Biometry & IOL Power Calculations for Presbyopia Correcting IOLs

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Refractive Surgery

*Lens vs. Cornea*

- Limitations of LASIK
  - High Hyperopes
  - High Myopes
  - Presbyopes

- Spherical Aberration
  - Cornea (stable)
  - Crystalline lens (increasing + SA)

- Cataract
Accuracy → Success

- Patient Selection
- Biometry
- Lens Power Calculation
- Incision Construction
- Preoperative Astigmatism
Axial Length

• Applanation biometry can yield accurate and consistent results

• Increasing utilization of non-contact techniques
  – Zeiss IOLMaster™
IOLMaster™
Combined Biometry Instrument

- Axial length, corneal curvature, and anterior chamber depth

- The axial length measurement is based on an interference-optical method termed partial coherence interferometry
  - measurements compatible with acoustic immersion
  - accurate to within 30 microns
IOLMaster™

Limitations

• Optical biometry limited by dense media
  – PSC cataract
  – Dense NS
  – Vitreous hemorrhage

• Lack of lens thickness measurement
  (required variable in the Holladay II formula)
  Lens thickness can be estimated by the formula:
  $$4.0 + \left[ \frac{\text{age}}{100} \right]$$
**Immersion Ultrasound**

- **Quantel Axis II**

- **No limitations of media density**

- **IOLMaster more accurate for posterior staphyloma**

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**Immersion A-scan compared with partial coherence interferometry**

**Outcomes analysis**

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**ABSTRACT**

**Purpose:** To compare 2 methods of axial length measurement, immersion ultrasonography and partial coherence interferometry, and to elucidate surgical outcomes based on immersion measurements.

**Setting:** Oregon Eye Institute, Eugene, Oregon, USA.

**Methods:** Axial length measurements in 50 cataractous eyes were obtained by optical biometry IOLMaster® (Ziess Humphrey System) and immersion ultrasound (Ax II, Quantel Medical), and the results were compared. Immersion lens (IL) power calculations in the same eyes after corneal extraction and posterior chamber IOL implantation were evaluated retrospectively based on the postoperative spherical equivalent prediction error.

**Results:** Immersion ultrasonography and partial coherence interferometry measurements correlated in a highly positive manner (correlation coefficient = 0.999). Outcomes analysis demonstrated 92.0% of eyes were within ±0.5 diopter of emmetropia based on immersion axial length measurements.

**Conclusion:** Immersion ultrasonography provided highly accurate axial length measurements and permitted highly accurate IOL power calculations. J Cataract Refract Surg 2020; 26:239–242 © 2020 ASCRS and ESCRS

Axial length measurement remains an indispensable technique for intraocular lens (IOL) power calculation. Recently, partial coherence interferometry has emerged as a new modality for biometry. Postoperative results achieved with this modality have been considered “analogous” to those achieved with the ultrasound immersion technique. Reportedly “user-friendly” and less dependent on technician’s expertise than ultrasound methods, noncontact optical biometry is, however, limited by dense media, eg, posterior subcapsular cataract. A second limitation of the optical method is the lack of a lens thickness measurement, a required variable in the Holladay 2 IOL power calculation software, version 2.30.9705. However, according to Holladay, the lens thickness can be estimated by the formula 4.0 + (age/100). Also, optical biometry can provide keratometry measurements, obviating the need for a second instrument.

Immersion ultrasound is an accurate method of axial length measurement, generally considered superior to...
Immersion Ultrasound

• Immersion and partial coherence interferometry correlated well

• 92% of eyes ± 0.50D with Axis II
Keratometry
Keratometry

Normal Cornea

Standard keratometry and CVK are accurate in measuring four sample points to determine the steepest and flattest meridians yielding accurate central corneal power.
Keratometry

Following Keratorefractive Surgery

• Sample points are not sufficient to provide an accurate assessment of corneal refractive power

• Determination of the corneal refractive power from the anterior corneal curvature may no longer be valid
  – refractive index of the cornea (1.338) may have changed
  – especially true when corneal tissue has been removed (PRK and LASIK)
  • a change in the relationship between the anterior and posterior curvatures of the cornea
Calculating Corneal Power

• Methods requiring historical data
  – Clinical history
  – Modified values from CVK
  – Feiz-Mannis
  – Corneal bypass

• Methods with unreliable historical data
  – Effective RP
  – Hard contact lens
  – Modified Maloney
Calculating Corneal Power

Clinical History Method

The change in manifest refraction at the corneal plane induced by the refractive procedure is subtracted from the keratometric values prior to refractive surgery.

\[ K = \text{Preop } K - \Delta \text{MRx (corneal plane)} \]
Calculating Corneal Power

Clinical History Method

- Sabotaged by cataract formation
  \[ \Delta \text{MRx may be confounded by NS} \]

- More useful in RLE
Calculating Corneal Power
Modified Values From CVK

- Simple method
- Requires the historical surgically induced refractive change (RC)
- Effective Refractive Power (Eff RP)

- Refractive power of the corneal surface within the central 3 mm pupil zone
- Obtained from Holladay Diagnostic Summary display

Holladay Diagnostic Summary 2000

- Patient ID: 66507
- Exam #: 1, OD

Refractive Map
- Steep RP = 39.51D @ 99°
- Flat RP = 38.45D @ 33°
- Eff Astig = +1.00D @ 99°
- Eff RP = 38.90D

Local ROC (Radius) Map
- Steep Sim K = 39.33D @ 76°
- Flat Sim K = 38.65D @ 166°
- Delta K = +0.68D @ 76°
- Avg Sim K = 38.99D

Profile Difference Map
- H Pupil Dec = 0.10mm OUT
- V Pupil Dec = 0.00mm UP
- Delta K = +0.68D @ 76°
- Avg Pupil Dia = 2.99mm
- Reg Astig = +0.82D @ 111°

Distortion Map
- Jurisov Dec = 0.13
- CU Index = 100%
- PC Acuity = 20/12
- I-S Value = 0.54 (p=0.222)

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Calculating Corneal Power

*Modified Values From CVK*

**Post Myopia**

Adjusted Eff RP = Eff RP – 0.15 (RC) – 0.05

**Post Hyperopia**

Adjusted Eff RP = Eff RP – 0.16 (RC) – 0.28
Calculating Corneal Power

Feiz-Mannis Method

- IOL power is initially calculated as though the patient had not undergone previous refractive surgery

$$\text{Final IOL} = \text{IOL} + \frac{\text{RC}}{0.7}$$

- Method unreliable
Calculating IOL Power

**Corneal Bypass Method**

- Assume no previous RS surgery
- Target IOL for pre LASIK refractive error (SE)
  - Pre LASIK Ks
  - Pre LASIK SE
  - Post LASIK Axial Length
  - Holladay 2
Mean post-op refraction = 0.03 D (± 0.42 D)
Calculating IOL Power

Corneal Bypass Method

![IOL Selection Chart]

- Post LASIK K’s
- Clinical History Method
- Double-K Method
- Our Method
- True IOL

IOL Power (D)
Calculating Corneal Power

Unreliable Historical Data

- Effective RP
- Useful Post RK

Effective RP and Holladay 2 with Double K method

80% ± 0.50 D emmetropia

Calculating Corneal Power

*Hard Contact Lens Method*

- Calculates the corneal refractive power as a summation of the contact lens base curve, power, and the difference between the manifest refraction with and without the contact lens.
- Not useful with reduced VA from cataracts (not be an issue in RLE candidates).
- Reliability questionable.
Calculating Corneal Power

*Modified Maloney Method*

- Takes into account the difference in anterior and posterior curvature following LASIK

- **Corneal Power =**
  
  \(( \text{Central Topographic Power} \times 1.11 ) - 6.1\)
Keratometry Following Keratorefractive Surgery

- Historical Information
  - Not Available

- Post RK
  - Effective RP

- Post LASIK / PRK
  - Modified Maloney

- Post RK/LASIK/PRK
  - Clinical History
    - Modified CVK
    - Corneal Bypass
IOL Calculation Formulas
Formulas

• 3\textsuperscript{rd} Generation
  – SRK/T
  – Hoffer Q
  – Holladay 1

• 4\textsuperscript{th} Generation
  – Holladay 2
Holladay 2

- Designed to improve determination of the final effective lens position ELP
  - Horizontal corneal white-to-white
  - Phakic lens thickness
  - Anterior chamber depth
  - Axial length
  - Age
  - Refraction
  - Keratometry
    - Problematic s/p keratorefractive surgery
ELP s/p Refractive Surgery

- Previous myopic LASIK → Hyperopic

- Flatter K (used for IOL calculation) will predict more anterior ELP and a lower IOL power than would be used if pre-op K utilized
• Post-op RS K’s for vergence formula to determine refractive power of eye

• Pre-op RS K’s for ELP
Holladay 2

- Improved the accuracy of our IOL calculations
- Formula of choice for cataract and RLE
- Confirmation
  - SRK/T - Long eyes
  - Hoffer Q - Short eyes
Final Comments

Attention to detail $\rightarrow$ Accurate results $\rightarrow$ Patient Satisfaction

- Patient Selection
- Biometry
- Lens Power Calculation
- Incision Construction
- Preoperative Astigmatism
Thank You