Management of Astigmatism in Cataract Surgery

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Financial Disclosure

- Alcon
  - Consultant
- Allergan
  - Consultant
- Bausch and Lomb
  - Consultant
The goal of cataract surgery in the year 2012 is to achieve emmetropia or balance with the fellow eye.

1. The **spherical component** is calculated using
   - IOL Master or LensStar
   - 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
   - Toric IOLs
   - Post-operative
     - Astigmatic Keratotomy, Wound Revision or Excimer laser
Control of Astigmatism is especially important with the use of accommodating and pseudo-accommodating IOLs and phakic IOLs

Goal is to achieve $\leq 0.50$ D of post-op cylinder
What is the best way to manage astigmatism?

- PCRI
- 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
  - Heals faster
  - Refractive effect stabilizes quickly
  - Less irregular astigmatism, glare and foreign body sensation
Pre-operative Assessment of Astigmatism
Magnitude and Axis

- Manual Keratometry
- IOL master or LENSTAR
- Corneal Topography
- Elevation mapping
Pre-operative Assessment of Astigmatism

- **Best test for axis**
  - IOL master – quantitative
  - Topography – qualitative

- **Best test for power**
  - Manual Keratometry
Peripheral Corneal Relaxing Incisions - Technique

- Alignment is critical!
- Mark the 6 o’clock position on the patient’s limbus with the patient sitting up looking straight ahead with both eyes open.
III. Peripheral Corneal Relaxing Incisions - Technique

Mark the steep corneal axis, in the OR, using a marked fixation ring, astigmatic ruler or arcuate marker with the 90° mark aligned with 6 o’clock.
Many different types of astigmatic markers are available.

Mark in **mm** or in **degrees** – depending upon which nomogram used.
III. Peripheral Corneal Relaxing Incisions - Technique

- Measure the thinnest limbal corneal thickness and set the diamond knife or use a preset diamond knife set to 550 or 600 microns.
- Make incisions before cataract surgery using a single footplate front cutting diamond blade.
III. Peripheral Corneal Relaxing Incisions - Nomograms

- Can correct 1.00 – 3.00D of astigmatism
- Base technique on one of many established nomograms:
  - a. Gills/Fenzel
  - b. Nichamin
  - c. Koch

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### Koch nomogram

<table>
<thead>
<tr>
<th>Cataract WTR Astigmatism (steep meridian at 090)*</th>
<th>Pre-op Astig</th>
<th>Age</th>
<th>Number</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75 – 1.00 D</td>
<td>&lt;65</td>
<td>2 or 1</td>
<td></td>
<td>45° = 4.5mm</td>
</tr>
<tr>
<td></td>
<td>&gt;65</td>
<td>1</td>
<td></td>
<td>60° = 6.0mm (if asymmetric)</td>
</tr>
<tr>
<td>1.01-1.75 D</td>
<td>&lt;65</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td>&gt;1.75 D</td>
<td>&lt;65</td>
<td>2</td>
<td></td>
<td>80° = 8.0mm</td>
</tr>
<tr>
<td></td>
<td>&gt;65</td>
<td>2</td>
<td></td>
<td>60-70° = 6.0-7.0mm</td>
</tr>
</tbody>
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*combined w/ 3.0mm corneal temporal wound (150°-30° OD, 0°-30° OS)

### Cataract ATR/Oblique Astigmatism (steep meridian at 180)*

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<tr>
<td>1.00-1.25 D**</td>
<td>--</td>
<td>1</td>
<td>35-40° = 3.5-4.0mm</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>2</td>
<td>30° = 3.0mm</td>
</tr>
<tr>
<td>1.26-2.00 D**</td>
<td>--</td>
<td>1</td>
<td>45° = 4.5mm</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>2</td>
<td>40° = 4.0mm</td>
</tr>
<tr>
<td>&gt;2.00 D</td>
<td>--</td>
<td>2</td>
<td>45° = 4.5mm</td>
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*combined w/ 3.0mm corneal temporal wound (150°-30° OD, 0°-30° OS)
III. Peripheral Corneal Relaxing Incisions - Example

Example:

A 75yo pt. With 2.5 D @ 180°:

Use paired 45° cuts (Koch) at the limbus at the 3 o’clock position or paired 50° cuts (Nichamin) at 180°

**Koch Nomogram ATR**

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<tr>
<td></td>
</tr>
<tr>
<td>&gt;2.00 D</td>
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*combined w/ 3.0mm corneal temporal wound (150°-30° OD, 0°-30° OS)
Example:

A 75yo pt. With 2.5 D @ 180°:

- Use one 6mm cut (Koch) at the limbus at the 3 o’clock position or paired 50° cuts (Nichamin) at 180°.
Peripheral Corneal Relaxing Incisions
- Technique -

- Make incisions at the beginning of the case
- As first step, before paracentesis
- After paracentesis, after filling the eye with viscoelastic till firm
III. Peripheral Corneal Relaxing Incisions

- After PCRI is made, make your usual temporal cataract incision

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

- If the PCRI is **with-the-rule**, make paracentesis peripherally and PCRI more centrally

- Calculate the IOL in the same way as normal - **no change in spherical equivalent** is produced
PCRI w/ ReSTOR
Future Developments

Femto-second LRIs

Limbal Relaxing Incisions
Future Developments

Refining the Astigmatism axis location

- SensoMotoric Instruments (SMI)
- TrueVision 3D system
Future Developments

Intra-operative aberometry

WaveTec
ORA
Peripheral Corneal Relaxing Incisions
Special Indications

- High corneal astigmatism
  - > 5.00 D
  - Combine PCRI with Toric IOLs
- Low corneal astigmatism
  - 0.75 – 1.25 D
- Irregular corneal astigmatism
  - Non-orthogonal axis
  - When exact axis in question
- Inability to implant a planned Toric IOL secondary to capsular break or zonular instability, still can correct cylinder with a PCRI
Toric Lenses

STAAR

Alcon

RUSH
Rayner Toric IOLs

C-flex IOL (570C)  Superflex® IOL (620H)  Sulcoflex® Toric (653T)
II. Staar Toric IOL

A. A plate-haptic style foldable silicone IOL

B. A biconvex 6mm optic IOL with a spherocylinder anterior surface and a spherical posterior surface
II. Staar Toric IOL

C. The interhaptic diameter is 10.8 mm with a 1.15 mm round hole

D. Powers of 2.0 D and 3.5 D that can correct from 1.5 - 3.5 D of preoperative astigmatism
II. Staar Toric IOL

Complications:
- Decentration of IOL - ?? increased in plate IOL’s?
- Lens rotation or shift
  - Lose 3.3% of cylinder with each degree off axis
  - May need manipulation of IOL, at slit lamp or in the OR
- Increased posterior capsule opacification??
- Increased pitting of silicone with YAG??
- Bad IOL for Pt.s at risk for vitrectomy
**AcrySof® TORIC IOL**

- **Design**
  - AcrySof Single-Piece platform
  - Aspheric
  - Posterior toricity
  - Spherical Power Range +6 to +30 D
  - Astigmatic power 1 – 5 D

- **Dimensions**
  - Overall length: 13.0 mm
  - Optic diameter: 6.0 mm
  - A-Constant – 119.0 for SN6AT

- **Delivery**
  - Monarch III Injector
  - B, C or D Cartridge

**Steep K alignment marks**
Cylinder Powers

A wide range of cylinder powers means more candidates can benefit from AcrySof® IQ Toric IOL.

<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>
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</thead>
<tbody>
<tr>
<td>IOL Plane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder Power</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>3.60 D</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>

*Based on average pseudophakic human eye.
Cylinder Powers

Distribution of Pre-operative Cylinder

Estimated Distribution of Preoperative Cylinder
Toric IOL Procedural Considerations

- Surgeon performs **standard** cataract procedure from capsulorhexis through phacoemulsification

- Toric IOL implantation requires **only minor variation** from standard procedure:
  1. IOL calculation
  2. Marking of the eye
  3. IOL alignment (on-axis)
1. IOL Calculation

**Step I:**
- Determine required spherical power using preferred method

**Step II:**
- Utilize AcrySof Toric IOL Calculator to determine
  - The correct Toric model
  - Optimal axis location of the IOL
  - [www.acrysoftoriccalculator.com](http://www.acrysoftoriccalculator.com)
Please select the appropriate AcrySof® Toric IOL model for implantation.

- **AcrySof® Toric IOL**
  - Models: SN60T3, SN60T4, SN60T5, SN60T6, SN60T7, SN60T8, SN60T9
  - Suggested A-Constant: 118.4°

- **AcrySof® IQ Toric IOL**

- **aspheric**
  - Models: SN6AT3, SN6AT4, SN6AT5, SN6AT6, SN6AT7, SN6AT8, SN6AT9
  - Suggested A-Constant: 119.0°

- **AcrySof® IQ ReSTOR® Multifocal Toric IOL**
  - aspheric Models: SND1T2, SND1T3, SND1T4, SND1T5
  - Suggested A-Constant: 118.9°
AcrySof Toric IOL Calculator

**Precision Calculations:**
- 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
2. Marking of the Eye

I. Reference Marks (pre-op)

- Single mark at 6:00 limbus
- Patient in sitting position (avoid cyclotorsion)

II. Axis Marks (intra-op)

- Axis marks identify the optimal axis of IOL placement
- Axis marks are placed on the eye using 6 o’clock pre-op reference mark for alignment steep axis
Reference Marks

Axis Marks

6 o'clock

Astig. axis
3. IOL Alignment

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

I. Gross Alignment

- Rotate IOL clockwise to approximately 5 - 10 degrees short of desired position or on axis if can be kept stable
- Complete while the IOL is unfolding in the capsular bag
IOL Alignment

II. Stabilize IOL During OVD Removal

- Take care to prevent IOL from rotating past intended axis during OVD removal
  - 2nd instrument
  - I/A tip - polyester
  - Bi-manual I/A
  - Thoroughly remove all the OVD from behind IOL
II. Stabilize IOL During OVD Removal
III. Final Alignment

- Carefully rotate IOL clockwise precisely onto the intended axis of alignment with infusion running
- Tap IOL down into 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
Dealing with the Compromised Cornea in Cataract Surgery

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Chicago, IL
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Causes for Compromised Endothelium in the Cataract Patient

- Fuchs’
- Advanced age
- History of angle closure
- History of trauma
- Chronic inflammation
- Previous anterior segment surgery
Fuchs’ Dystrophy

- Bilateral, non-inflammatory, progressive loss of endothelium
- A leading cause of endothelial dysfunction
- Relatively common corneal dystrophy
  - Affects ~ 1% of population
  - Approximately 15% of keratoplasties
Fuchs’ Dystrophy

- Inherited with variable penetrance
  - Autosomal Dominant
  - A defect in type VIII collagen?
- Onset usually 30’s – 50’s, clinically significant by 60’s – 80’s
- Women > Male (4:1 at time of keratoplasty)
- Commonly associated with cataract and COAG
Fuchs’ Dystrophy

**Signs:**
- Guttata (excrescences of Descemet’s)
  - First centrally, eventually beaten metal appearance
  - Best seen with indirect illumination, retro-illumination or sclerotic scatter
- Decreased endothelial cell count
  - Specular microscopy
  - Confocal microscopy
- Corneal edema
  - Central, pre-Descemet’s first,
  - Eventually epithelial edema
- Descemet’s folds
- Cataract
- Glaucoma
Fuchs’ Dystrophy

- **Symptoms:**
  - Early AM blurred Va from corneal edema
  - Disrupted quality of Va secondary to guttata
  - Eventually, continuous blurred Va, glare and haloes
  - Pain/foreign body sensation and worse Va from epithelial edema in later stages
  - Decreased Va also from cataract and/or glaucoma
Fuchs’ Treatment Dilemma

- Surgery based upon assessment of visual impairment from cornea versus cataract
- Perform cataract surgery alone
  - Quicker Va recovery, if cornea can recover
- Perform corneal surgery first
  - DSEK first
    - Worry about damaging new endothelium with eventual cataract surgery
- Combined DSEK/Phaco/PCL
Pre-Op Corneal Assessment

- **Pachymetry**
  - Best assessment of endothelial cell function
    - Optical – slit lamp
    - Ultra-sound
    - Pentacam/Galilei
    - Specular Microscope
    - Confocal Microscope
  - Want central pach < 620 μ
  - Need clinical correlation – assess symptoms to see if corneal edema is clinically significant
Pre-Op Corneal Assessment

- **Endothelial Cell Studies**
  - Slit lamp – specular reflection
  - Specular microscopy
  - Confocal microscopy
  - Especially in corneas with significant corneal edema
Pre-Op Corneal Assessment

- **Endothelial Cell Studies**
  - Endothelial cell count - age dependent
    - **Want > 1000 cells**
  - Polymegathism
  - Pleomorphism
  - Percent hexagonality
    - **> 60%**
Pre-Op Corneal Assessment

- Polymegathism
  - size

- Pleomorphism
  - shape
Surgical Options
Decision

Cataract Surgery alone vs DSEK/Phaco

- **Best criteria based upon patient’s symptoms:**
  - Early AM blur or clouding
  - Hazy Va after shower or in high humidity
  - Early AM foreign body sensation

- **Signs less helpful**
  - Frank edema at slit lamp
  - Pach > 620 microns
  - Cell count < 1000 cells/mm²
Surgical Options

- Cataract Surgery first
  - Technique to minimize endothelial cell trauma
  - BSS+
  - Low flow slow mo settings
  - Peripheral clear corneal incision
  - Dispersive OVD – re-apply
  - Phaco chop – low phaco time
  - ? Smaller capsulorhexis
  - IOL power at -1.25 D
    - Avoid presbyopic IOLs
Combined Procedures

**DSEK/Phaco/PCL**

- Perform normal Phaco/PCL first, then DSEK
  - Need relatively good view through cornea
- 2.4 mm clear corneal incision first then enlarge to 4.0 mm
- DSEK performed under cohesive viscoelastic
  - Need meticulous removal of a cohesive viscoelastic
IOL Considerations

- **Cataract Surgery first, DSEK later**
  - Aim for -1.25 of myopia
  - Keratometry may be inaccurate if corneal edema
  - Three piece IOL may be better
  - Avoid presbyopic IOLs
  - Toric IOL may be OK, however K’s may change after 4mm DSEK incision and IOL position could change after DSEK
IOL Considerations

- **DSEK/Phaco/PCL**
  - Corneal power changes are relatively predictable, therefore IOL calculations can be made from pre-op corneal keratometry
  - DSEK does flatten the cornea, so plan for ~-1.25 of myopia in calculating IOL power
  - Thin DSEK and DMEK will cause less central corneal flattening
DSEK/Phaco
1 month post-op