ADVANCED IOL POWER CALCULATIONS

Jack T. Holladay, MD, MSEE, FACS

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 convexiplano ~ 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
Financial Disclosure

- I have the following financial interests or relationships to disclose:
  - Abbott Medical Optics: C;
  - AcuFocus, Inc.: C,O;
  - Alcon Laboratories, Inc.: C;
  - ArcScan: C,O;
  - Carl Zeiss Inc: C;
  - Clerio Vision: C,O;
  - Oculus, Inc.: C;
  - OcuPhire: C,O;
  - RX Vision: C,O;
  - M & S Technologies: C;
  - Visiometrics: C,O;

Vergence Formula

- Theoretical Formula has not changed in 173 years
- Physiologic Assumptions may be slightly different
  - Retinal thickness
  - Corneal Index of Refraction
**Vergence Formula**

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

**E L P**

**Effective Lens Position**
- 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**
- <1980 Constant (0) 4.5
- 1981 Binkhorst 2 (1) AL
- 1988 Holladay 1 (2) AL, K
- 1995 Olsen (4) AL, K, ACD, LT
- 1996 Holladay 2 (7) AL, K, ACD, LT, HWTW, REF, AGE
- 2012 Olsen II (5) AL, K; ACD, LT, C constant
- 2015 Barrett Universal II (7) AL, K, ACD, LT, HWTW, REF, Lens Factor
• Can estimate the PRE-REF K from back surface in PRK & LASIK with toMography

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

- 95% 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 Eyes

- 90% Normal Anterior Segment Size
- 10% 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

Long Eyes ( > 27 mm)

- 0% Normal Anterior Segment Size
- 90% Small Anterior Segment Size
- 10% Large Anterior Segment Size

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
Eye Model must include

NINE

types of eyes not only

THREE

CONCLUSION: 9 EYES

Anterior Segment Size

Axial Length

Large

Megalocornea

+ axial hyperopia

(0%)

Large Eye

Buphthalmos

Megalocornea

+ axial myopia

(10%)

Megalocornea

Normal

axial hyperopia

(2%)

Megalocornea

axial myopia

(90%)

Normal

axial hyperopia

(80%)

Small

Microcornea

+ axial splay

(0%)

Megalocornea

axial myopia

(2%)

Small eye

Nanophthalmia

(20%)

Normal

Short

Normal

Long

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

EMMETROPIC IOL POWER

THE HOLLADAY 2 FORMULA

More Measurements

More Accuracy
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

FORMULA PERFORMANCE

CONCLUSIONS

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

Myopic Staphyloma

Subtract from A-scan measured Axial Length ~ 0.8 mm

Fig. 8.1. Myopic cornea.

Zaldivar-Holladay JCRS May 2000
Zeiss - IOL Master - 2000
Wang/Koch Linear Regression to compensate for Long Eyes (> 25)
Go half-way between

Formula Prediction Error versus Axial Length
N = ~ 20,000

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

Holladay 1 formula
\[ a = 0.8046x + 4.9195 \]
\[ R^2 = 0.9766 \]

Holladay 2 formula
\[ b = 0.8332x + 4.2134 \]
\[ R^2 = 0.9655 \]
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

Horizontal Angle & Alpha & Kappa

Angle Kappa on IOL Master, LenStar and penlight ~ 0.33 mm
If > 0.70 mm then concern!


IOL MASTER 500 – ZEISS
Version 7.70

Anterior chamber depth values

<table>
<thead>
<tr>
<th>ACT</th>
<th>3.13 mm</th>
<th>ACT</th>
<th>3.24 mm</th>
</tr>
</thead>
</table>

White-to-white values

<table>
<thead>
<tr>
<th>ACT</th>
<th>3.5 mm</th>
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<tbody>
<tr>
<td>3.5 mm</td>
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Reference image capture

No image

IOL MASTER 500 – ZEISS
Version ≥ 7.10

OD

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<tr>
<td>10.3 mm</td>
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<tr>
<td>0.0 mm</td>
</tr>
<tr>
<td>0.4 mm</td>
</tr>
<tr>
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<tr>
<td>0.0 mm</td>
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</table>

Horizontal Angle & Alpha & Kappa

OC PC VA

α < Κ

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)
Cataract Surgery ...
IOL Power Calculations
Following Refractive Surgery

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

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

Corneal Power Decision Tree

K = 44 D

70% of cases
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)

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If SD for K’s > ± 0.20 D (> ± 0.030 mm) Test for Dry Eye

ToPography/ToMography

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### Keratometry values

<table>
<thead>
<tr>
<th>Method</th>
<th>Wavelength</th>
<th>K1</th>
<th>K2</th>
<th>SD</th>
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<tr>
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<td>±0.00 mm</td>
<td>±0.00 mm</td>
<td>±0.00 mm</td>
<td></td>
</tr>
<tr>
<td>IOL Master</td>
<td>40.34/42.35 D</td>
<td>40.26 D × 179°</td>
<td>3.93 mm</td>
<td></td>
</tr>
<tr>
<td>IOL Master</td>
<td>42.33 D × 89°</td>
<td>42.26 D × 97°</td>
<td>4.00 mm</td>
<td></td>
</tr>
<tr>
<td>IOL Master</td>
<td>40.34 D × 179°</td>
<td>40.26 D × 179°</td>
<td>4.00 mm</td>
<td></td>
</tr>
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### Anterior chamber depth values

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<th>Method</th>
<th>Wavelength</th>
<th>DCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACD</td>
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<td></td>
</tr>
<tr>
<td>DCD</td>
<td>3.13 mm</td>
<td></td>
</tr>
</tbody>
</table>

### White-to-white values

<table>
<thead>
<tr>
<th>Method</th>
<th>Wavelength</th>
<th>DCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCT</td>
<td>542 μm</td>
<td></td>
</tr>
</tbody>
</table>

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**Analysis**

- **Measured values**
  - AL: 22.30 mm (SD = ±0.1 mm)
  - ACD: 2.96 mm (SD = ±0.1 mm)
  - LT: 3.06 mm (SD = ±0.1 mm)
  - R1: 7.83 mm @ 158° (SD = ±0.1 mm)
  - R2: 7.69 mm @ 68° (SD = ±0.1 mm)
  - ΔD: -0.75 mm @ 158°

- **Keratometry values**
  - m = 1.3753
  - WTW: 11.9 mm
  - WT: 5.4 mm
  - P: 4.7 mm

---

**Ring Diameter affects Keratometry**

- 44.5 D
- 44.3 D
- 44.0 D

Man IOL M

Manual Keratometer Measures 44.0 D Causes Optical A-Constant to be ~ 0.3 D Higher than Manual Keratometry
**Initial Visit 6 wks after Dry Eye Rx**

If SD > ± 0.20 D (> ± 0.030 mm)

- **Not Dry Eye**
  - Topography/Topography

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**Corneal Power after LASIK, PRK, RK**

- Ideally, Calculation from both surfaces...
- Calculation from Prior Data Trial
- Hard Contact Lens
- Corneal Topography
- Automated Keratometry
- Manual Keratometry

---

**Always Topography/Topography if Correcting Astig**

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

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**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

Keratometry: Measures Front Surface. Ring of Lenticle
(nominal 2.0, 2.5 or 3.2 mm & assumes back radius (N = 4, 6 or 28)

Topography: Measures Front Surface of Lenticle (N = 74,000)

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)

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

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

Post Mean K = 44.00 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: 34.15 @ 94  36.80 @ 145 2.64 D @4
  - JAVAL: 35@80º  37@180º // 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@45º  38@155º // 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>Procedure</th>
<th>STD</th>
<th>D</th>
</tr>
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<tbody>
<tr>
<td>Prior</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Sx</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>LASIK</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>RK</td>
<td>0.94</td>
<td></td>
</tr>
</tbody>
</table>

Asymmetric Bowtie
Early Keratoconus
Post LASIK

Normal       LASIK         RK
41 to 44 D  3 D Range
36 to 41 D  5 D Range
32 to 45 D  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
- Silicone
- Acrylic

AL_{1555}
AL_{1532}
AL_{1532} + 0.4
AL_{1532} - 0.6
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.”

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

Toric IOL’s

- Always choose toricity to undercorrect corneal astigmatism – WRONG!
- LEAVE MIN RESIDUAL CYL!
- Eg: Steep calc yields 24.0 D Flat calc yields 27.0 D
- Ideal Toricity is 3.0 D
(Use 24.0 D with < 3.0 D of toricity)
**Toric Calculators**

**Exact**
- Holladay On-line
- AMO Express On-line
- Holladay IOL Consult

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

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

<table>
<thead>
<tr>
<th>Angle Error (°)</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>
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<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 sin^2(Steep axis of astigmatism)

SIA
<table>
<thead>
<tr>
<th>Steep Axis (°)</th>
<th>Magnitude (D)</th>
<th>Axis of Flattening (°)</th>
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<tr>
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<td>0.20</td>
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<tr>
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<tr>
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<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: ↓ K WTR by 0.75 D
          ↑ K ATR by 0.25 D
Two Sources of Error

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

**Measuring Current Axis**
PREOP 6 D Toric IOL
**Toric Calc Example 2**

### Manual:
- \(42.00 \degree @ 170\) & \(42.87 \degree @ 85\)

### LenStar:
- \(41.34 \degree @ 128\) & \(42.80 \degree @ 38\)

1. (40\(\degree\))
2. (146\(\degree\))

Visually:
- Steep @ 40 and Flat @ 0
- So optimal @ 20
Exchange Toric Case #2

Lessons

- Irregular Astigmatism – outcomes unpredictable
- Post Op: measure the orientation of the IOL at slit lamp (reticule)
- 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 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

\[ IOL = \frac{1336}{1000} \left( \frac{1336}{1000} \cdot \frac{K}{\text{PreRx}} - ELP \right) \]

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**

\[
IOL = \frac{1336}{1000 + \frac{K}{PreRx \cdot V}} - \frac{ELP}{1000 + \frac{K}{PreRx \cdot V}}
\]

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

Phakic IOL Calculation

**Input Variables**

REFRACTION FORMULA

\[
IOL = \frac{1336}{1000 + \frac{K}{PreRx \cdot V}} - \frac{ELP}{1000 + \frac{K}{PreRx \cdot V}}
\]


Phakic IOL Calculation

**Input Variables**

**Refraction and Vertex**

Soft Contact Lens @ Vtx = 0 w Small Over-Refraction (< ± 2 D) is most accurate.
Phakic IOL Calculations

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

Thank you!