I. Formulas and Measurements
   A. Variables Used to Predict ACD
      1. Binkhorst 2 - 1981 - AL
      2. Holladay 1 - 1988 - AL, K
      3. SRK/T - 1990 - AL, K
      4. Hoffer Q - 1993 - AL, K
      5. Olsen - 1995 - AL, K, ACD
      6. Clarke - 1996 - AL, K1, K2, ACD, LT
      7. Holladay 2 - 1996 - AL, K, HWTW, REF, ACD, LT, AGE
   B. Normal Values for required Measurements
      1. Axial Length: mean = 23.5 mm, SD = 1.25 mm
      2. Keratometry: mean = 43.81 D, SD = 1.6 D
      3. Horizontal White-to-White (Corneal diameter): mean = 11.7 mm, SD = 0.46 mm
      4. Preoperative Refraction: mean = plano
      5. Anterior Chamber Depth (ultrasonic): mean = 3.1 mm, SD = 0.30 mm
      6. Crystalline Lens Thickness (ultrasonic): mean = 4.7 mm, SD = 0.41 mm
      7. Age: mean = 72, SD = 12 years
II. Axial length Measurements in Aphakic and Pseudophakic eyes
   A. Aphakia - 1532 M/sec
   B. Pseudophakia
      1. PMMA - 2718 M/sec
      2. Silicone - 980 M/sec
      3. Acrylic- 2120 M/sec
III. Determination of corneal power following Keratorefractive Sx (PRK, LASIK, RK)
   A. Manual Keratometry
   B. Automated Keratometry
   C. Corneal Topography
   D. Calculation from pre- keratorefractive surgery K’s
   E. Determination from hard contact lens trial
IV. Data Screening Techniques on Preoperative Measurements
   A. Probability of unusual measurements (one eye only)
   B. Probability of asymmetrical measurements (both eyes)
V. IOL Calculations requiring Axial Length Measurements
   A. Standard Cataract Removal with IOL
      1. Piggy-Back IOL’s: Use 34 D IOL posterior in bag
      2. Multifocal IOL’s: Target distance plano, near for -3.00 D.
      3. Toric IOL’s: IOL Cylinder to Corneal Cylinder ~ 1.46, but not exact for low (1.75) and high (1.20) power IOLs
         a. Optimization of Cataract Incision Location: Normal 4 locations for zero residual astigmatism
         b. Back calculation for surprise: 1) P.O. Refraction &, 2) P.O. Ks OR Current IOL axis
   B. Cataract Removal with IOL and Silicone in Vitreous: use convexplano ~ 3 D more, for biconvex ~ from 5 - 6 D more in IOL.
VI. IOL Calculations not requiring Axial Length
   A. Secondary Implant for Aphakia: in sulcus or anterior chamber angle
   B. AC IOL in phakic patient: High myopia ( - IOL) & High hyperopia ( + IOL)
      C. Secondary Piggy-Back IOL for high hyperopia (or myopia within 1 year)

VII. Pediatric IOL calculations
   A. Ideal Postoperative Target Refraction: plano to -1.00 D.
   B. Expected Myopic Shift with age: 4 D from age 2 to age 21.

VIII. Minimizing Prediction Error
   A. Personalizing Formula Constants (A-const, ACD or Surgeon Factor)
   B. Prediction Error vs. IOL Power
   C. Creating personalized constants for subgroups
      1. Axial Length (< 22 mm or > 26 mm)
      2. Keratometry (< 40 D or > 48 D)
      3. Preoperative Refraction (< -4 D or > +4 D)

IX. Calculating SIRC (Surgically induced refractive change)
   A. From pre and post operative keratometry
   B. From pre and post operative refraction

X. Outcomes Analysis
   A. Prediction Error Analysis: Mean absolute prediction error should be < 0.50 D.
   B. Formula Comparisons: more predictors, better results in unusual eyes
   C. SIRC Results: Astigmatic Analysis
   D. Visual Acuity Results
      1. Best corrected
      2. Uncorrected

XI. Back-calculations
   A. For determining source of error with refractive surprise
   B. Comparison of back-calculated lens constant and actual lens constant
**Vergence Formula**

\[
IOL = \frac{1336}{AL - ELP} - \frac{1336}{1000} - \frac{1336}{1000} + \frac{K}{DPostRx}
\]

**Effective Lens Position (E.L.P)**
- Distance from corneal vertex to principal plane of thin IOL (no thickness)
- Same as ACD, but avoids confusion with anatomy

**Prediction of E.L.P**
1. <1980 Constant \( (0) \) 4.5
2. 1981 Binkhorst \( (1) \) AL
3. 1988 Holladay 1 \( (2) \) AL, K
4. 1995 Olsen \( (4) \) AL, K, ACD, LT
5. 1996 Holladay 2 \( (7) \) AL, K, ACD, LT, HWTW, REF, AGE

**Investigation**
- International Study - 1993
  - 34 investigators (15 U.S.)
  - Additional measurements are taken
    - 35 eyes < 21 mm
    - 35 eyes > 26 mm
    - 35 eyes = normal
Measurements taken for Predictors of ELP
1. Axial Length
2. Average K
3. Horizontal WTW
4. ACD
5. LT
6. Pre-op Refraction
7. Age

HWTW Gauge
- Horizontal Corneal Diameter

IOL MASTER 500 – ZEISS
Version 7.70

LENSTAR – HAAG-STREIT

Normal Eyes
- 98% Normal Anterior Segment Size
- 2% Small Anterior Segment Size
- 2% Large Anterior Segment Size

Short Eyes (< 21 mm)
- 80% Normal Anterior Segment Size
- 20% Small Anterior Segment Size
- 0% Large Anterior Segment Size
Normal Physiologic Values

- **Al**: 23.5 mm ± 1.25 mm
- **K**: 43.81 D ± 1.6 D
- **Hwtw**: 11.7 mm ± 0.46 mm
- **Ref**: -0.60 D ± 2.00 D

Normal Physiologic Values

- **ACD**: 3.1 mm ± 0.30 mm
- **LT**: 4.7 mm ± 0.41 mm
- **Age**: 72 years ± 12.0 years

Critical Data

- **Corneal Power**
- **“Optical” Axial Length**
- **Horizontal “White-to-White” (11.7)**
  - AC angle = WTW + 1.0 (12.7)
  - Sulcus = WTW + 1.5 (13.2)
  - Bag = WTW – 1.0 (10.7)

CONCLUSION: 9 EYES

CONCLUSION

Eye Model must include

**NINE**
types of eyes not only

**THREE**

Anterior Segment Size

<table>
<thead>
<tr>
<th>Large</th>
<th>Megalocornea + axial hyperopia (0%)</th>
<th>Megalocornea normal (2%)</th>
<th>Large Eye Buphthalmos 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>axial hyperopia (50%)</td>
<td>normal (4%)</td>
<td>normal (10%)</td>
</tr>
<tr>
<td>Small</td>
<td>Smaller eye Nanophthalmia (20%)</td>
<td>Microcornea normal (2%)</td>
<td>Microcornea + axial myopia (0%)</td>
</tr>
<tr>
<td>Short</td>
<td>Normal (20%)</td>
<td>Microcornea normal (2%)</td>
<td>Microcornea + axial myopia (0%)</td>
</tr>
</tbody>
</table>
Relative Importance of Predictors for ELP

1. Axial Length: 100
2. Average K: 76
3. Horizontal WTW: 24
4. Refraction: 18
5. ACD: 8
6. LT: 7
7. Age: 1

RESULTS

New Holladay 2:

- Normal eye: 50% ± 0.40 D
- Unusual eye: 50% ± 0.80 D

Previous results:

- Normal eye: 50% ± 0.50 D
- Unusual eye: 50% ± 5.00 D
CONCLUSIONS

- **Prediction Errors in Short Eyes:** significantly improved by more measurements
- **Prediction Errors in Long Eyes:** due to bad Axial Lengths, B-Scan

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**Myopic Staphyloma**

---

**Subtract from A scan measured Axial Length ~ 0.8 mm**

- Zaldivar-Holladay JCRS May 2000
- Zeiss - IOL Master ~ 2000

---

**Optimizing intraocular lens power calculations in eyes with axial lengths above 25.0 mm**

Li Wang, MD; Mario Shenoy, MD; Tingrui Ma; Thomas Kohnen, MD, PhD; Hoffer, Douglas D. Koch, MD


**Wang/Koch Linear Regression to compensate for Long Eyes (> 25)**

Go half-way between...
Holladay Non-Linear Regression to compensate for Long Eyes (> 24)
(Equal # of + and – prediction errors)

<table>
<thead>
<tr>
<th>Å insist</th>
<th>Å Insist Adj</th>
<th>Å Insist Adj 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>24.00</td>
<td>24.00</td>
</tr>
<tr>
<td>25</td>
<td>25.01</td>
<td>24.95</td>
</tr>
<tr>
<td>26</td>
<td>25.92</td>
<td>25.90</td>
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<tr>
<td>27</td>
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<td>28</td>
<td>27.62</td>
<td>27.75</td>
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<td>29</td>
<td>28.48</td>
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<td>29.34</td>
<td>29.55</td>
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<tr>
<td>31</td>
<td>30.20</td>
<td>30.43</td>
</tr>
<tr>
<td>32</td>
<td>31.05</td>
<td>31.30</td>
</tr>
</tbody>
</table>

Holladay Non-Linear Axial Length Adjustment in Long Eyes (> 24.0 mm) shortens the axial length < Wang/Koch and results in ZERO PREDICTION ERROR (equal # of hyperopic and myopic errors).

**Zeiss-Humphrey IOL Master**

**LenStar**

**Difficult Cases**
- Asteroid Hyalosis (vit. debris)
- Extreme Length (26.5 mm)
- Uses Average Index ➔ Too Long
- Extreme Short (< 21 mm)
- Pseudophakic Eyes
- Silicone in Vitreous

Angle Kappa on IOL Master, LenStar and penlight ~ 0.33 mm

*If > 0.70 mm then concern!*
Horizontal Angle & Alpha & Kappa

BEST CENTRATION
OF IOL

IOL MASTER 500 – ZEISS
Version 7.70

Anterior chamber depth values

White-to-white values

Reference image capture

IOL MASTER 500 – ZEISS
Version ≥ 7.10

OD

IOL MASTER 700 – ZEISS
Version ≥ 1.1

Central corneal thickness

White-to-white values

Reference Image

Horizontal Angle & Alpha & Kappa

BEST CENTRATION
OF IOL
Data Screening Monocular and Binocular

- Using Mean and St. Dev., an exact p-value for each measurement can be calculated.
- Any measurement beyond two Std. Dev. from the mean should be double checked (p<0.05).

Monocular: AL = 19.75 mm
p = 0.001

Binocular: K_right - K_left = 1.5 D
p = 0.0005

Cataract Surgery ...
IOL Power Calculations Following Refractive Surgery

Preoperative Assessment
- Endothelial Cell Count
- Pachymetry
- Direct Ophthalmoscope @ 16"
- Corneal Topography
- Determining Corneal Power
- IOL Calculation
Corneal Power Decision Tree

SD > 0.20 D

- Keratometry
  - SD > 0.20 D
    - Dry Eye?
    - Yes
    - No
  - SD < 0.20 D
    - 4.5 mm Zonal K
    - Ref Sx, KC, PMD, ...
    - No
    - Yes
  - Toric?
    - Yes
    - ATR Adjustment
    - Exact Toric Calc w Back Surface
    - No
    - SD < 0.20 D
    - 4.5 mm Zonal K
    - Yes

H2, Olsen, Barrett Formula

70% of cases

SD < 0.20 D

- H2, Olsen, Barrett Formula (1 variable)
- Exact Toric Calc
- ATR Adjustment
- Topography

70% of cases

K = 44 D

IOL Master

2.5 mm

LenStar

1.7 & 2.3 mm

Astigmatism Measurement for a 44 D Cornea

- Manual Keratometer
  - 3.2 mm Diameter
- IOL Master® Keratometer
  - 2.5 mm Diameter
- LenStar® Keratometer
  - 2.35 & 1.65 mm Diameters
  - (Average 2.0 mm Diameter)

* Carl Zeiss Meditec AG, Goeschwitzer Str. 51-52, 07745 Jena, Deutschland
† Haag-Streit AG, Gartenstadtstrasse 10, 3098 Koeniz, Switzerland

Ring Diameter affects Keratometry

If SD for K's

> ± 0.20 D (> ± 0.030 mm)

Test for Dry Eye

ToPography/ToMography

70% of cases

K = 44 D

70% of cases

K = 44 D

70% of cases

K = 44 D
### Initial Visit

6 wks after Dry Eye Rx

If SD > ± 0.20 D (> ± 0.030 mm)

Not Dry Eye

Topography/ToMography

### Corneal Power after LASIK, PRK, RK

1. Ideally, Calculation from both surfaces
2. Calculation from Prior Data Trial
3. Hard Contact Lens
4. Corneal Topography
5. Automated Keratometry
6. Manual Keratometry

- Methods listed in order of reliability
- Methods 3, 4 and 5 almost always exceed true power & result in hyperopic error
- Use lowest reliable value

---

### Advanced IOL Calculations

**JACK T. HOLLADAY, MD, MSEE, FACS**

Page 11 of 29
Always Topography/Tomography if Correcting Astig

- To determine if REGULAR and does not change radially
- Tomography can confirm if posterior astig is WTR (~ 0.22D)

Never Perfect Bow Tie

- 44.8 @ 96 & 40.6 @ 6
  - ASTIG = +4.2 @ 96
- 43.5 @ 105 & 41.2 @ 15
  - ASTIG = +2.3 @ 105

Corneal Lenticule:
The projection of the pupil onto the cornea from macula

ToMography: Measures Total Power and Total Astigmatism of Lenticle
ToPography: Measures Front Surface Power of Lenticle and then uses back radius of 0.82 of front radius for Total Power and can ADD 0.22 D ATR for Total Astigmatism
Keratometry: Measures Front Surface Ring or annulus Power of Lenticle (nominal 2.0 to 3.2 mm for 44 D cornea) then uses back radius of 0.82 of front Radius for Total Power. Should ADD 0.22 D ATR for Total Astigmatism.

Note: 3.0 mm Mean Zonal Power = 43.00 D
3.2 mm Sim K = 43.75 D
Never use Sim K’s … same as keratometer

4 mm OZ with 6 cuts ~~ - 4.00 D
1. Calculation from Prior Data (Pre K & Δ MR known)

Pre KR Mean K  =  44.00 D
Change in SEQ Ref  =  -4.50 D
Calc Mean K  =  39.50 D

2. Calculation from Prior Data (Post Std. K's & Δ MR only)

Post Mean K  =  40.58 D
Change in SEQ Ref  =  -4.50 D
STD K's: -0.24 * SEQ =  -1.08
Calc Mean K  =  39.50 D
3. Calculation from Prior Data
(Post Ctr Top Power & Δ MR only)

Post Mean K = 40.27 D
Change in SEQ Ref = -4.50 D
Ctr Top: -0.15 * SEQ = -0.77
Calc Mean K = 39.50 D

4. Trial Hard Contact Lens
(Rigid Contact lens only)

Plano HCL Base Curve = 41.50 D
SEQ Ref without CL = +0.50 D
SEQ Ref with CL = -1.00 D
Front K = 41.50 - 1.50 = 40.00 D
40.00 D - 10% (4.50) = 39.50 D
Mean K = 39.50 D

5. Multiple K-readings
- Right Eye
  - Topcon: 35.13 @ 90° 37.02 @ 180° -1.89D ax90°
  - Galilei: 34.16 @ 94° 36.80 @ 4° 2.64 D @4
  - JAVAL: 35@80° .37@180° // IRREGULAR
- Left Eye
  - Topcon: 35.06 @ 50° 37.11 @ 140° -2.05D ax50
  - Galilei: 34.99 @50° 37.44 @ 140° 2.46 @140
  - JAVAL: 35.25@45° 38@155° // IRREGULAR

Post-operative
- Initial Hyperopic Shift
- Long Term Hyperopic Drift
- ATR Astigmatism Drift
If Posterior to Anterior Radius Ratio?

ToMography
Accuracy of EKR

<table>
<thead>
<tr>
<th>Prior Sx</th>
<th>STD 4.5 (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LASIK</td>
<td>0.56</td>
</tr>
<tr>
<td>RK</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Asymmetric Bowtie
Early Keratoconus
Post LASIK

Normal       LASIK         RK
41 to 44 D  36 to 41 D  32 to 45 D
3 D   Range  5 D Range  13 D Range

Summary
- Optimal Zone
  - LASIK: 4.5 mm
  - RK: 5.0 mm
  - Customize for small/large pupils
- Accuracy
  - LASIK: ± 0.56 D
  - RK: ± 0.94 D
  - Error on MYOPIC side
IOL CALCS in Keratoconus

- Corneal is Bifocal
- Patient does not look through cone for distance (may use at 10 cm as magnifier)
- Look at Power Distribution
- Use Paracentral Power (65% Mean Power)

Keratoconus Calculation #1

**OS**

- Used Km = 46.5 D => +1.00 D
- Should have used 65% Mean
  - 45.5 D => plano
  - should have targeted -0.50 D
    (-0.50 always better than +0.50)
IOL Calcs Using Axial Length

- Cataract or Clear Lens Removal
- Primary Piggy-Back IOL’s
- Multifocal IOL’s
- Toric IOL’s
- Silicone in Vitreous Compartment

Axial Length Measurements

- Phakia
- Aphakia
- Pseudophakia
  - PMMA: AL_{1532} + 0.4
  - Silicone: AL_{1532} - 0.6
  - Acrylic: AL_{1532} + 0.2

Primary Piggy-Back IOL’s

- Current Formulas are very inaccurate
- ELP underestimated due to AL
- Back lens displaced posteriorly
- Severe hyperopic errors (+5 D)

Primary PIGGY-BACK INTRAOCULAR LENSES

Polypseudophakia

Up to 4 IOL’s
PIGGY-BACK INTRAOCULAR LENSES

J.T. Holladay  James P. Gills
Jane Leidlein  Myra Cherchio

“Achieving Emmetropia In Extremely Short, Eyes With Two Piggy-Back Posterior Chamber Intraocular Lenses.”  
July 1996  Blue Journal

Primary Piggy-Back Complications

Acrylic
- Interlenticular membrane
- 3 to 5 D hyperopic shift @ 3 yr
Silicone
- Interlenticular membrane
- Flat Spot

Minimizing Prediction Error

- Holladay 2 Formula
- Personalize Constant
- Prediction Error vs. IOL power
- Constants for Sub-groups
  - Axial Length, K’s and Refraction

Toric IOL’s

- Current Formulas do not work because calculate different ELP for steep and flat meridian
- Predicted ELP must be the same for each meridian – only one IOL position

Toric IOL’s

- Calculate IOL power for steep and flat meridian using same ELP
- Difference in IOL powers is the toricity necessary to completely correct corneal astigmatism
**Ideal Toric IOL Calcs**
- Accurate corneal power and astigmatism ... repeat is SD > 0.020 D (0.030 mm)
- Exact Toric Calculator (not a constant ratio of corneal astigmatism to toricity (1.46)
- Proper Surgically Induced Astigmatism (SIA) for incision location and magnitude and axis of PreOp astigmatism ... must account for ATR over 3 to 6 months PostOp
- Results will be greater than 80% within 0.50 D

**Never Perfect Bow Tie**

<table>
<thead>
<tr>
<th>Toric IOL’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always choose toricity to undercorrect corneal astigmatism – <strong>WRONG</strong>!</td>
</tr>
<tr>
<td><strong>LEAVE MIN RESIDUAL CYL!</strong></td>
</tr>
<tr>
<td><strong>Eg</strong>: Steep calc yields 24.0 D Flat calc yields 27.0 D</td>
</tr>
<tr>
<td>Ideal Toricity is 3.0 D (Use 24.0 D with &lt; 3.0 D of toricity)</td>
</tr>
</tbody>
</table>

**Toric Calculators**

**Exact**
- Holladay On-line
- AMO Express On-line
- Holladay IOLConsult

**Approximate**
- Alcon On-line
- B & L On-line
- Barrett On-line

**Toric IOL Calculations**
- Commercial Calculators use a constant ratio (1.46) for the corneal cylinder to the IOL cylinder
- Exact Calculation depends on IOL SEQ Power and ELP ... to correct 2D of corneal astigmatism
  - 10 D IOL => 3.3 D Cylinder
  - 22 D IOL => 2.9 D Cylinder
  - 34 D IOL => 2.4 D Cylinder
- A **1.1 D difference** from 10 D to 34 D!

**Dioptric Error vs. Angular Error for a 1.00 D of astigmatism**

<table>
<thead>
<tr>
<th>Angle</th>
<th>Dioptric Error (D)</th>
<th>% Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>0.00</td>
<td>0%</td>
</tr>
<tr>
<td>15°</td>
<td>0.52</td>
<td>52%</td>
</tr>
<tr>
<td>30°</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>45°</td>
<td>1.41</td>
<td>141%</td>
</tr>
<tr>
<td>60°</td>
<td>1.73</td>
<td>173%</td>
</tr>
<tr>
<td>75°</td>
<td>1.93</td>
<td>193%</td>
</tr>
<tr>
<td>90°</td>
<td>2.00</td>
<td>200%</td>
</tr>
</tbody>
</table>

Dioptric Error = 2 * Cyl * sin (angular error)

---

Surgically Induced Astig (SIA)
- Critical to use correct value
- Not ~0.35 D WTR for small (2.5 mm), near-clear temporal incision
- Better to use Zero SIA and Baylor Nomogram
  - ↓ WTR (steep 90) by ONE Toric Size (T4 → T3)
  - ↑ ATR (steep 180) by ONE Toric Size (T3 → T4)
  - No change in Oblique
- Equivalent to ADDING ~ 0.51 D ATR as SIA

---

Wang/Koch Recommendation
- WTR: Subtract 0.6 D from measured
- ATR: Add 0.2 D to measured
- Oblique: No change
Equivalent to:
SIA = 0.2 + 0.4 sin²(Steep axis of astigmatism)
0 = 0.2@90  45 = 0.4@90  90 = 0.6@90

---

<table>
<thead>
<tr>
<th>Steep Axis (°)</th>
<th>SIA (D)</th>
<th>Axis of Flattening (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.20</td>
<td>90</td>
</tr>
<tr>
<td>10</td>
<td>0.21</td>
<td>90</td>
</tr>
<tr>
<td>20</td>
<td>0.25</td>
<td>90</td>
</tr>
<tr>
<td>30</td>
<td>0.30</td>
<td>90</td>
</tr>
<tr>
<td>40</td>
<td>0.37</td>
<td>90</td>
</tr>
<tr>
<td>45</td>
<td>0.40</td>
<td>90</td>
</tr>
<tr>
<td>50</td>
<td>0.43</td>
<td>90</td>
</tr>
<tr>
<td>60</td>
<td>0.50</td>
<td>90</td>
</tr>
<tr>
<td>70</td>
<td>0.55</td>
<td>90</td>
</tr>
<tr>
<td>80</td>
<td>0.59</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>0.60</td>
<td>90</td>
</tr>
</tbody>
</table>
Additional Factors (Wang/Koch)

- Posterior cornea has ~ 0.25 D WTR
- WTR decays ~ 0.50 D WTR
- ATR decays ~ 0.00 D ATR
- Result: \( \downarrow K_{\text{WTR}} \) by 0.75 D
  \( \uparrow K_{\text{ATR}} \) by 0.25 D

Post Op Toric Calculators

- Holladay IOL Consultant
  - www.hicsoap.com
- Berdahl & Hardten Toric IOL Calculator
  - www.astigmatismfix.com
Two Sources of Error

- IOL misaligned (wrong axis)
- IOL Toricity wrong (over/under)

Or

- Both

*Measuring Current Axis*
Exchange Toric Case #2

Lessons

- Irregular Astigmatism – outcomes unpredictable
- Post Op: measure the orientation of the IOL at slit lamp (reticle)
- Run Exact Post Op Back Calc with CURRENT AXIS for ideal axis and resulting refraction
**Silicone in Vitreous Cavity**
- Use Convexo-Plano IOL to minimize effect of Silicone (add 3 D to calculated IOL)
- If Biconvex IOL (add 6 D to calculated IOL)
- When Silicone removed -- 2 to 5 D of induced myopia

**IOL Calculations using a Refractive Formula** (ignore axial length)

**IOL Calculation without AL**
- Secondary AC or PC IOL for Aphakia
- Secondary Piggy-Back AC or PC IOL for Pseudophakia
- Primary AC IOL in Phakia

**REFRACTION FORMULA**

\[
\text{IOL} = \frac{1336}{1000} + \frac{K}{V} + \text{ELP} \quad \frac{1336}{1000} + \frac{K}{V} + \text{ELP}
\]

**Secondary Piggy-Back IOL’s Indications**
- Intolerable Pseudophakic Refractive Error

**Refractive Surprises**
1. Previous RK, PRK, LASIK
2. Bad axial length - short/long
3. Mislabeled IOL
4. Axially displaced
5. Misc.
Secondary Piggy-Back Calc
Advantages over Exchange

1. Mislabeled IOL irrelevant
2. Less risk to capsule or zonules
3. Mismeasured AL irrelevant
4. No AP shift of existing IOL
5. Fewer unknown variables

Phakic IOL's
(Secondary Piggy Back IOL's)

Refraction Formula

Phakic IOL Calculation
Input Variables

- Refraction and Vertex
- Keratometry
- Desired Refraction
- Predict ELP (ACD)
- Effective Lens Position

IOL Power Calcs for Phakic IOLs
(2º Piggy-Back & IOL Exchange after Refractive Surprise)

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**Phakic IOL Calculations**

- + IOL’s to Specs ~ 1.5 to 1
- - IOL’s to Specs ~ 1.0 to 1
- Approximation only

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**Thank you!**

Sydney April 23, 2002