Improving Accuracy with Toric IOLs

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Preferred method of keratometry for Toric IOL calculation?

<table>
<thead>
<tr>
<th></th>
<th>EU</th>
<th>US</th>
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</thead>
<tbody>
<tr>
<td>Manual</td>
<td>9.0%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Auto K</td>
<td>12.4%</td>
<td>6.4%</td>
</tr>
<tr>
<td>IOL Master</td>
<td>42.1%</td>
<td>30.7%</td>
</tr>
<tr>
<td>Lenstar</td>
<td>5.6%</td>
<td>14.2%</td>
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<tr>
<td>Topography</td>
<td>31.0%</td>
<td>26.2%</td>
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</table>


Astigmatism Correction
Measurement of Astigmatism

- Pre-operative
  - Natural conditions
  - Effect of surgery estimated

- Intra-operative
  - Artificial conditions
  - Effect of surgery measured

The importance of toric IOL alignment

- Every degree of misalignment corresponds to a 3.3% error in correction
- Misalignment of 30° negates the correction of the IOL – it is as though you implanted a spherical IOL
- Greater than 30° of misalignment will increase astigmatism
- IOL alignment is crucial at higher cylindrical powers

Contribution of posterior corneal astigmatism to total corneal astigmatism

Purpose: To determine the contribution of posterior corneal astigmatism to total corneal astigmatism and the error in estimating total corneal astigmatism from anterior corneal measurements only using a dual-refracting aligner.

METHODS: Cullen Eye Institute, Baylor College of Medicine, Houston, Texas, USA.

RESULTS: Total corneal astigmatism was calculated using a custom toric corneal keratometer, anterior corneal astigmatism, and posterior corneal astigmatism, and the error was calculated by estimating total corneal astigmatism from anterior corneal measurements only.

CONCLUSION: Ignoring posterior corneal astigmatism may yield incorrect estimation of total corneal astigmatism. Greater than 30° of misalignment will increase astigmatism. IOL alignment is crucial at higher cylindrical powers.
Influence of corneal biomechanical properties on surgically induced astigmatism in cataract surgery

Alexandre Dhere, MD, PhD, Xavier Fournel, MD, Charlie Van Wael, MD, Antoine Lachic, MD, PhD, Christophe Reinvoz, MD, PhD, PARYO

Purpose: To perform an overall follow-up of the refractive, optical, and biomechanical properties of the cornea to determine new parameters influencing the refractive outcome of cataract surgery.

Methods: Patients scheduled for cataract surgery were assessed for surgically induced astigmatism (SIA) and higher-order aberrations (HOAs) using a Scheimpflug-based OCT-ASIA Analyzer by the Ocular Response Analyzer preoperatively and 1 day, 30 days postoperatively. The visual and refractive outcomes were compared to other variables (age, sex, ethnicity, corneal thickness, and central corneal thickness [CTC], keratometric astigmatism, and interocular astigmatism [IOA]).

Results: The study included 40 patients (24 men, 16 women). The SIA and HOAs were significantly lower after cataract surgery (1.25 D vs. 2.35 D after small incision surgery [SIS]) with the Ocular Response Analyzer. The CTA was significantly lower with a direct corneal incision compared with a 4.5-mm SIS incision. However, the HOAs were not significantly different between the two groups.

Conclusions: In addition to the well-known influence of incision size on SIA, HOAs also modulate surgical changes. The biomechanical factors of the cornea should be taken into account preoperatively to better predict the refractive outcome of cataract surgery.

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Considerable improvements in intraocular lens (IOL) design and technology, as well as new surgical techniques, have been made with the aim of optimizing the visual outcomes after cataract surgery. Although new spherical and toric IOLs provide excellent outcomes, the surgical procedure can itself induce astigmatism, which could explain variations in the final refractive results in some cases and thereby a lack of accurate predictability and reproducibility. Surgically induced astigmatism changes after cataract surgery stem from various factors. Some include the incision location and width, whereas others have yet to be identified.

Development of new corneal topographies and keratometer models is parallel to better understanding of the role of preoperative corneal biomechanical properties (PCBM) on surgically induced astigmatism. A decrease in the corneal rigidity has been reported to reduce surgically induced corneal astigmatism (SIA) and control higher-order aberrations (HOAs), which tend to be significantly reduced after cataract surgery (SMIS procedures). In some cases, however, surgically induced corneal changes are more substantial than expected, which hinder visual outcomes and patient satisfaction, especially when using multifocal and/or toric IOLs. Thus, identification of other factors that may influence the impact of a surgical procedure on corneal optical properties is needed.

Surgically induced astigmatism, as a combined function of preoperative CH and incision width, was studied. Multivariate analysis following stepwise regression revealed that SIA at 30 days after surgery depended on both preoperative CH (P < .01) and incision width (P < .05) as detailed by equation 1. Solid-lined box shows high SIA related to low preoperative CH, whatever the incision width; dotted-lined box shows low values of SIA due to high preoperative CH.

Figure 5. Surgically induced astigmatism as a combined function of preoperative CH and incision width. Multivariate analysis following stepwise regression revealed that SIA at 30 days after surgery depended on both preoperative CH (P < .01) and incision width (P < .05), as detailed by equation 1. Solid-lined box shows high SIA related to low preoperative CH, whatever the incision width; dotted-lined box shows low values of SIA due to high preoperative CH.
Improving toric IOL alignment: Marking

- Visual marking with ink markers is the most traditional approach
- It is inherently inaccurate and ink diffuses on the eye
- Improvements in marking:
  - **Wet-Field Osher Thermodot** for ink-free marking
  - **Bubble level marker** for more accurately marking the horizontal axis
  - **Akahoshi Electronic marker** provides auditory and visual cues to indicate accurate horizontal marks
    - Surgeon does not have to take eyes off the limbus

Toric IOL Guidance

- Tomark (Geuder)
- Devgan (Accutome)
Iris Fingerprinting

- Uses landmarks in the iris to guide IOL orientation

- **Haag-Streit Osher Toric Alignment System** and Micron Imaging systems
  - Take a picture of the dilated iris and superimpose a protractor, the keratometric medians, and IOL goal line on the image
  - Hard copy of the image is used during surgery

Limbal Registration

- **Alcon Verion**
  - Memorize the pre-op image and overlay it with the operative image to show the location of the axis

- **Tracey Technologies iTrace system**
  - Topography is overlaid onto a corneal or limbus image that can be used to mark the axis of astigmatism

- **Carl Zeiss Callisto Eye and Z Align**
  - Provide an eye tracking system so that the alignment tracks with eye movement during surgery

- **TrueVision 3D system**
  - Automatically registers the pre-op topography and an eye image to the live 3D view of the eye
New features:
- **Green Arrow** showing primary incision location
- **Yellow Shaded Area** showing surgeon primary incision zone

**TrueCapture Preoperative Planning**
- **Incision Optimized button**
- **Angle Kappa value**
- **Surgical Plan button** to further customize plan
Auto-Registration of Preop Image to Surgical View

Preop image is superimposed and auto-registered onto the live surgical view. Surgeon can make final adjustments as needed.

Dynamic Incision and IOL Guidance

Dynamic optimization of primary incision with astigmatism correction. Real-time calculation of predicted residual astigmatism.

Toric IOL Guidance Outcomes Analysis

- Initial 14 eyes using Alcon/AMO/B&L toric IOLs
- Cassini Topography and Baylor Nomogram Adjustment
- TrueGuide surgical guidance algorithm

- Mean Preop Keratometric Astigmatism
  - 1.65 +/-0.96 D
  - Range 0.54 to 3.34 D

- Mean Absolute Value Postop Refractive Cylinder
  - 0.39 +/-0.35 D
- **TrueGuide Mean Absolute Value Predicted Error**
  - 0.37 +/-0.28 D

- **Mean Axis Identification Error**
  - 3.29 +/-0.94 degrees compared to reference image

- **Mean Toric IOL Axis Alignment Error**
  - 2.5+/-0.60 degrees compared to intended axis
  - 50% better than published benchmark error (Visser JCRS 2011)

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**Intra-operative Aberrometry**

- **WaveTec ORA system**
  - Intra-op wavefront aberrometer: allows real-time analysis of refraction, astigmatism, and aphakic lens power during procedures – adjustments can be made intra-operatively

  - Based on Talbot-Moiré interferometry

  - Reflected wavefront passes through a grating pair – results in diffractive fringe pattern which is translated into the refractive state of the eye using algorithms

  - Enables real-time surgical course correction
**Effect of intraoperative aberrometry on the rate of postoperative enhancement: Retrospective study**

Mark Packer, MD

**PURPOSE:** To determine whether the use of intraoperative aberrometry reduces the incidence of postoperative enhancement compared to aberrometry alone.

**METHODS:** Prospective, randomized, controlled trial of 500 patients with functional corneal astigmatism. The intraoperative aberrometry group (n=250) had aberrometry performed during surgery, while the control group (n=250) had aberrometry performed before surgery.

**RESULTS:** The intraoperative aberrometry group had a significantly lower rate of postoperative enhancement compared to the control group (p<0.05).

**CONCLUSION:** Intraoperative aberrometry is an effective method to reduce the rate of postoperative enhancement.

**Toric Cylinder Reduction**

- Pre-op Keratometric Astigmatism
  - N=2132, Mean Cyl 1.89 0.96

- Post-op Refractive Cylinder
  - N=2132, Mean Cyl 0.48 0.48

**Posterior Corneal Astigmatism**
**Toric IOLs**

- Toric IOLs are an effective means for astigmatism correction
  - However, they are only as effective as pre-operative and intra-operative diagnostic tools
- Several new developments in toric IOL alignment can help achieve better outcomes
- Newer developments on the horizon
  - e.g. Holos from Clarity Medical Systems
- Important to use more than one technique
  - No technique is error-free

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**Mean pre-op keratometric astigmatism:** 1.92 D ± 0.74  
**Mean post-op refractive astigmatism:** 0.29 D ± 0.28  
**Mean post-op refractive astigmatism**  
**Calculator:** 0.36 D ± 0.35  
**ORA with VerifEye:** 0.29 D ± 0.28  
**p=0.041**