more than one-third have astigmatism that exceeds 1.0 D.

In diagnosing astigmatism, cataract surgeons need to focus principally on the cornea, rather than internal astigmatism. If lenticular astigmatism is treated with a toric intraocular lens (IOL), astigmatism will be induced. Lenticular astigmatism is corrected by removal of the natural lens.

If discrepancies occur during preoperative assessments (i.e., optical biometry, topography, examination of patient’s glasses, and others that are necessary), the surgeon should repeat the measurements.

Posterior astigmatism is an important consideration. Researchers have reported that if it is not taken into account, total corneal astigmatism may be calculated incorrectly. In more than 7000 corneas, Koch et al. found that the anterior curvature was steep vertically in more than half and the posterior curvature was steep vertically in approximately 87%.

To achieve optimal outcomes, surgeons need to optimize their lens constants and calculate their surgically induced astigmatism. A number of additional factors may result in residual astigmatism, such as cyclorotation and IOL rotation.

Intraoperatively, surgeons can use either manual or digital marking techniques to improve orientation of the IOL. Some researchers have reported that digital methods are more effective, however, others have stated that results were similar.

When correcting astigmatism with a toric IOL, European surgeons can choose from among several alternatives. A few of those options include toric lenses manufactured by Abbott Medical Optics (AMO), Alcon, and Rayner.

With the AMO Tecnis Toric IOL, 94% of eyes had 0.50 or less residual refractive cylinder. Monocular corrected distance visual acuity was 20/20 or better in 88%. In addition, the IOL has shown rotational stability; the mean axis change was 2.74 degrees during a period of 6 months.

With the Alcon AcrySof IQ IOL, 94% achieved uncorrected distance vision of 20/40 or better, and more than 81% were within 5 degrees of the intended axis.

In patients in whom the Rayner T-Flex Aspheric Toric IOL was implanted, 96% of eyes had 20/40 uncorrected distance vision or better and 62% had 20/25 or better 3 months after surgery. More than 92% had IOL rotation less than 10 degrees.

Intraoperative aberrometry has been used to guide IOL implantation, however, additional research is necessary.

Despite a surgeon’s best efforts, residual astigmatism may remain after surgery. To manage postoperative error, surgeons need to identify the cause.

Residual astigmatism may be treated with laser vision correction or arcuate incisions created with a femtosecond laser. If realignment of the toric IOL is necessary, software programs such as the Berdahl and Hardten calculator (http://astigmatismfix.com/) provide the ideal toric IOL position. If residual error exceeds 1.25 D, IOL exchange often is performed.

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