Management of Astigmatism in Cataract Surgery

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• Bausch and Lomb - consultant

The goal of cataract surgery is to achieve emmetropia or balance with the fellow eye.

1. The **spherical component** is achieved with the proper choice of IOL
   • IOL Master
   • Water bath ultrasound
   • Keratometry or topography

2. The **astigmatic component** can be controlled by
   • Size and location of the cataract wound
   • Intra-operative relaxing incisions (blade or femto-second)
   • Toric IOLs
   • Post-operative astigmatic keratotomy, wound revision or Excimer laser

• Goal is to achieve ≤ 0.50 D post-op cylinder
What is the best way to manage astigmatism?

• PCRI vs Toric IOLs

Peripheral Corneal Relaxing Incisions (PCRI)

• Incisions made ~ 90% depth, in front of the limbus, in the steep meridian of the cornea

• Incisions in the peripheral clear cornea
  – Heal faster than central incisions
  – Refractive effect stabilizes quickly
  – Less irregular astigmatism, glare and foreign body sensation

Peripheral Corneal Relaxing Incisions - Technique

• Alignment is critical!!!

• Mark the 6 o’clock position on the patient’s limbus with the patient sitting up or lying down, looking straight ahead with both eyes open
• Then, identify and mark the steep corneal axis, in the OR, using a marked fixation ring, astigmatic ruler or arcuate marker with the 90º mark aligned with 6 o’clock position

• Mark in mm or in degrees – depending upon which nomogram used

• Make incisions before cataract surgery using a single or double footplate front cutting diamond blade

• Incisions can be created before or after the paracentesis

• Make the paracentesis, as usual

• Instill non-preserved lidocaine +/- epinephrine if desired

• Fill the eye with visco-elastic through the paracentesis

• Make sure that the pressure is normal before making incisions

• Measure the thinnest limbal corneal thickness and set the diamond knife or use a preset diamond knife set to 600 microns

• Can correct 1.00 – 3.75 D of astigmatism

• Base technique on one of many established nomograms:
  – a. Gills/Fenzel
  – b. Nichamin
  – c. Koch
  -- d. Donnenfeld
  e. LRIcalculator.com
**Koch LRI nomogram – With-The-Rule**  
Cataract With-The –Rule Astigmatism  
(stEEP meridian at 90 degrees)

<table>
<thead>
<tr>
<th>Pre-OP Astigmatism</th>
<th>Age</th>
<th>Number of incisions</th>
<th>Length of incisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75 – 1.00 D</td>
<td>&lt;65</td>
<td>2</td>
<td>45 deg = 4.5 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>60 deg = 6.0 mm</td>
</tr>
<tr>
<td>0.75 – 1.00 D</td>
<td>&gt;65</td>
<td>1</td>
<td>45 deg = 4.5 mm</td>
</tr>
<tr>
<td>1.01 – 1.75 D</td>
<td>&lt;65</td>
<td>2</td>
<td>60 deg – 6.0mm</td>
</tr>
<tr>
<td>1.01 – 1.75 D</td>
<td>&gt;65</td>
<td>2</td>
<td>50 deg = 5.0mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>60 deg = 6.0 mm</td>
</tr>
<tr>
<td>&gt;1.75 D</td>
<td>&lt;65</td>
<td>2</td>
<td>80 deg = 8.0 mm</td>
</tr>
<tr>
<td>&gt;1.75 D</td>
<td>&gt;65</td>
<td>2</td>
<td>60 – 70 deg = 6 – 7 mm</td>
</tr>
</tbody>
</table>

Combined with a 3.0 mm corneal temporal wound
**Koch LRI nomogram – Against-The-Rule**
Cataract Against-The–Rule/Oblique Astigmatism (steep meridian at 180 degrees)

<table>
<thead>
<tr>
<th>Pre-OP Astigmatism</th>
<th>Age</th>
<th>Number of incisions</th>
<th>Length of incisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 – 1.25 D</td>
<td>N/A</td>
<td>1</td>
<td>35 – 40 deg = 3.5 – 4.0 mm</td>
</tr>
<tr>
<td>1.00 – 1.25 D</td>
<td>N/A</td>
<td>2</td>
<td>30 deg = 3.0 mm</td>
</tr>
<tr>
<td>1.26 – 2.00 D</td>
<td>N/A</td>
<td>1</td>
<td>45 deg = 4.5 mm</td>
</tr>
<tr>
<td>1.26 – 2.00 D</td>
<td>N/A</td>
<td>2</td>
<td>40 deg = 4.0 mm</td>
</tr>
<tr>
<td>&gt;2.00 D</td>
<td>N/A</td>
<td>2</td>
<td>45 deg = 4.5 mm</td>
</tr>
</tbody>
</table>

Combined with a 3.0 mm corneal temporal wound
**Nichamin LRI nomogram – With-The-Rule**

With-The-Rule Astigmatism (steep axis 45° - 145°)

<table>
<thead>
<tr>
<th>Pre-op cylinder</th>
<th>Number of incisions</th>
<th>30 – 40 yo</th>
<th>41 – 50 yo</th>
<th>51 – 60 yo</th>
<th>61 – 70 yo</th>
<th>71 – 80 yo</th>
<th>81 – 90 yo</th>
<th>&gt; 90 yo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 – 1.50</td>
<td>2</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
<td>30°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>60°</td>
<td>55°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
<td>30°</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>70°</td>
<td>65°</td>
<td>60°</td>
<td>55°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80°</td>
<td>75°</td>
<td>70°</td>
<td>65°</td>
<td>60°</td>
<td>55°</td>
<td>45°</td>
<td></td>
</tr>
</tbody>
</table>

Degrees of arc to be incised

*Combine with “neutral” temporal clear corneal incision*
### Nichamin LRI nomogram – Against-The-Rule

Against-The-Rule Astigmatism  
(stEEP axis 0-30° / 150°-180°)

<table>
<thead>
<tr>
<th>Pre-op cylinder</th>
<th>Number of incisions</th>
<th>30 – 40 yo</th>
<th>41 – 50 yo</th>
<th>51 – 60 yo</th>
<th>61 – 70 yo</th>
<th>71 – 80 yo</th>
<th>81 – 90 yo</th>
<th>&gt; 90 yo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75 – 1.25 D</td>
<td>1 nasal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35°</td>
</tr>
<tr>
<td>0.75 – 1.25 D</td>
<td>2</td>
<td>55°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.50 – 2.00 D</td>
<td>2</td>
<td>70°</td>
<td>65°</td>
<td>60°</td>
<td>55°</td>
<td>45°</td>
<td>40°</td>
<td>35°</td>
</tr>
<tr>
<td>2.25 – 2.75 D</td>
<td>2</td>
<td>90°</td>
<td>80°</td>
<td>70°</td>
<td>60°</td>
<td>50°</td>
<td>45°</td>
<td>40°</td>
</tr>
<tr>
<td>3.00 – 3.75 D</td>
<td>2</td>
<td>90° at 8mm OZ</td>
<td>90° at 9mm OZ</td>
<td>85°</td>
<td>70°</td>
<td>60°</td>
<td>50°</td>
<td>45°</td>
</tr>
</tbody>
</table>

Degrees of arc to be incised

*Combine with “neutral” temporal clear corneal incision*
• After PCRI is made, make your usual temporal cataract incision

• If the PCRI is against-the-rule, limit the PCRI to 3mm length or less and make cataract incision within the PCRI

• Calculate the IOL in the same way as normal - no change in spherical equivalent is produced

**Peripheral Corneal Relaxing Incisions Complications**

• Under correction

• Over correction - including flipped axis

• Perforation – examine peripheral cornea pre-op to look for peripheral thinning

• Wound leak
  – Relaxing incision made coincident with cataract wound at 180°
  – Secondary to tear of the PCRI

• Interference with paracentesis - when PCRI made at 90 degrees

**Peripheral Corneal Relaxing Incisions Special Indications**

• High corneal astigmatism
  – > 5.00 D - Combine PCRI with Toric IOLs

• Low corneal astigmatism
  – 0.75 – 1.5 D

• Irregular corneal astigmatism
  – Non-orthogonal axis
  – When exact axis in question precluding Toric IOL placement

• Inability to implant a planned Toric IOL secondary to capsular break or zonular instability, still can correct cylinder with a PCRI
Toric Lenses

Staar Toric IOL

• A. A plate-haptic style foldable silicone IOL similar to the currently available plate-haptic IOL’s

• B. A biconvex 6mm optic IOL with a spherico-cylinder anterior surface and a spherical posterior surface

• C. The interhaptic diameter is 10.8 mm with a 1.15 mm round hole in each haptic to help foster equatorial lens epithelial cell ingrowth which maintains good centration

• D. The lenses come with astigmatic powers of 2.0 D and 3.5D that can correct from 1.5 - 3.5 D of preoperative astigmatism

• Complications:
  – Decentration of IOL - ?? increased in plate IOL’s?
  – Lens rotation or shift in postop period
    • May need manipulation of IOL, at slit lamp or in the OR
    • Lose 3.3% of cylinder with each 1 degree off axis
    • > 37º shift in IOL will change refractive axis
    • May need explantation
  – Increased posterior capsule opacification??
  – Increased pitting of silicone with YAG??
  – Bad IOL for Pt.s at risk for vitrectomy

Tecnis Toric IOL

- ZCT 100 corrects 0.50 – 0.75 D cyl
- ZCT 150 corrects 0.75 – 1.50
- ZCT 225 corrects 1.50 – 2.00
- ZCT 300 corrects 2.00 – 2.75
- ZCT 400 corrects 2.75 – 3.25

On line toric calculator
- [www.tecnistoriccalc.com](http://www.tecnistoriccalc.com)
B & L Trulign Toric Accommodating Intraocular Lens
Based upon the Crystalens platform
• Corrects 0.83, 1.33, 1.83 D at the corneal plane
• On line Toric calculator
  • www.trulign.toriccalculator.com

AcrySof® TORIC IOL

• Single-Piece Acrysoft design

• Minimal post-op rotation secondary to shrink wrap effect
  (average is < 4º)

• Spherical Power Range = +6 to +30 D

• Astigmatic power range = 1.5 – 5.0 D with cylindrical correction on posterior surface

• Aspheric design  SN6AT3 – 9

<table>
<thead>
<tr>
<th>ALCON® LENS MODELS</th>
<th>SN6AT3</th>
<th>SN6AT4</th>
<th>SN6AT5</th>
<th>SN6AT6</th>
<th>SN6AT7</th>
<th>SN6AT8</th>
<th>SN6AT9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IOL Plane</td>
<td>1.50 D</td>
<td>2.25 D</td>
<td>3.00 D</td>
<td>3.75 D</td>
<td>4.50 D</td>
<td>5.25 D</td>
<td>6.00 D</td>
</tr>
<tr>
<td>Corneal Plane*</td>
<td>1.03 D</td>
<td>1.55 D</td>
<td>2.06 D</td>
<td>2.57 D</td>
<td>3.08 D</td>
<td>3.60D</td>
<td>4.11 D</td>
</tr>
<tr>
<td>Recommended Corneal Astigmatism Correction Range</td>
<td>0.75 D to 1.54 D</td>
<td>1.55 D to 2.05 D</td>
<td>2.06 D to 2.56 D</td>
<td>2.57 D to 3.07 D</td>
<td>3.08 D to 3.59 D</td>
<td>3.60 D to 4.10 D</td>
<td>4.11 D and up</td>
</tr>
</tbody>
</table>

• Surgeon performs standard cataract procedure from capsulorhexis through phacoemulsification
• AcrySof Toric IOL implantation requires only minor variation from standard procedure:
  • IOL calculation
  • Marking of the eye
  • IOL alignment (on-axis)

AcrySof Toric IOL Procedural Considerations

1. IOL Calculation
• Determine required spherical power using preferred method
• Utilize AcrySof Toric IOL Calculator to determine
  --www.acrysoftoriccalculator.com
  --The correct IOL model, and
  --Optimal axis location of the IOL in the capsular bag
  --Uses vector analysis to determine correct axis
  --Compensates for surgically induced astigmatism

Data Input:
- Preoperative manual keratometry
- IOL power
- Incision location
- Estimated surgically induced astigmatism
**Doctor & Patient Information**

- **Doctor Name**: Dr. Smith
- **Patient Information**: Mr. Jones
- **Eye Selection**: OS (Left)

**Lens Details**

- **AcrySof® Toric IOL**: SN60T4
- **IOL Spherical Equivalent (SE)**: 21.0 D
- **Axis of Placement**: 36°
- **IOL Cylinder (Cyl)**: 2.25 D

**Calculation Details**

- **Pre-op Corneal Cylinder**: 2.20 x 30°
- **Surgically Induced Cylinder**: 0.50 x 90°
- **CROSSED-CYLINDER RESULT (CORNEAL PLANE)**: 2.00 x 36°
- **CROSSED-CYLINDER RESULT (IOL PLANE)**: 2.92 x 36°

**Patient Data**

- **Flat K**: 41.60 D
- **G Flat Meridian**: 120°
- **Steep K**: 43.80 D
- **G Steep Meridian**: 30°
- **IOL Spherical Power (P-IOL)**: 21.0 D
- **Surgically Induced Cylinder (SIC)**: 0.50 D
- **Incision Location (IL)**: 0°

**Notes**:

- Flat K41.60 D @ 120°  steep K43.80 D @ 30°
- P-IOL 21.00 SK=0.500 IL=30° [V2.0.2]
- 9511f1dbb02fceb840d017aceb1f03 3/2/06 18:15:55
- V: 2.0.2
2. Marking of Eye

I. Reference Marks (pre-op)
   - Single mark at 6:00 limbus
   - Patient in sitting position (cyclotorsion)

II. Axis Marks (intra-op)
   - Axis marks identify the optimal axis of IOL placement as determined by the AcrySof Toric Calculator
   - Axis marks are placed on the eye using 6 o’clock pre-op reference mark for alignment of instrument

3. IOL Alignment

a. 3 Step Procedure:
   I. Gross alignment
   II. Removal of OVD
   III. Final alignment

I. Gross Alignment
   - Rotate IOL clockwise to approximately 10 degrees short of desired position
   - Completed while the IOL is unfolding in the capsular bag

II. Stabilize IOL During OVD Removal
   - Take care to prevent IOL from rotating past intended axis during OVD removal
     - 2nd instrument
     - I/A tip as chamber maintainer
III. Final Alignment

– Carefully rotate IOL clockwise precisely onto the intended axis of alignment with separate infusion running
– Tap IOL down onto capsular bag to seat lens in place

Patient Selection

• 1 to 5 diopters of cylinder
• Intact capsule
• Continuous curvilinear capsulotomy (CCC)
• In the bag lens placement

New Technology

■ Refining axis location
  o Cassini/TrueVision 3D system
  o Clarity-Holos
  o Verion
  o Calliso Eye
■ Intra-operative Aberrometry to confirm axis
  o ORA with Verifeye
  o Clarity-Holos

In Summary

• Need to know how and when to use both Toric IOLs and PCRLs
• PCRLs – remain a necessary part of your surgical armamentarium