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 + [age/100]

Immersion Ultrasound

- Quantel Axis II

- No limitations of media density
- IOLMaster more accurate for posterior staphyloma

Immersion A-scan compared with partial coherence interferometry

Outcomes analysis

Mark Packer, MD, I. Howard Fine, MD, Richard S. Hoffman, MD, Peggy G. Coffman, COT, Laurie K. Brown, COMT, COE

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®, Zeiss Humphrey Systems) and immersion ultrasound (Axis II, Quantel Medical), and the results were compared. Intraocular lens (IOL) power calculations in the same eyes after cataract 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 = 0.996). 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 2002; 28:239–242 © 2002 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.[1] Postoperative results achieved with this modality have been considered "analogous" to those achieved with the ultrasound immersion technique.[2] Reportedly "user-friendly" and less dependent on technician 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

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None of the authors has a proprietary or financial interest in any product mentioned.

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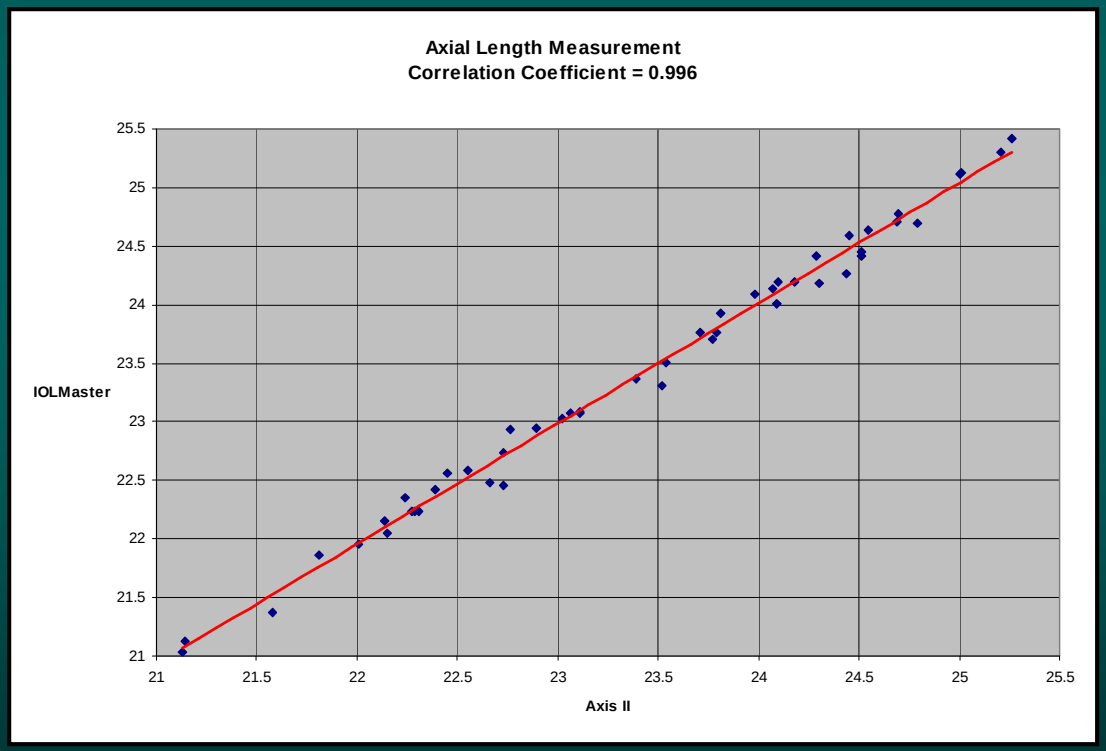
Immersion Ultrasound

- Immersion and partial coherence interferometry correlated well



Correlation Coefficient = 0.996

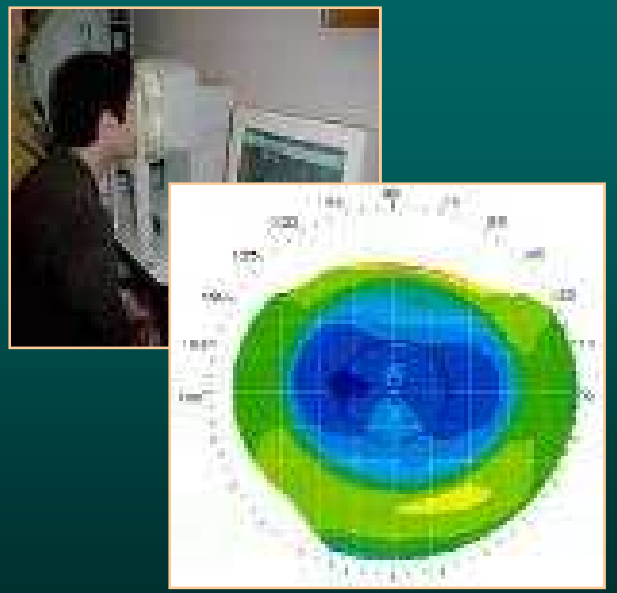
- 92% of eyes ± 0.50D with Axis II

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

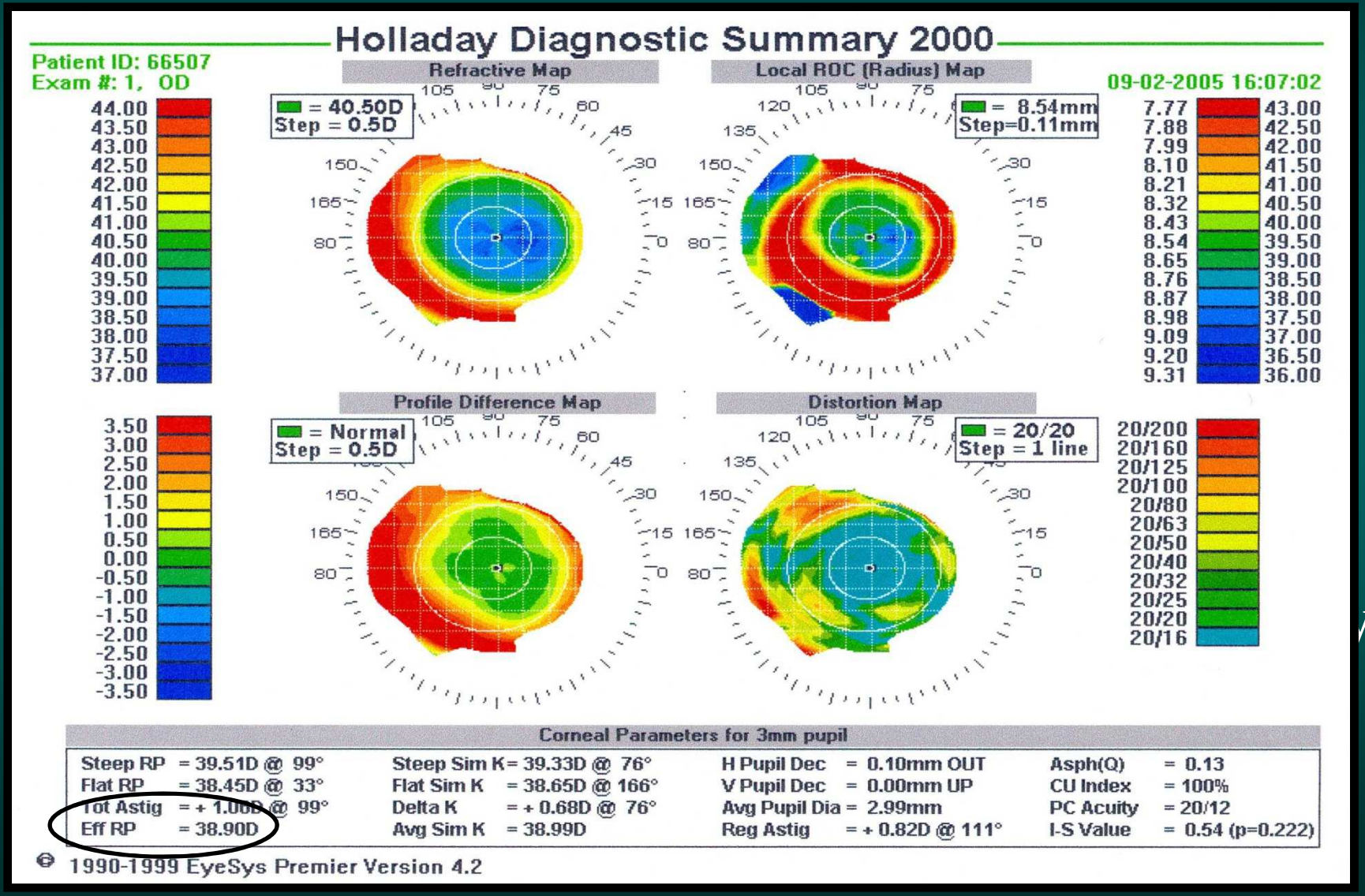
- Sabotaged by cataract formation

  Δ MRx may be confounded by NS

- More useful in RLE

Calculating Corneal Power

Modified Values From CVK



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

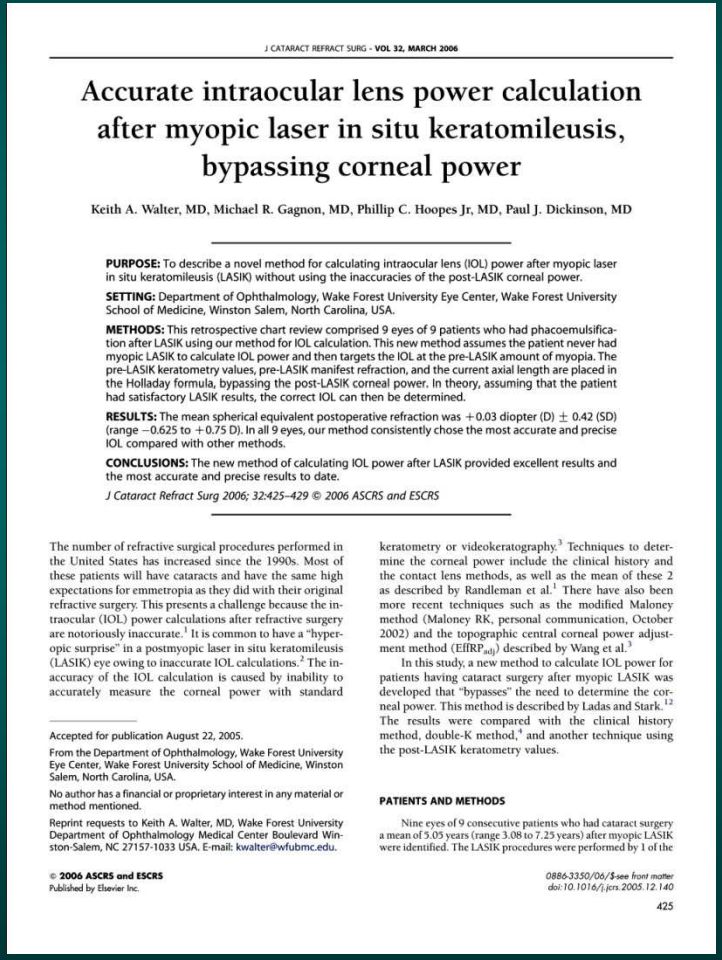
Final IOL = IOL + RC/0.7

- 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



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Accurate intraocular lens power calculation after myopic laser in situ keratomileusis, bypassing corneal power

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PURPOSE: To describe a novel method for calculating intraocular lens (IOL) power after myopic laser in situ keratomileusis (LASIK) without using the inaccuracies of the post-LASIK corneal power.

SETTING: Department of Ophthalmology, Wake Forest University Eye Center, Wake Forest University School of Medicine, Winston Salem, North Carolina, USA.

METHODS: This retrospective chart review comprised 9 eyes of 9 patients who had phacoemulsification after LASIK using our method for IOL calculation. This new method assumes the patient never had myopic LASIK to calculate IOL power and then targets the IOL at the pre-LASIK amount of myopia. The pre-LASIK keratometry values, pre-LASIK manifest refraction, and the current axial length are placed in the Holladay formula, bypassing the post-LASIK corneal power. In theory, assuming that the patient had satisfactory LASIK results, the correct IOL can then be determined.

RESULTS: The mean spherical equivalent postoperative refraction was +0.03 diopter (D) ± 0.42 (SD) (range −0.625 to +0.75 D). In all 9 eyes, our method consistently chose the most accurate and precise IOL compared with other methods.

CONCLUSIONS: The new method of calculating IOL power after LASIK provided excellent results and the most accurate and precise results to date.

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The number of refractive surgical procedures performed in the United States has increased since the 1990s. Most of these patients will have cataracts and have the same high expectations for emmetropia as they did with their original refractive surgery. This presents a challenge because the intraocular (IOL) power calculations after refractive surgery are notoriously inaccurate.[1] It is common to have a "hyperopic surprise" in a postmyopic laser in situ keratomileusis (LASIK) eye owing to inaccurate IOL calculations.[2] The inaccuracy of the IOL calculation is caused by inability to accurately measure the corneal power with standard keratometry or videokeratography.[3] Techniques to determine the corneal power include the clinical history and the contact lens methods, as well as the mean of these 2 as described by Randleman et al.[1] There have also been more recent techniques such as the modified Maloney method (Maloney RK, personal communication, October 2002) and the topographic central corneal power adjustment method ($EffRP_{adj}$) described by Wang et al.[3]

In this study, a new method to calculate IOL power for patients having cataract surgery after myopic LASIK was developed that "bypasses" the need to determine the corneal power. This method is described by Ladas and Stark.[12] The results were compared with the clinical history method, double-K method,[4] and another technique using the post-LASIK keratometry values.

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No author has a financial or proprietary interest in any material or method mentioned.

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PATIENTS AND METHODS

Nine eyes of 9 consecutive patients who had cataract surgery a mean of 5.05 years (range 3.08 to 7.25 years) after myopic LASIK were identified. The LASIK procedures were performed by 1 of the

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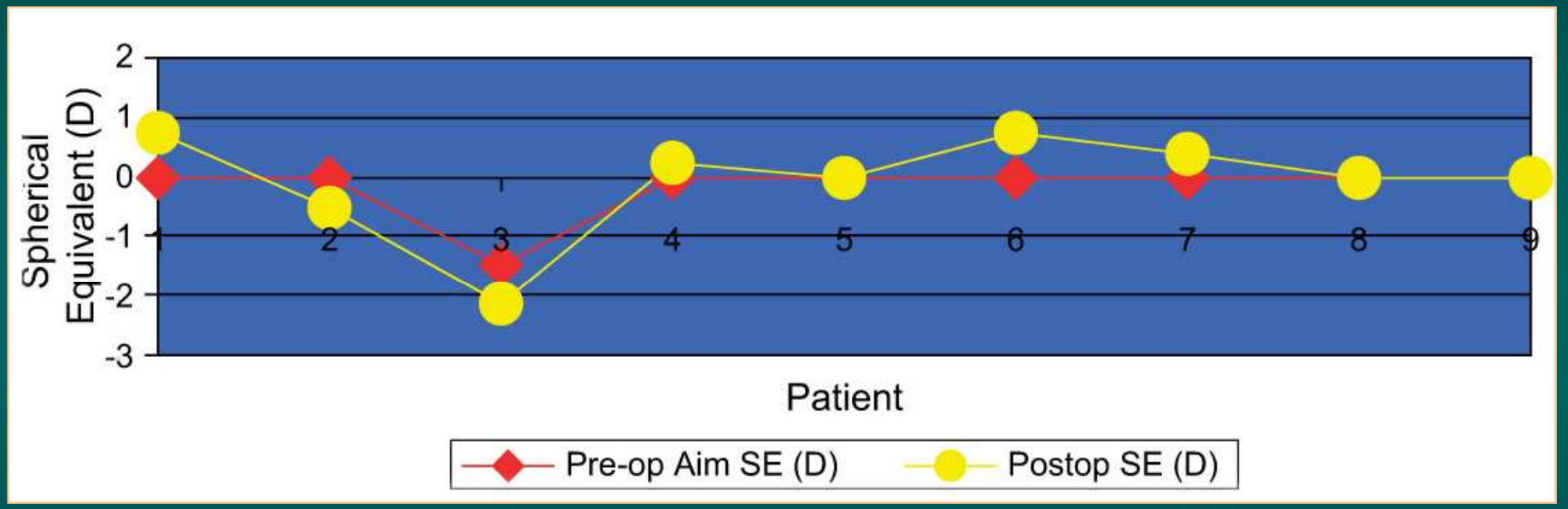
Calculating IOL Power

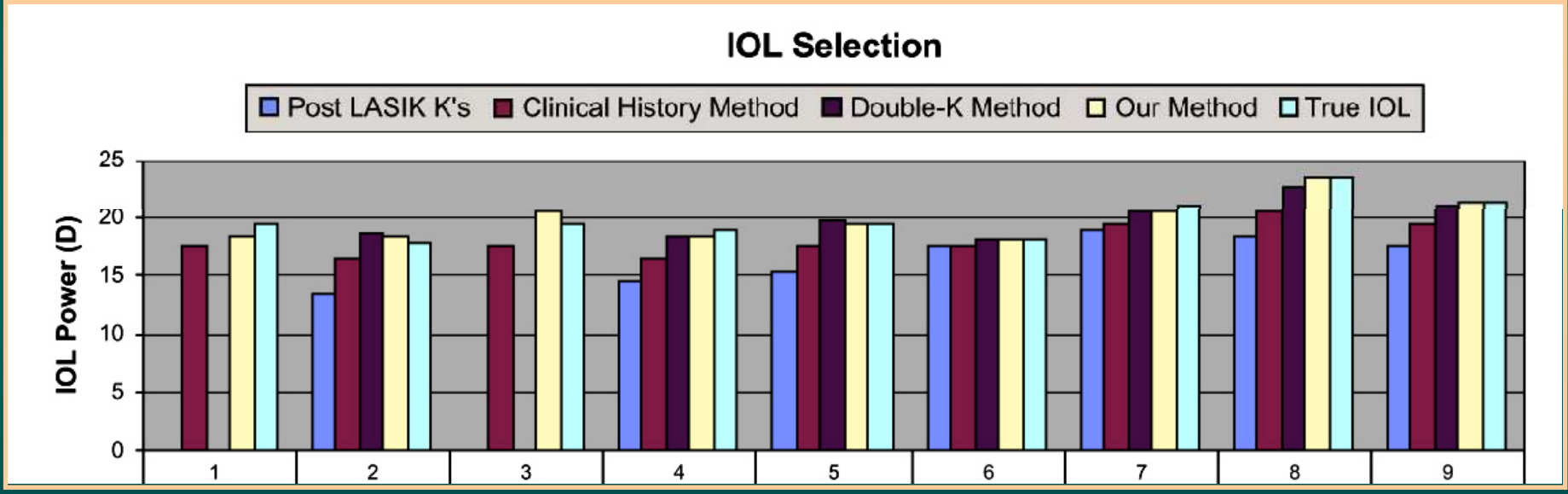
Corneal Bypass Method



Mean post-op refraction = 0.03 D (± 0.42 D)

Calculating IOL Power

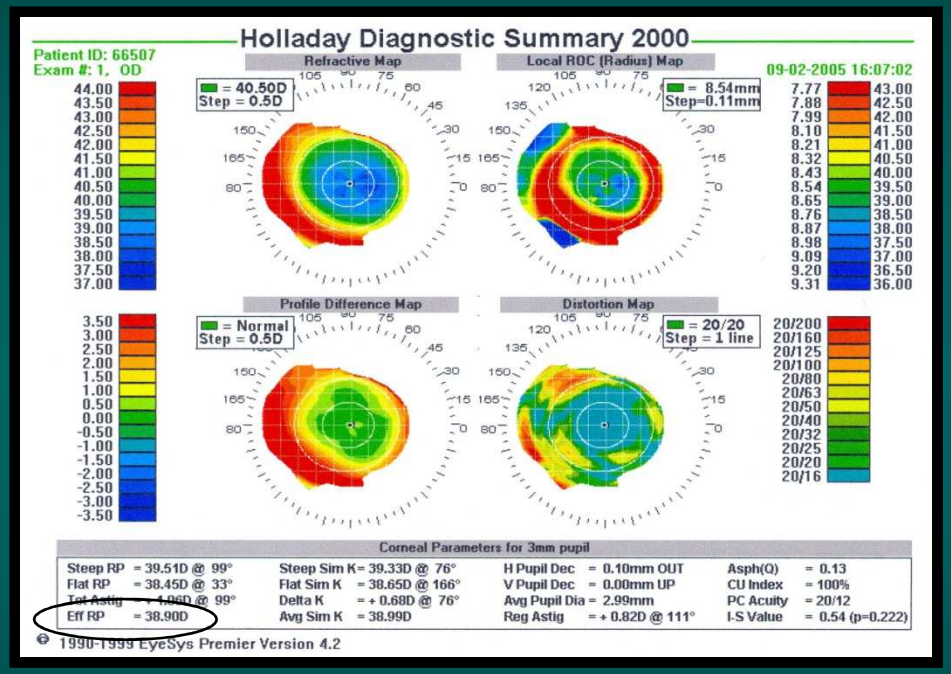
Corneal Bypass Method



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

Packer M, Brown LK, Hoffman RS, Fine IH. Intraocular lens power calculation after incisional and thermal keratorefractive surgery. J Cataract Surg 2004; 30:1430-1434

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

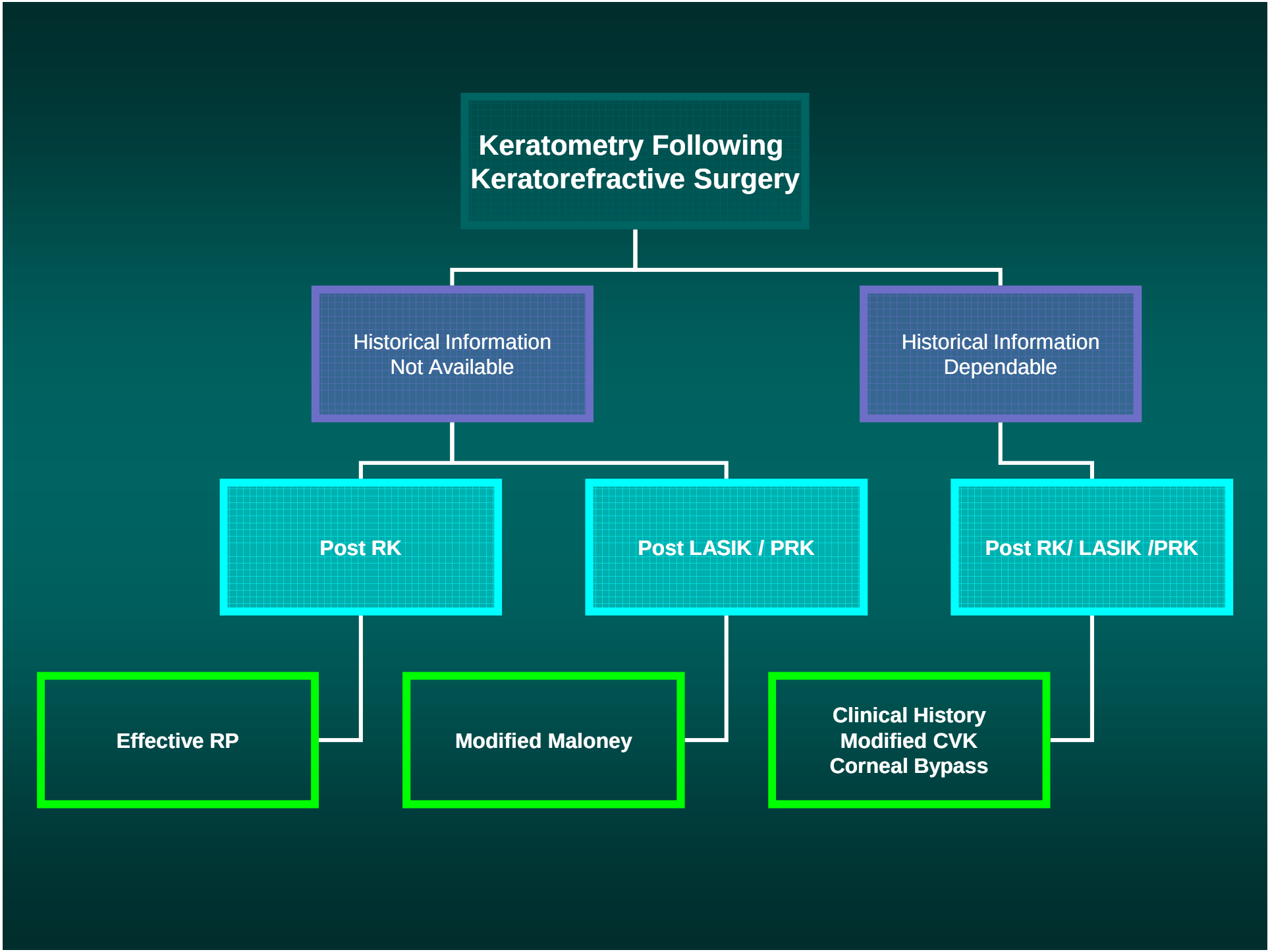
Calculating Corneal Power

Modified Maloney Method

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

- Corneal Power =

  (Central Topographic Power x 1.11) - 6.1


Keratometry Following Keratorefractive Surgery
Historical Information Not Available
Historical Information Dependable
Post RK
Post LASIK / PRK
Post RK/ LASIK /PRK
Effective RP
Modified Maloney
Clinical History Modified CVK Corneal Bypass

IOL Calculation Formulas

Formulas

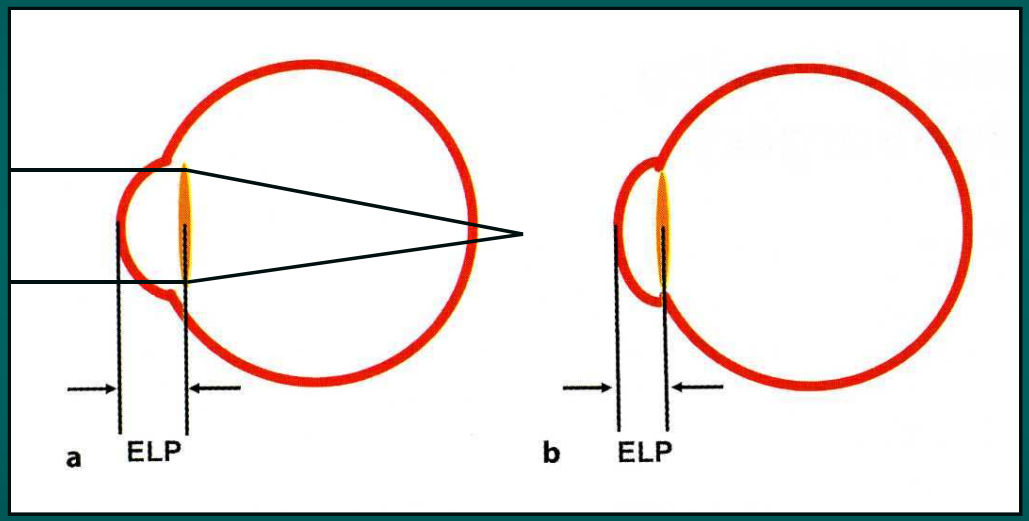
- 3rd Generation
  - SRK/T
  - Hoffer Q
  - Holladay 1
- 4th Generation
  - Holladay 2

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

Holladay 2

Double K Method

- 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 → Accurate results → Patient Satisfaction

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

Thank You