Update on Post-Refractive Surgery IOL Calculations
Hawaiian Eye 2014 Kauai

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Financial Disclosures

Research Funds: Accutome; Carl Zeiss Meditec; Ellex; Haag-Streit USA; Quantel Medical; Sonomed Escalon
We must first get the correct axial length!

- Eyes 25.0 mm or longer: Optical tends to measure long eyes too long – hyperopic surprises reported - do immersion and B-scan biometry to verify
Post-op using I mm:

OD:  -0.75 +1.25 X 140  (SE = -0.125)

OS:  -0.50 + 0.50  X 008  (SE = -0.25)
Optimizing Axial Length in Long Eyes

• Holladay I formula:
  \[0.8814 \times \text{AL(IOLM)} + 2.8701 = \text{Adjusted AL}\]

• Haigis formula:
  \[0.9621 \times \text{AL(IOLM)} + 0.6763 = \text{Adjusted AL}\]

• SRK/T formula:
  \[0.8981 \times \text{AL(IOLM)} + 2.5637 = \text{Adjusted AL}\]

• Hoffer Q formula:
  \[0.8776 \times \text{AL(IOLM)} + 2.9269 = \text{Adjusted AL}\]
Optimizing Axial Length in Long Eyes

- The problem with using an optimization equation is that sometimes optical gets it right!
- Adjusting a measurement that didn’t need adjusting will still lead to a post-op surprise
- The best way to measure the high myope is with ultrasound so you know it is correct
Immersion Technique

- **Probe immersed in shell of saline**
- **Most accurate/no corneal compression (0.015 - 0.05 mm depending on manufacturer)**
- **The method to which optical was calibrated in its development**
Why High Myopes are Harder to Measure
Why High Myopes are Harder to Measure

- The eye is misshapen, oval or elongated rather than round
- Macula on a “slope”
- Perpendicularly impossible
Posterior Staphyloma

- Uvea bulging into thin, stretched sclera
- Commonly in posterior pole
- Perpendicularly impossible
- Measurements vary greatly
B-Biometry Technique

- Align B-scan with “HMAC” position (probe on corneal vertex, marker nasal) with 4 or 5 mm of gel on probe tip.
- Corneal vertex and posterior lens surface centered on left, macula centered on right inferior to optic nerve.
- Macula ~4.5 mm down from center of optic disc.
- Place one caliper on front of cornea, move the other through the center of the lens to macular surface.
If you don’t see the cornea, you aren’t using enough gel!
B-biometry = 30.34 mm

A-scan = 30.03, 30.26, 30.0, 30.20, 30.15, 29.98
B-Biometry Technique
Comparison to Good Immersion

23.78 on A-scan

23.80 on B-scan
IOL Calculations after Refractive Surgery
The Post-Refractive Surgery Keratometry Challenge

- Central cornea either flattened (myopic correction) or steepened (hyperopic correction), causing erroneous readings from standard keratometers
- Readings now either underestimated or overestimated by reading the wrong area
- Results in hyperopic surprise after myopic correction, myopic surprise after hyperopic correction if not addressed
So What Do We Do?
Clinical History Method

- Previously considered “Gold Standard”, but now one of least favored methods
- Need three numbers:
  1. Pre-Op MR (sph eq)
  2. Pre-Op K’s (average)
  3. Post-Op MR (sph eq)
For example:

- **Average K pre-LASIK = 45.75 D**
- **- 5.00 D myope pre-LASIK**
- **- 0.25 D myope post-LASIK**
- **Change in MR = 4.75 D**
- **K = 45.75 D - (4.75 D) = 41.00 D**
• Measure $K$’s post-op (IOL Master or Sim K preferred), average, then

$$K = 1.14 \ (K \ post-op) - 6.8$$

• In his study, 93.3% within 1D of target
Shammas PHL
For Hyperopic LASIK

• Presented at ASCRS 2013
• Accepted for publication

\[ K_c = 1.0457 \ (K_{post-op}) - 1.9538 \]
Wang-Koch-Maloney Method

For myopic LASIK patients:
• Obtain topography post-op, then

\[ K = 1.114 \times (Ccp) - 6.1 \]

Where \( Ccp \) is the central corneal power with cursor at the exact center of the Axial Map
Recommend using Atlas topographer
• **Best performance in recent studies for PRK and LASIK patients (not RK!)**

• **Must know amount of correction from history** *(LSE = spherical equivalent of change after laser vision correction)*

\[
IOL \text{ Adjustment} = LSE \times (-0.326) + 0.101
\]
Masket Method
Masket S, Masket SE. JCRS 2006; 32:430-434

- Adjust final power, not measurements
- Used IOLM K’s and Biometry for study
- May use Sim K and immersion instead
- No need to determine corneal power
- Mean outcome -0.15 D, 28 out of 30 eyes within 0.5 D of target
Masket Formula Examples

Prior Myopia (use SRK/T):
- **Formula yields** +16.0 D
- **LSE** = -6.00 D
- \(-6.0 \times (-0.326) + 0.101 = +2.057\)
- \(+16.0 + 2.0 = +18.0 D\) Final IOL Power
Masket Formula Examples

Prior Hyperopia (use Hoffer Q):

- **Formula yields** +22.0 D
- **LSE** = +3.0 D
- +3.0 \times (-0.326) + 0.101 = -0.877
- +22.0 - 1.0 = +21.0 D Final IOL Power
Haigis L

- For both myopic and hyperopic LASIK
- Measure the patient on optical biometer as always and choose Haigis L for either myopic or hyperopic LASIK
- No other modifications necessary!
Haigis L

- For myopia, Haigis L has a correction function for IOL Master keratometry plus a correction factor for the ACD change (0.5 mm steeper since part of cornea removed) due to ablation – no history required.

- For hyperopia, since no ablation, has correction function for K’s only.
ASCRS website
Post-Refractive Surgery
IOL Calculator
www.ASCRS.org
(link at top of home page)

IOL power calculation in eyes that have undergone LASIK/PRK/RK

- Prior Myopic LASIK/PRK
- Prior Hyperopic LASIK/PRK
- Prior RK

Warren Hill, M.D.
Li Wang, M.D., Ph.D.
Douglas D. Koch, M.D.

Version 4.4
Made possible by an unrestricted educational grant from Alcon Laboratories
and The ASCRS Foundation

Uses Holladay I with double K method
## Prior Myopic LASIK/PRK

### IOL Calculator for Eyes with Prior Myopic LASIK/PRK

(Your data will not be saved. Please print a copy for your record.)

Please enter all data available and press "Calculate"

<table>
<thead>
<tr>
<th>Doctor Name</th>
<th>Patient Name</th>
<th>Eye</th>
<th>IOL Model</th>
</tr>
</thead>
</table>

### Pre-LASIK/PRK Data:

- **Refraction**
  - Sph(D) 
  - Cyl(D)* 
  - Vertex (If empty, 12.5 mm will be used)

- **Keratometry**
  - K1(D) 
  - K2(D)

### Post-LASIK/PRK Data:

- **Refraction**
  - Sph(D) 
  - Cyl(D)* 
  - Vertex(mm)

- **Topography**
  - EyeSys
  - EffRP
  - Atlas 9000
  - Tomey ACCP
  - Nidek*ACP/APP
  - Galilei
  - TCP**
    - V5.2.1 or later
    - V5.2 or earlier

- **Atlas Ring Values**
  - 0mm
  - 1mm
  - 2mm
  - 3mm

### Optical (IOLMaster/Lenstar)/Ultrasound Biometric Data:

- **Ks**
  - K1(D) 
  - K2(D)

- **AL(mm)**
  - ACD(mm)

- **Lens Constants**
  - A-const(SRK/T) 
  - SF(Holladay 1)

- **Haigis a0**
- **Haigis a1**
- **Haigis a2**

*If entering "Sph(D)”, you must enter a value for "Cyl(D)”, even if it is zero.*

§Most recent stable refraction prior to development of a cataract.

# Magellan ACP or OPD-Scan III APP 3-mm manual value (personal communication Stephen D. Klyce, PhD).

**Select the version of your Galilei device: “V5.2 or earlier” or “V5.2.1 or later”.

***Select the keratometric index (n) of your device. Instruments in North America typically default to 1.3375.

****Enter any constants available; others will be calculated from those entered. If ultrasonic AL is entered, be sure to use your ultrasound lens constants.
## Prior Myopic LASIK/PRK

| IOL calculation formulas used: Double-K Holladay 1<sup>1</sup>, Shammas-PL<sup>2</sup>, & Haigis-L<sup>3</sup> |
|---|---|---|
| **Using Pre-LASIK/PRK Ks + ΔMR** | **Using ΔMR** | **Using no prior data** |
| History | 1<sup>1</sup>Adjusted EffRP | 2<sup>2</sup>Wang-Koch-Maloney |
| Feiz-Mannis | 2<sup>2</sup>Adjusted Atlas 9000 (4mm zone) | 2<sup>2</sup>Shammas Method |
| Corneal Bypass | 1<sup>1</sup>Adjusted Atlas Ring Values | 3<sup>3</sup>Haigis-L |
| | Masket Formula | 1<sup>3</sup>Galilei |
| | Modified-Masket | |
| | 1<sup>1</sup>Adjusted ACCP/ACP/APP | |

Average IOL Power (ΔMR only & No Prior Data):

Average IOL Power (All Available Formulas):

Min: 
Max:
Prior Myopic LASIK/PRK

- From results from thousands of eyes at two major centers, methods in second and third columns performed better than those of the first column.
- Now shows average of 2\textsuperscript{nd} and 3\textsuperscript{rd} columns above average from entire calculator.

<table>
<thead>
<tr>
<th>IOL calculation formulas used: Double-K Holladay\textsuperscript{1}, Shammas-PL\textsuperscript{2}, &amp; Haigis-L\textsuperscript{3}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using Pre-LASIK/PRK Ks + ΔMR</strong></td>
</tr>
<tr>
<td>History --</td>
</tr>
<tr>
<td>Feiz-Mannis --</td>
</tr>
<tr>
<td>Corneal Bypass --</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Average IOL Power (ΔMR only & No Prior Data):* \textsuperscript{--}  

*Average IOL Power (All Available Formulas):* \textsuperscript{--}  

Min: \textsuperscript{--}  

Max: \textsuperscript{--}
Prior Myopic LASIK/PRK

Best results were from Masket, Shammas, Haigis-L, and Wang-Koch-Maloney

IOL calculation formulas used: Double-K Holladay $^1$, Shammas-PL $^2$, & Haigis-L $^3$

<table>
<thead>
<tr>
<th>Using Pre-LASIK/PRK Ks + ΔMR</th>
<th>Using ΔMR</th>
<th>Using no prior data</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>$^1$Adjusted EffRP</td>
<td>$^2$Wang Koch-Maloney</td>
</tr>
<tr>
<td>Feiz-Mannis</td>
<td>$^2$Adjusted Atlas 9000 (4mm zone)</td>
<td>$^2$Shammas Method</td>
</tr>
<tr>
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<td>$^1$Adjusted Atlas Ring Values</td>
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<tr>
<td></td>
<td>Masket Formula</td>
<td>$^2$Galilei</td>
</tr>
<tr>
<td></td>
<td>Modified-Masket</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$^1$Adjusted ACCP/ACP/APP</td>
<td></td>
</tr>
</tbody>
</table>

Average IOL Power (ΔMR only & No Prior Data):

Average IOL Power (All Available Formulas):

Min: -

Max: -
**Prior Hyperopic LASIK/PRK**

### IOL Calculator for Eyes with Prior Hyperopic LASIK/PRK

(Your data will not be saved. Please print a copy for your record.)

Please enter all data available and press "Calculate"

<table>
<thead>
<tr>
<th>Doctor Name</th>
<th>Patient Name</th>
<th>Eye</th>
<th>IOL Model</th>
</tr>
</thead>
</table>

**Pre-LASIK/PRK Data:**

- **Refraction:** Sph(D) ___________ Cyl(D) ___________ Vertex (If empty, 12.5 mm will be used)
- **Keratometry:** K1(D) ___________ K2(D) ___________

**Post-LASIK/PRK Data:**

- **Refraction:** Sph(D) ___________ Cyl(D) ___________ Vertex (mm) ___________
- **Topography:**
  - Eyesys
  - EffRp
  - Atlas
  - 0mm ___________ 1mm ___________ 2mm ___________ 3mm ___________

**Biometric Data:**

- IOLMaster Ks**
  - K1(D) ___________ K2(D) ___________
- Keratometric Index (n)***
  - 1.3375
  - 1.332
  - Other
- IOLMaster/Ultrasound
  - AL(mm) ___________ ACD(mm) ___________ Target Ref(D) ___________
- Lens Constants****
  - A-const(SRK/T) ___________ SF(Holladay1) ___________ Haigis a0 ___________ Haigis a1 ___________ Haigis a2 ___________

*If entering "Sph(D)" you must enter a value for "Cyl(D)" even if it is zero.
**Not manual SimKs from other devices.
***Select the keratometric index (n) of your device. Instruments in North America typically default to 1.3375.
****Enter the constant available; the other will be calculated. If ultrasonic AL is entered, be sure to use your ultrasound lens constants.

[Calculate] [Reset Form]
### Prior Hyperopic LASIK/PRK

<table>
<thead>
<tr>
<th>IOL Powers Calculated Using Double-K Holladay 1 Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using Pre-LASIK/PRK Ks + ΔMR</strong></td>
</tr>
<tr>
<td>Clinical History: --</td>
</tr>
<tr>
<td>Feiz-Mannis:   --</td>
</tr>
<tr>
<td>Corneal Bypass: --</td>
</tr>
<tr>
<td><strong>Using ΔMR</strong></td>
</tr>
<tr>
<td>Adjusted EffRP: --</td>
</tr>
<tr>
<td>Adjusted Atlas 0-3: --</td>
</tr>
<tr>
<td>Masket Formula: --</td>
</tr>
<tr>
<td>Modified-Masket: --</td>
</tr>
<tr>
<td><strong>Using no prior data</strong></td>
</tr>
<tr>
<td>Haigis-L: --</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Average IOL Power:</strong></th>
<th>--</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Min:</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Max:</strong></td>
<td>--</td>
</tr>
</tbody>
</table>
### IOL Calculator for Eyes with Prior RK

(Your data will not be saved. Please print a copy for your record.)

Please enter all data available and press "Calculate"

<table>
<thead>
<tr>
<th>Doctor Name</th>
<th>Patient Name</th>
<th>Eye</th>
<th>IOL Model</th>
</tr>
</thead>
</table>

**Topographic Data:**

<table>
<thead>
<tr>
<th>EyeSys EffRP</th>
<th>Average Central Power*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlas 1mm</td>
<td></td>
</tr>
<tr>
<td>Pentacam PWR_SF_40**</td>
<td>CT_MIN**</td>
</tr>
</tbody>
</table>

**Optical (IOLMaster/Lenstar)/Ultrasound Biometric Data:**

<table>
<thead>
<tr>
<th>Ks</th>
<th>K1(D)</th>
<th>K2(D)</th>
<th>Keratometric Index (n)**</th>
<th>1.3375</th>
<th>1.332</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL(mm)</td>
<td></td>
<td></td>
<td>Target Ref(D)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lens Constants***</td>
<td>A-cons (SRK/T)</td>
<td>SF (Holladay1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not SimK values; average central corneal powers from other devices.

**PWR_SF_40 refers to the Pentacam Power Distribution display for the Sagittal Curvature (Front) Mean (Km) value at a 4.0 mm zone and centered on the pupil. Click on PWR_SF_40 to see this topographic display. CT_MIN is the minimum central corneal thickness in microns as displayed by the Pentacam.

***Select the keratometric index (n) of your device. Instruments in North America typically default to 1.3375.

****Enter the constant available; the other will be calculated. If ultrasonic AL is entered, be sure to use your ultrasound lens constants.
## Prior RK

**IOL Powers Calculated Using Double-K Holladay 1 Formula**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EyeSys EffRP</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Average Central Power (other)</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Atlas 1-4</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Pentacam</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>IOLMaster/Lenstar</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Average IOL Power:</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Min:</strong></td>
<td>--</td>
</tr>
<tr>
<td><strong>Max:</strong></td>
<td>--</td>
</tr>
</tbody>
</table>
RK Patients

- **History method not as good for post-RK due to unstable post-op refraction**
- **Measure them in morning rather than afternoon – K’s flatter in the am, steeper in pm**
- **Make them plano in the am, myopic in pm – not hyperopic am, plano pm!**
**RK Patients**

- **Aim for -0.75 or -1.00 in post-RK patients because of hyperopic shift over several years**
- **Don’t want them to drift into hyperopia - drift into plano instead**
- **After RK, many patients have a hyperopic surprise that will settle out over time**
- **Do NOT do IOL exchange until after 2 stable refractions on 2 different visits at least 2 months out!**
**Patient Unsure**

- Patient had LASIK OU, wasn’t sure what type
- When asked if she was nearsighted or farsighted beforehand, her answer was “both”

<table>
<thead>
<tr>
<th>Measuring mode</th>
<th>Mode</th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial length</td>
<td>AL</td>
<td>26.64 mm ±0.007 mm</td>
<td>26.51 mm ±0.008 mm</td>
</tr>
<tr>
<td>Cornea thickness</td>
<td>CCT</td>
<td>398 μm ±6.0 μm</td>
<td>359 μm ±1.2 μm</td>
</tr>
<tr>
<td>Aqueous depth</td>
<td>AD</td>
<td>3.02 mm ±0.010 mm</td>
<td>3.46 mm ±0.007 mm</td>
</tr>
<tr>
<td>Anterior chamber depth incl.</td>
<td>ACD</td>
<td>3.42 mm ±0.006 mm</td>
<td>3.82 mm ±0.007 mm</td>
</tr>
<tr>
<td>Lens thickness</td>
<td>LT</td>
<td>3.90 mm ±0.230 mm</td>
<td>3.15 mm ±0.020 mm</td>
</tr>
<tr>
<td>Retina thickness</td>
<td>RT</td>
<td>200** μm ±0.0 μm</td>
<td>200** μm ±0.0 μm</td>
</tr>
</tbody>
</table>

| Flat meridian        | K1   | 38.77 D @ 113° ±0.174 D | 36.24 D @ 78° ±0.184 D |
| Steep meridian       | K2   | 39.70 D @ 23° ±0.088 D  | 38.53 D @ 168° ±0.344 D |
| Astigmatism          | AST  | 0.93 D @ 23° ±4.5°    | 2.28 D @ 168° ±4.1°   |
| Keratometric index   | n    | 1.3375              | 1.3375              |
Patient Unsure

- Patient had LASIK on OS only to be able to read up close (monovision)
- Was plano OU beforehand
- Would that be myopic or hyperopic LASIK?

### Optical Data

<table>
<thead>
<tr>
<th></th>
<th>OD (Right eye)</th>
<th>OS (Left eye)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring mode</td>
<td>Mode</td>
<td>Measuring mode</td>
</tr>
<tr>
<td>Axial length</td>
<td>AL 23.05 mm ±0.007 mm</td>
<td>Phakic 23.44 mm ±0.009 mm</td>
</tr>
<tr>
<td>Cornea thickness</td>
<td>CCT 581 μm ±2.1 μm</td>
<td>Phakic 588 μm ±4.3 μm</td>
</tr>
<tr>
<td>Aqueous depth</td>
<td>AD 2.32 mm ±0.011 mm</td>
<td>Aqueous depth</td>
</tr>
<tr>
<td>Anterior chamber depth incl.</td>
<td>ACD 2.90 mm ±0.009 mm</td>
<td>Anterior chamber depth incl.</td>
</tr>
<tr>
<td>Lens thickness</td>
<td>LT 4.45 mm ±0.285 mm</td>
<td>Lens thickness</td>
</tr>
<tr>
<td>Retina thickness</td>
<td>RT 200** μm ±0.0 μm</td>
<td>Retina thickness</td>
</tr>
<tr>
<td>Flat meridian</td>
<td>K1 42.59 D @ 49°</td>
<td>Flat meridian</td>
</tr>
<tr>
<td>Steep meridian</td>
<td>K2 42.74 D @ 139°</td>
<td>Steep meridian</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>AST 0.15 D @ 139°</td>
<td>Astigmatism</td>
</tr>
<tr>
<td>Keratometric index</td>
<td>n 1.3375</td>
<td>Keratometric index</td>
</tr>
</tbody>
</table>
Topography
Myopic LASIK

- Flat zone centrally
Topography
Hyperopic LASIK

• Steep zone centrally
Conclusion

• *ALL methods require good data in!*
• *If measurements are not accurate, none of the methods work!*
• *Don’t forget to use ultrasound for long eyes!*
Thank you!
Mahalo!