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 Keratorefrative 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.

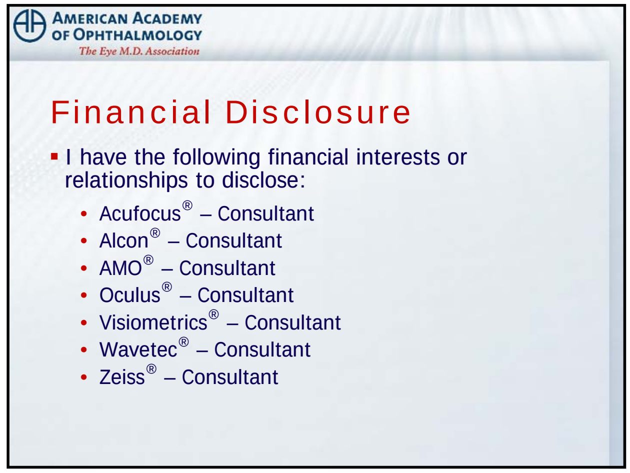
VIII. Minimizing Prediction Error
- A. Personalizing Formula Constants (A-const, ACD or Surgeon Factor)
- B. Prediction Error vs. IOL Power
- C. Creating personalized constants for subgroups
  1. Axial Length (< 22 mm or > 26 mm)
  2. Keratometry (< 40 D or > 48 D)
  3. Preoperative Refraction (< -4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


Advanced
IOL Power Calculations
Jack T. Holladay, MD, MSEE, FACS
Clinical Professor of Ophthalmology
Baylor College of Medicine
Houston, Texas, USA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The Eye M.D. Association
Financial Disclosure
I have the following financial interests or relationships to disclose:
Acufocus® – Consultant
Alcon® – Consultant
AMO® – Consultant
Oculus® – Consultant
Visiometrics® – Consultant
Wavetec® – Consultant
Zeiss® – Consultant


Jack T. Holladay, MD, MSEE, FACS
Clinical Professor of Ophthalmology
Baylor College of Medicine
Houston, Texas
Fax: 713 668 7336
www.docholladay.com
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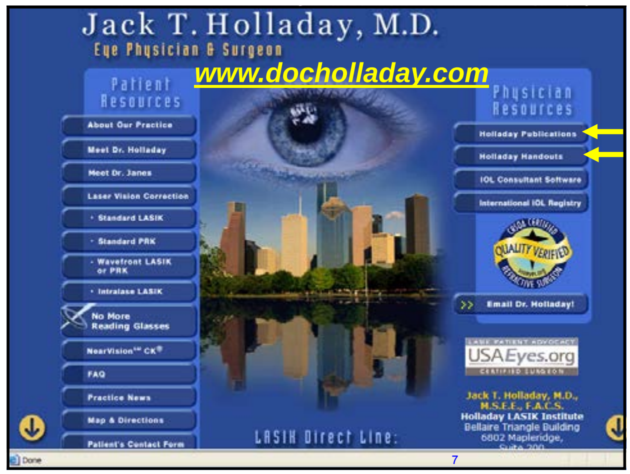
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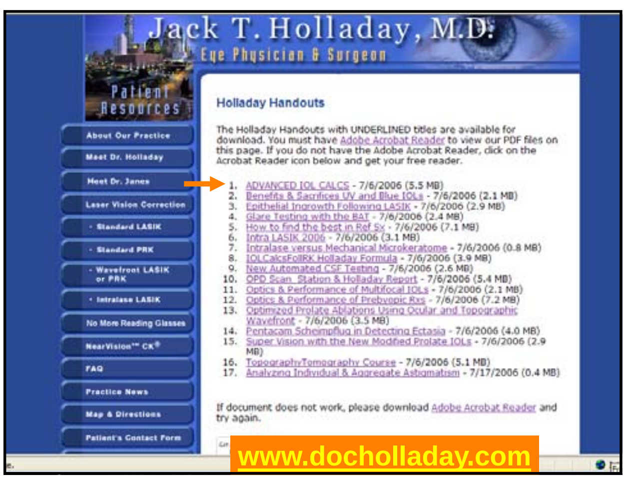
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2. Benefits & Sacrifices UV and Blue IOLs - 7/6/2006 (2.1 MB)
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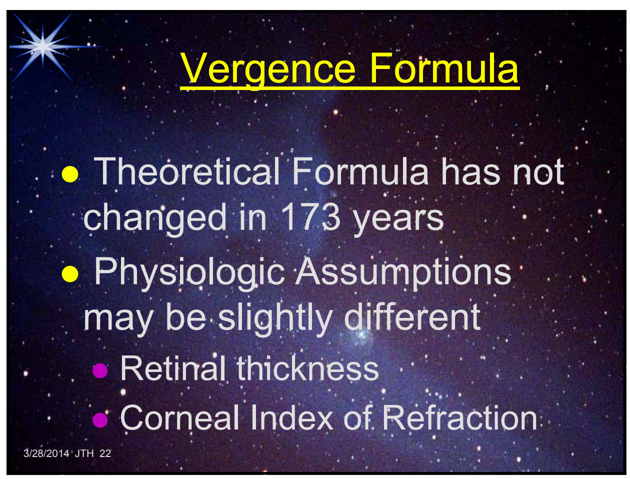
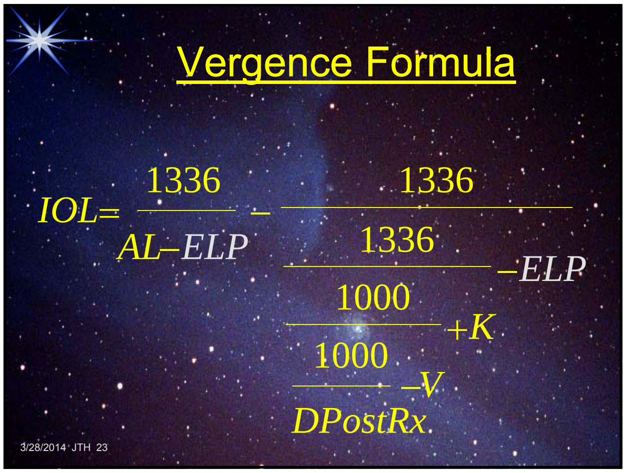
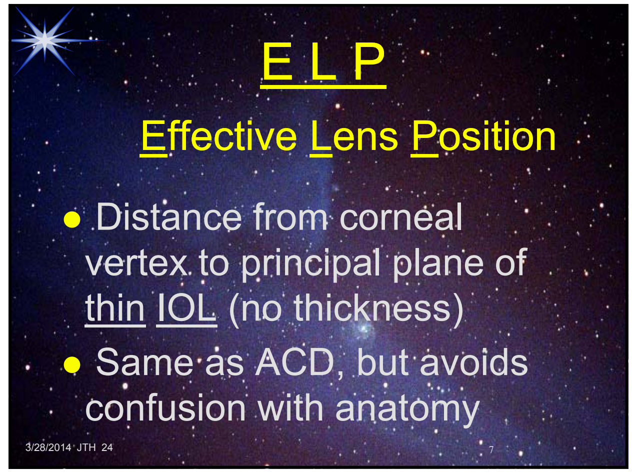
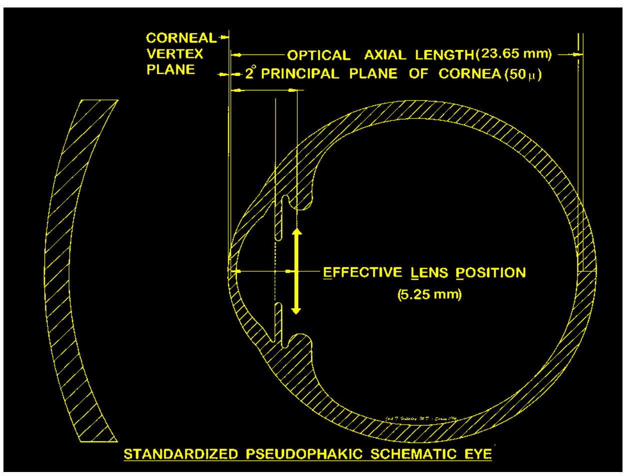
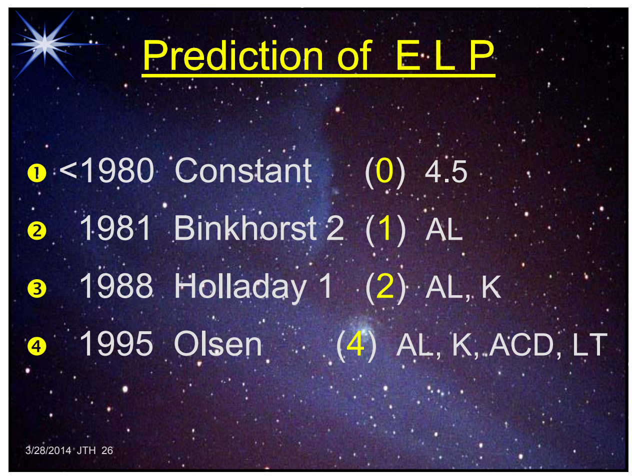
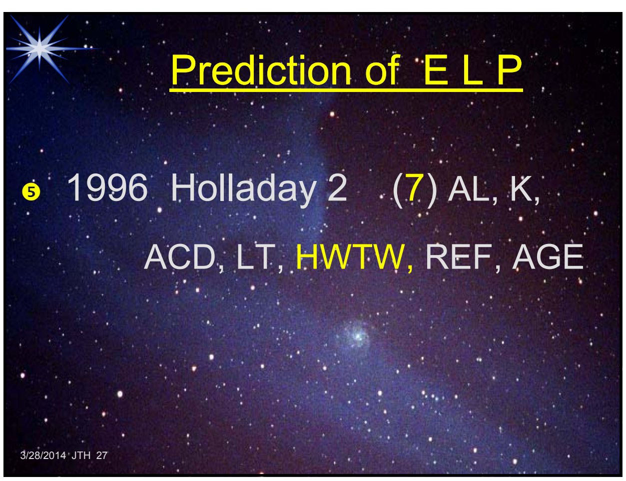

Vergence Formula
Theoretical Formula has not changed in 173 years
Physiologic Assumptions may be slightly different
Retinal thickness
Corneal Index of Refraction
3/28/2014 JTH 22

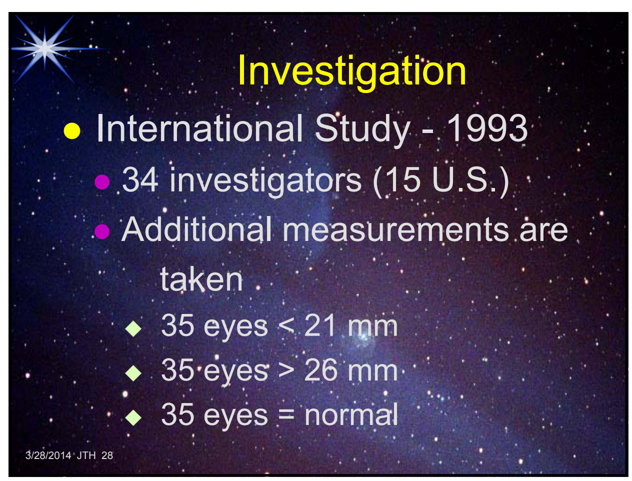

Vergence Formula
$$IOL=\frac{1336}{AL-ELP}-\frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{DPostRx}-V}+K}-ELP}$$
3/28/2014 JTH 23

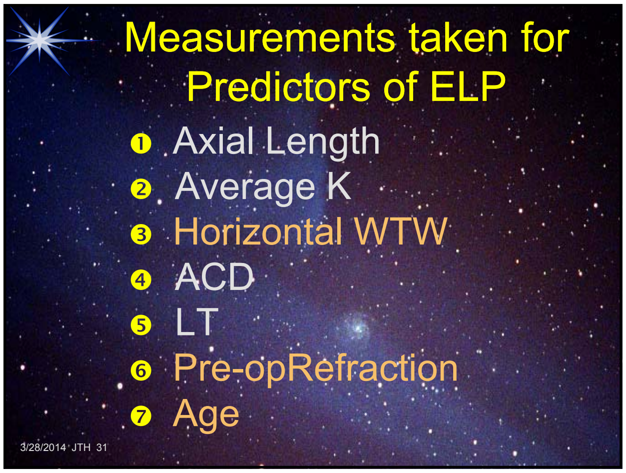

E L P
Effective Lens Position
Distance from corneal vertex to principal plane of thin IOL (no thickness)
Same as ACD, but avoids confusion with anatomy
3/28/2014 JTH 24

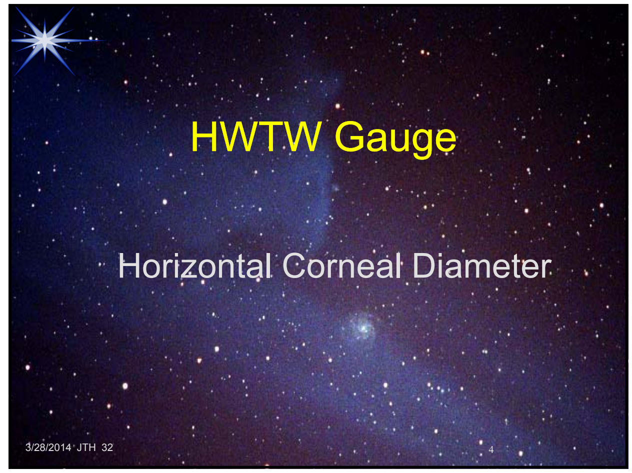

CORNEAL VERTEX PLANE
OPTICAL AXIAL LENGTH (23.65 mm)
2° PRINCIPAL PLANE OF CORNEA (50 µ)
EFFECTIVE LENS POSITION
(5.25 mm)
STANDARDIZED PSEUDOPHAKIC SCHEMATIC EYE


Prediction of E L P
❶ <1980 Constant (0) 4.5
❷ 1981 Binkhorst 2 (1) AL
❸ 1988 Holladay 1 (2) AL, K
❹ 1995 Olsen (4) AL, K, ACD, LT
3/28/2014 JTH 26

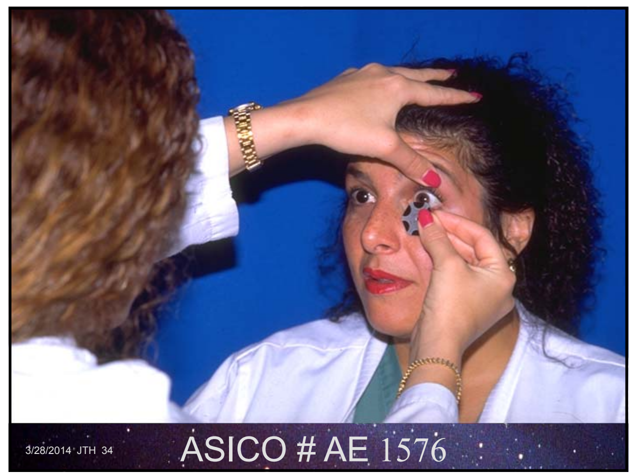

Prediction of E L P
❺ 1996 Holladay 2 (7) AL, K, ACD, LT, HWTW, REF, AGE
3/28/2014 JTH 27

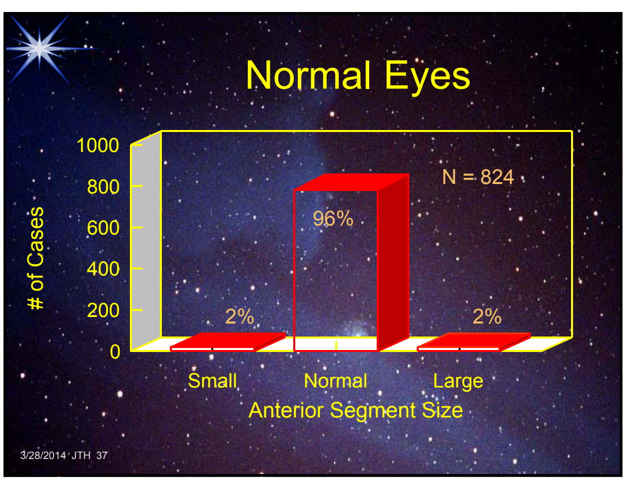

Investigation
International Study - 1993
34 investigators (15 U.S.)
Additional measurements are taken
35 eyes < 21 mm
35 eyes > 26 mm
35 eyes = normal
3/28/2014 JTH 28

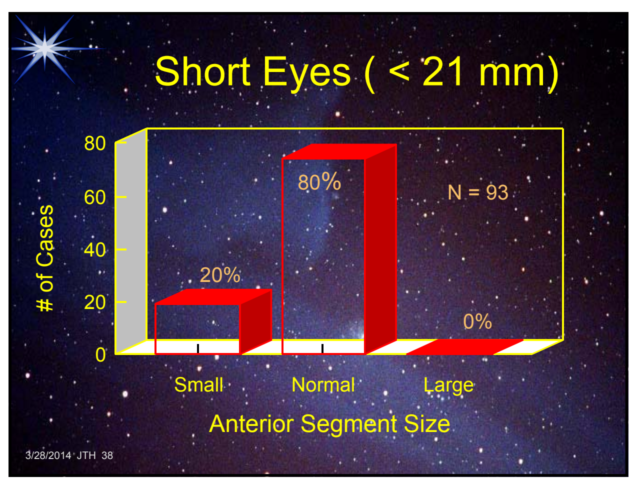

Measurements taken for Predictors of ELP
❶ Axial Length
❷ Average K
❸ Horizontal WTW
❹ ACD
❺ LT
❻ Pre-opRefraction
❼ Age
3/28/2014 JTH 31

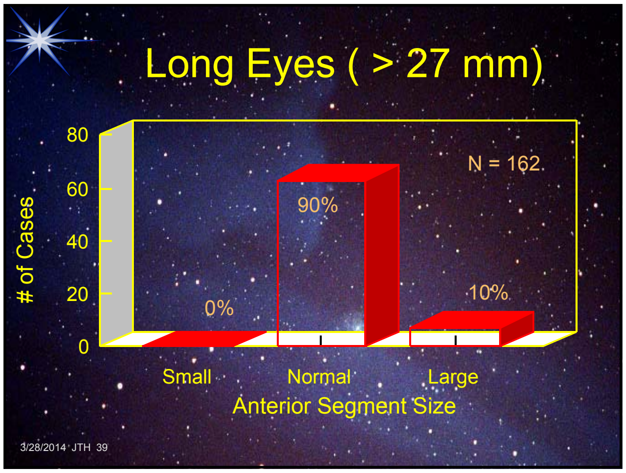

HWTW Gauge
Horizontal Corneal Diameter
3/28/2014 JTH 32

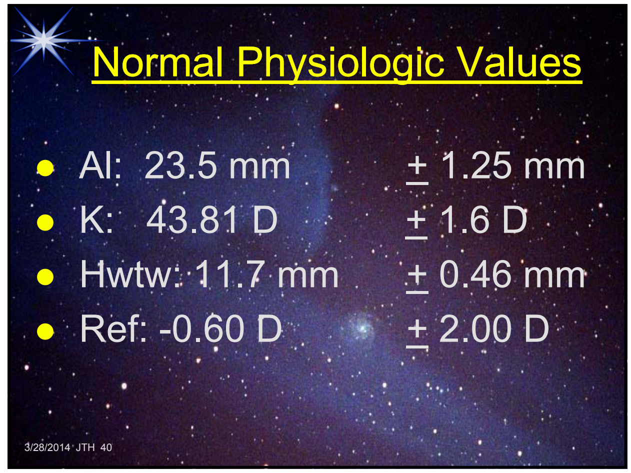

HOLLADAY-GODWIN
CORNEA GAUGE
ASICO # AE 1576
3/28/2014 JTH 33

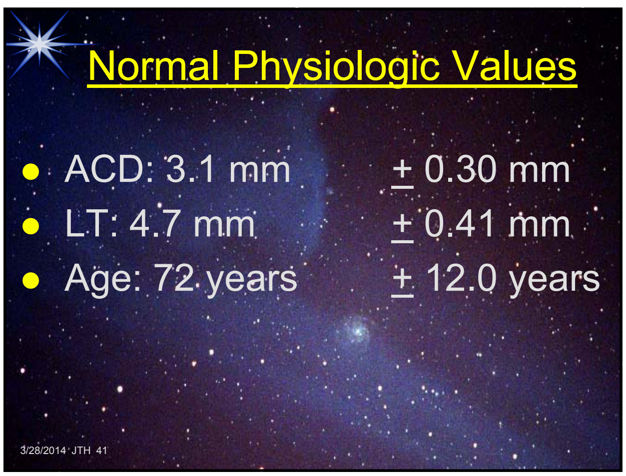

3/28/2014 JTH 34
ASICO # AE 1576

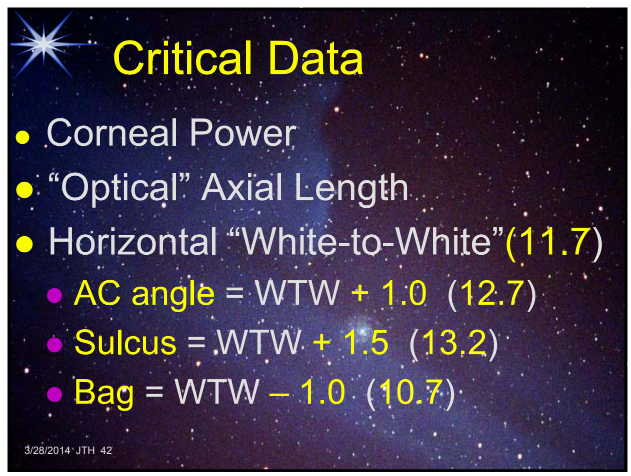

Normal Eyes
# of Cases
1000
800
600
400
200
0
N = 824
96%
2%
2%
Small
Normal
Large
Anterior Segment Size
3/28/2014 JTH 37

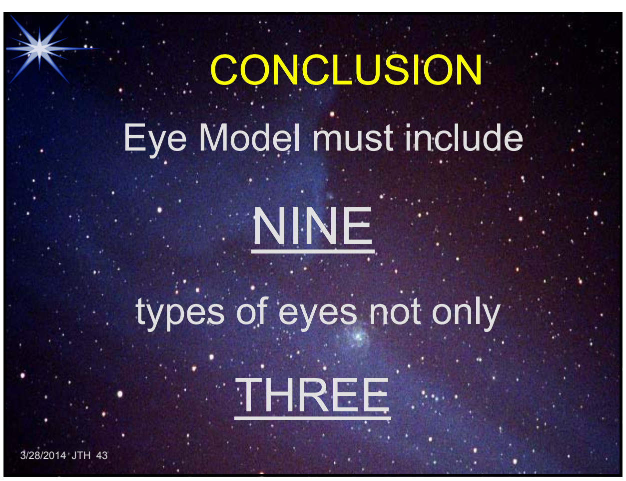

Short Eyes (< 21 mm)
# of Cases
80
60
40
20
0
80%
N = 93
20%
0%
Small
Normal
Large
Anterior Segment Size
3/28/2014 JTH 38

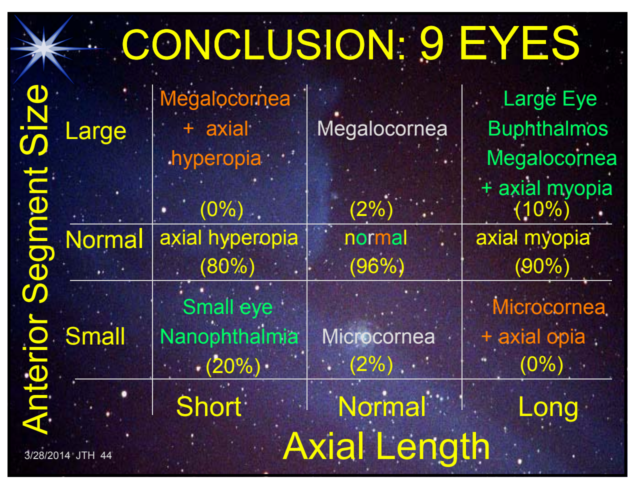

Long Eyes (> 27 mm)
# of Cases
80
60
40
20
0
N = 162
90%
0%
10%
Small
Normal
Large
Anterior Segment Size
3/28/2014 JTH 39


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
3/28/2014 JTH 40


Normal Physiologic Values
ACD: 3.1 mm ± 0.30 mm
LT: 4.7 mm ± 0.41 mm
Age: 72 years ± 12.0 years
3/28/2014 JTH 41


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)
3/28/2014 JTH 42


CONCLUSION
Eye Model must include
NINE
types of eyes not only
THREE
3/28/2014 JTH 43


CONCLUSION: 9 EYES
Anterior Segment Size
Large
Megalocornea + axial hyperopia (0%)
Megalocornea (2%)
Large Eye Buphthalmos Megalocornea + axial myopia (10%)
Normal
axial hyperopia (80%)
normal (96%)
axial myopia (90%)
Small
Small eye Nanophthalmia (20%)
Microcornea (2%)
Microcornea + axial opia (0%)
Short
Normal
Long
Axial Length
3/28/2014 JTH 44

Relative Importance of Predictors for ELP

❶ Axial Length	100
❷ Average K	76
❸ Horizontal WTW	24
❹ Refraction	18
❺ ACD	8
❻ LT	7
❼ Age	1

3/28/2014 JTH 45

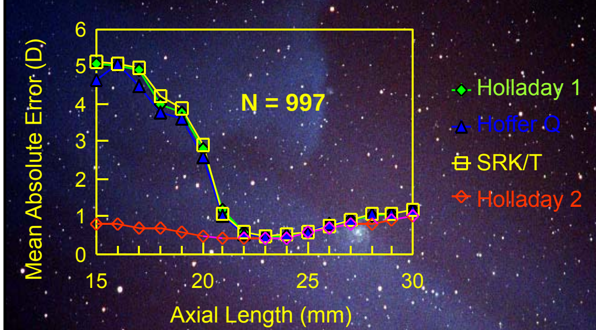
THE HOLLADAY 2 FORMULA

More Measurements

More Accuracy

3/28/2014 JTH 47

FORMULA PERFORMANCE



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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

3/28/2014 JTH 52

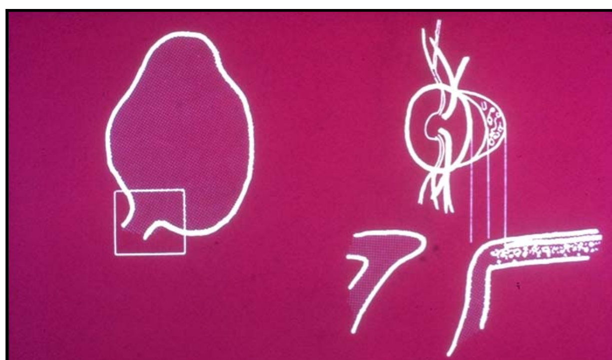

Fig. 8-1. Myopic conus.

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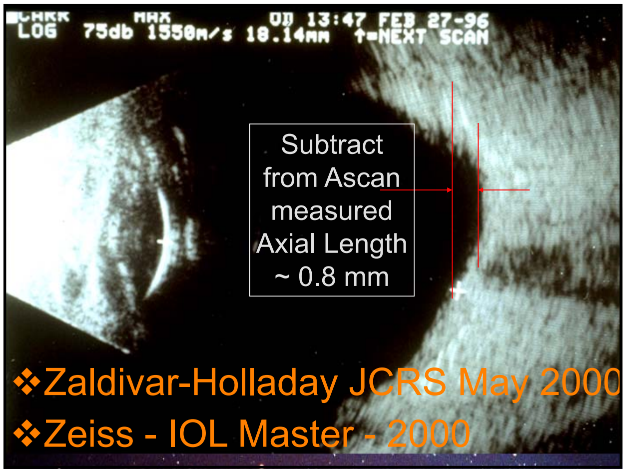
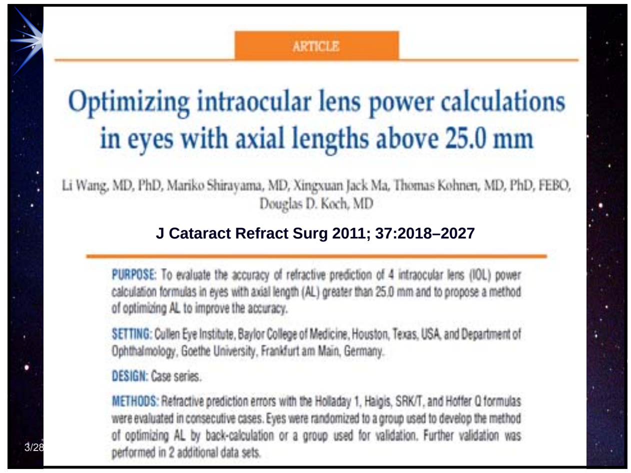



ARTICLE

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

Li Wang, MD, PhD, Mariko Shirayama, MD, Xingxuan Jack Ma, Thomas Kohnen, MD, PhD, FEBO, Douglas D. Koch, MD

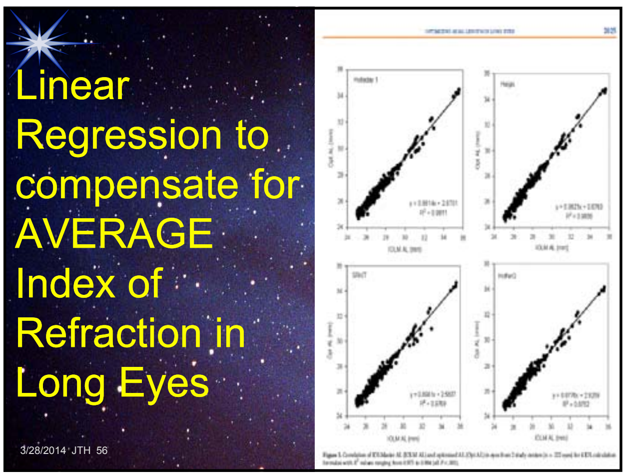
J Cataract Refract Surg 2011; 37:2018–2027

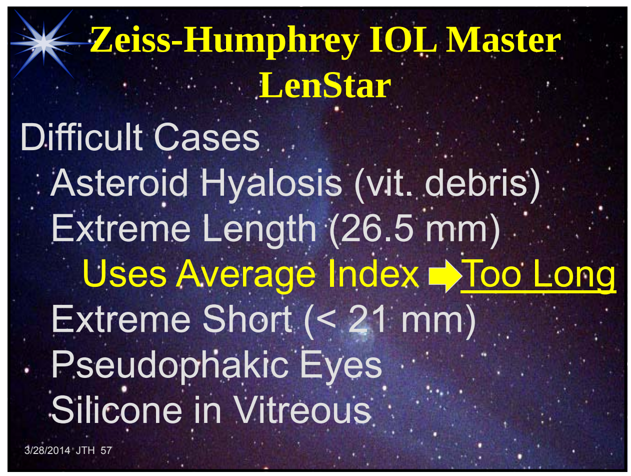
PURPOSE: To evaluate the accuracy of refractive prediction of 4 intraocular lens (IOL) power calculation formulas in eyes with axial length (AL) greater than 25.0 mm and to propose a method of optimizing AL to improve the accuracy.

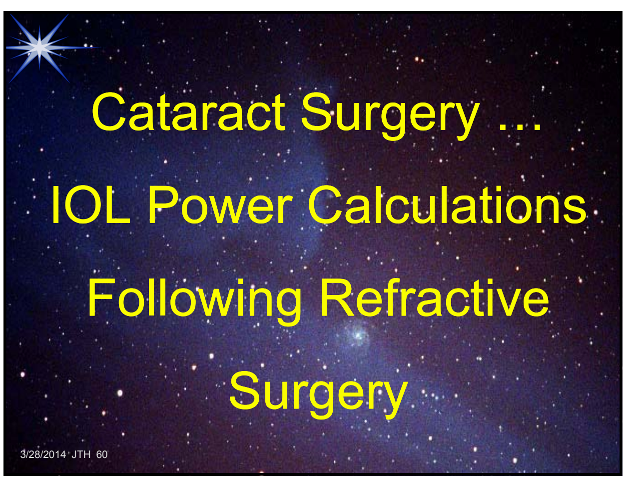
SETTING: Cullen Eye Institute, Baylor College of Medicine, Houston, Texas, USA, and Department of Ophthalmology, Goethe University, Frankfurt am Main, Germany.

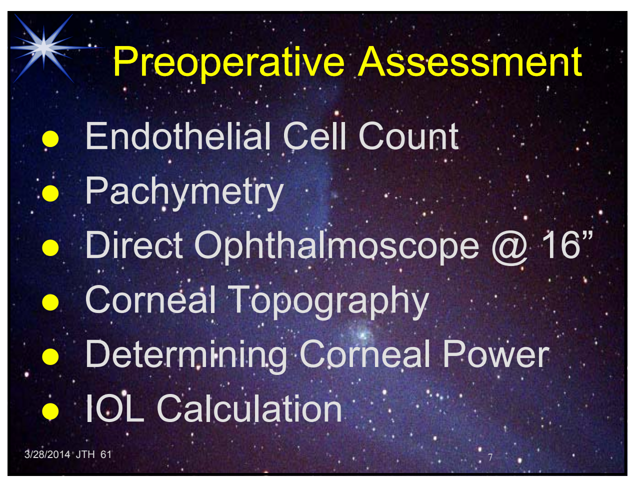
DESIGN: Case series.

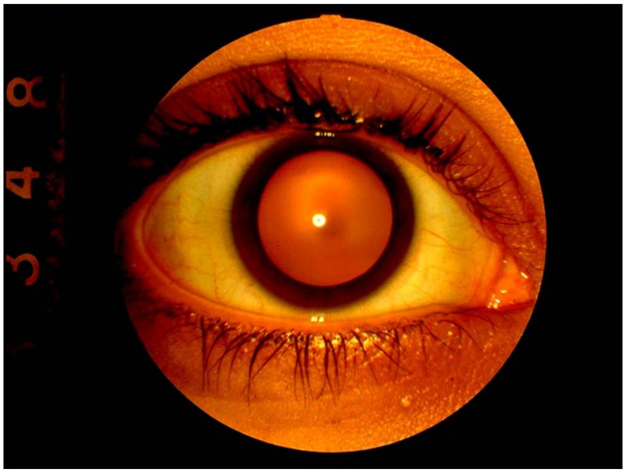
METHODS: Refractive prediction errors with the Holladay 1, Haigis, SRK/T, and Hoffer Q formulas were evaluated in consecutive cases. Eyes were randomized to a group used to develop the method of optimizing AL by back-calculation or a group used for validation. Further validation was performed in 2 additional data sets.

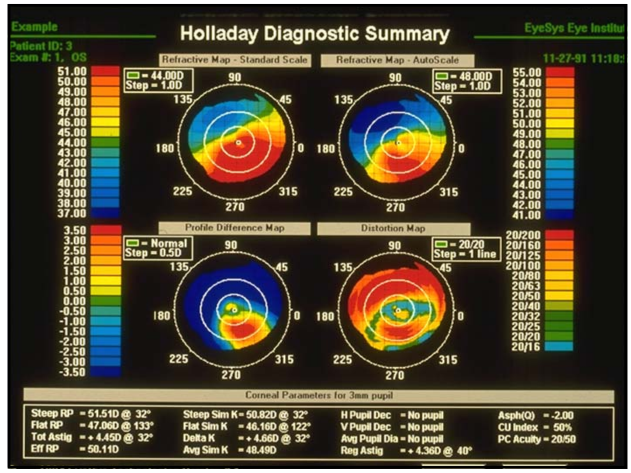




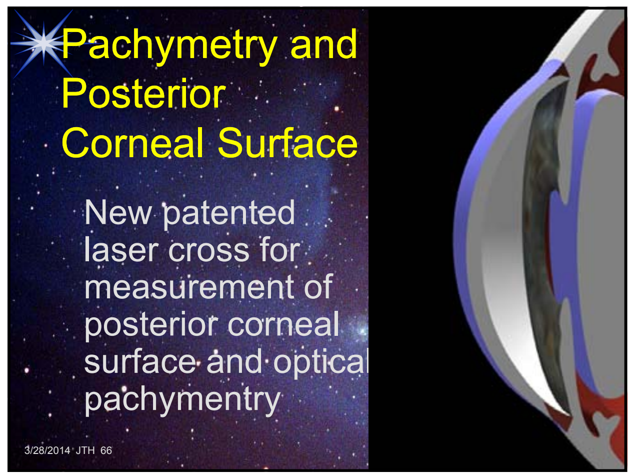


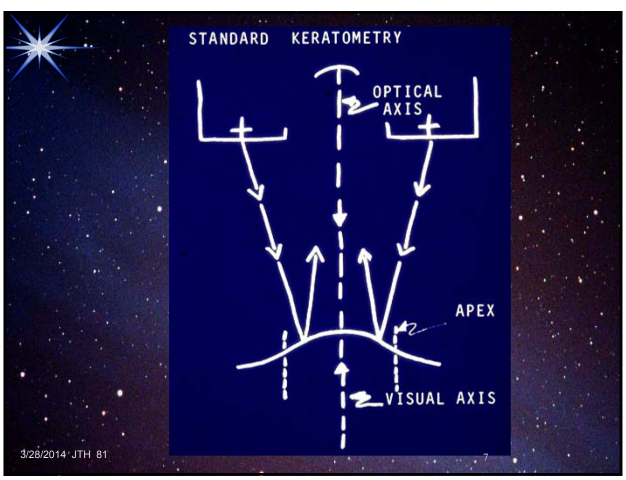


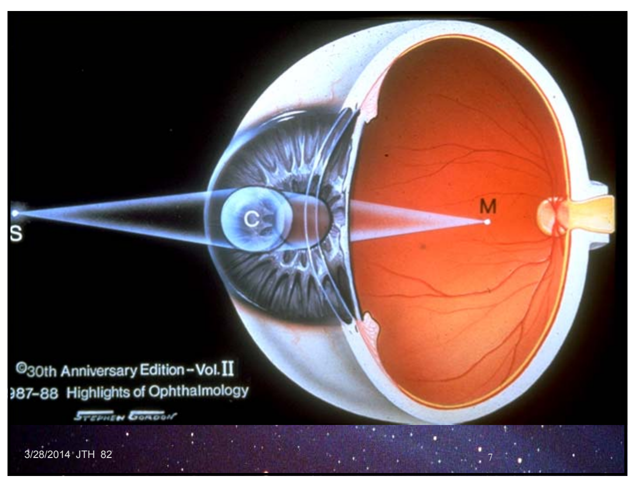



Holladay Diagnostic Summary
Refractive Map - Standard Scale
Refractive Map - AutoScale
Profile Difference Map
Distortion Map
Corneal Parameters for 3mm pupil


Corneal Power after LASIK, PRK, RK
❶ Ideally, Calculation from both surfaces …
❷ Calculation from Prior Data Trial
❸ Hard Contact Lens
❹ Corneal Topography
❺ Automated Keratometry
❻ Manual Keratometry
3/28/2014 JTH 64


Pachymetry and Posterior Corneal Surface
New patented laser cross for measurement of posterior corneal surface and optical pachymentry
3/28/2014 JTH 66


STANDARD KERATOMETRY
OPTICAL AXIS
APEX
VISUAL AXIS
3/28/2014 JTH 81


S
C
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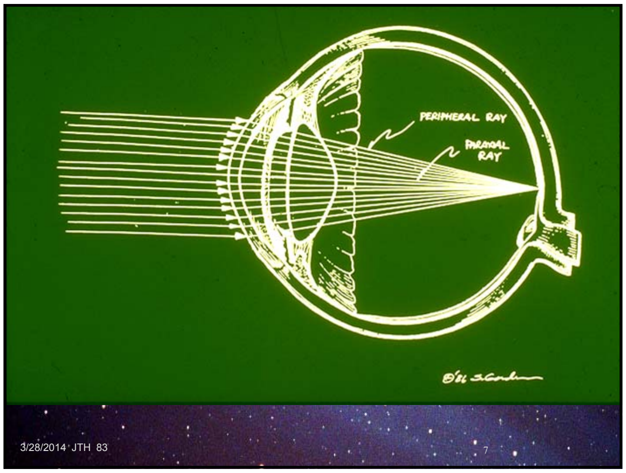
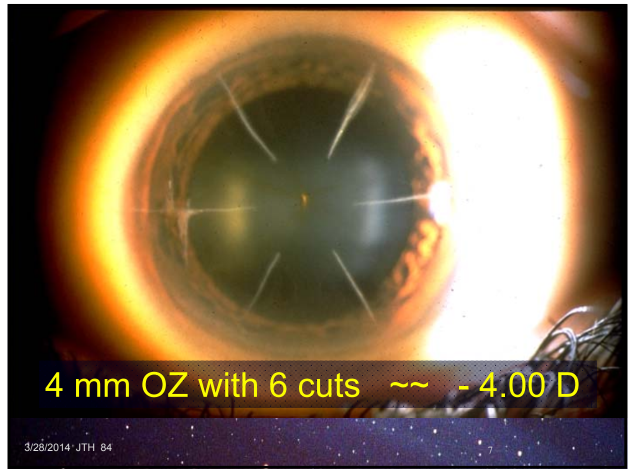
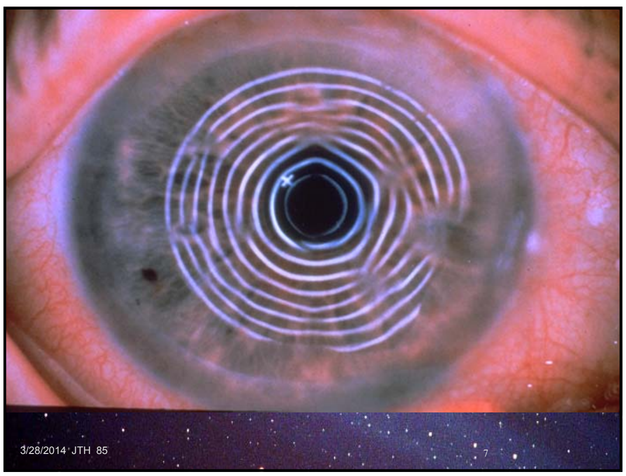
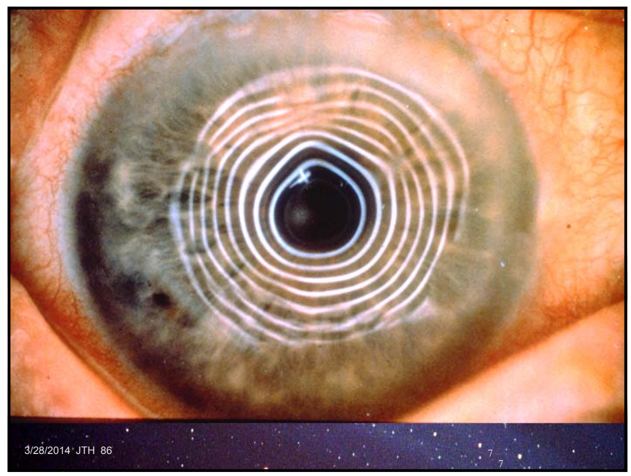
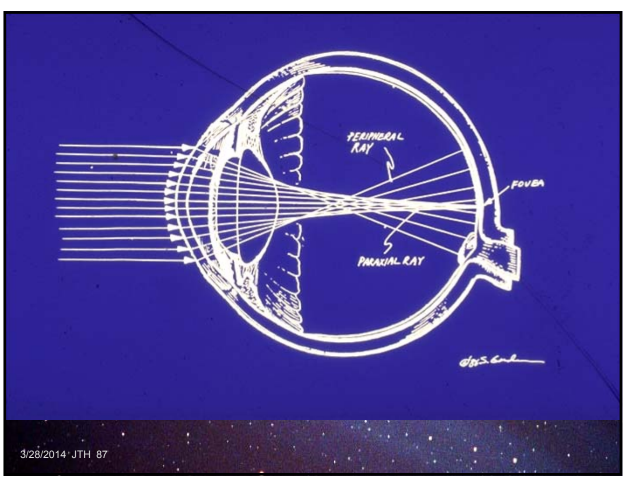
987–88 Highlights of Ophthalmology
3/28/2014 JTH 82

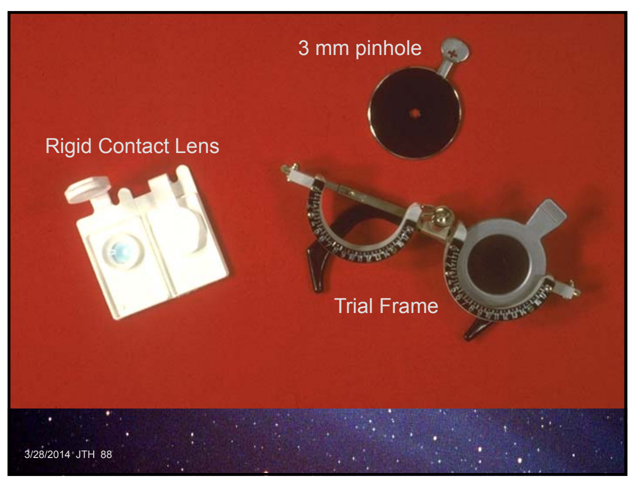

PERIPHERAL RAY
PARAXIAL RAY
3/28/2014 JTH 83

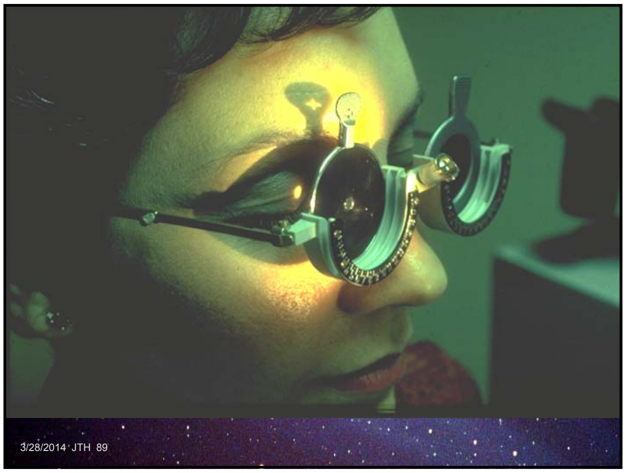

4 mm OZ with 6 cuts ~~ - 4.00 D
3/28/2014 JTH 84

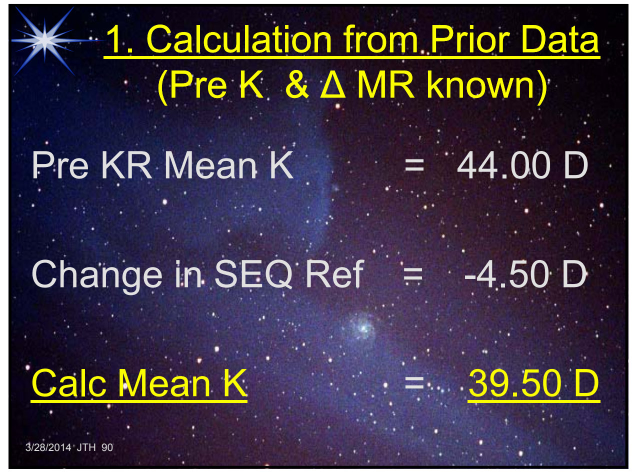

3/28/2014 JTH 85

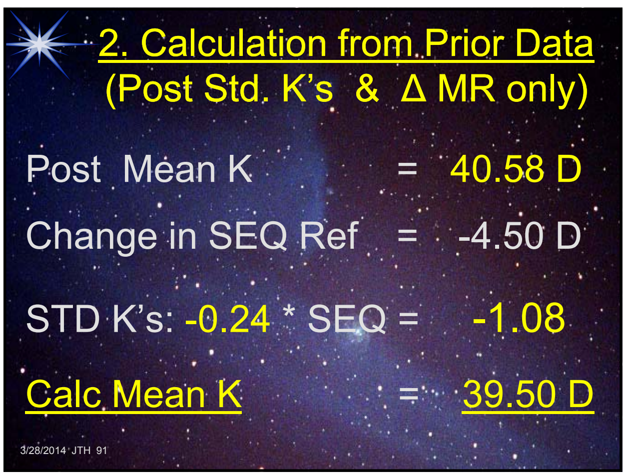

3/28/2014 JTH 86

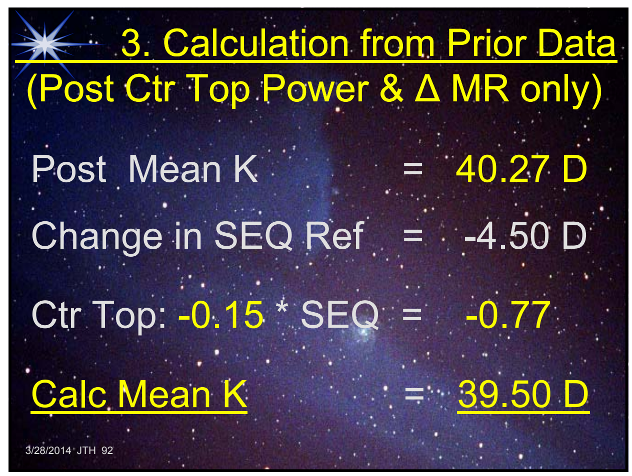

PERIPHERAL RAY
FOVEA
PARAXIAL RAY
3/28/2014 JTH 87

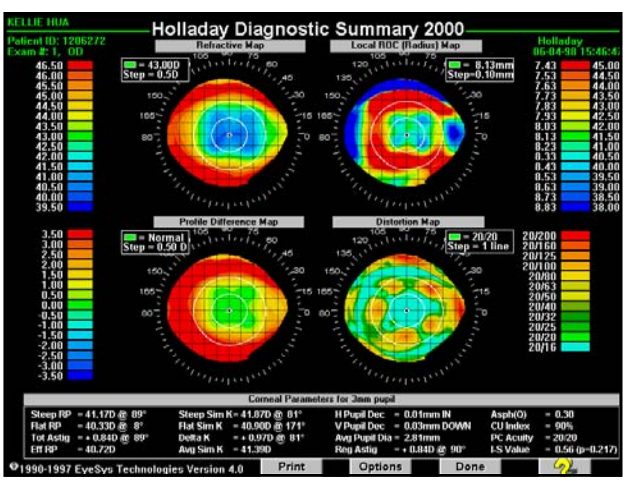

3 mm pinhole
Rigid Contact Lens
Trial Frame
3/28/2014 JTH 88

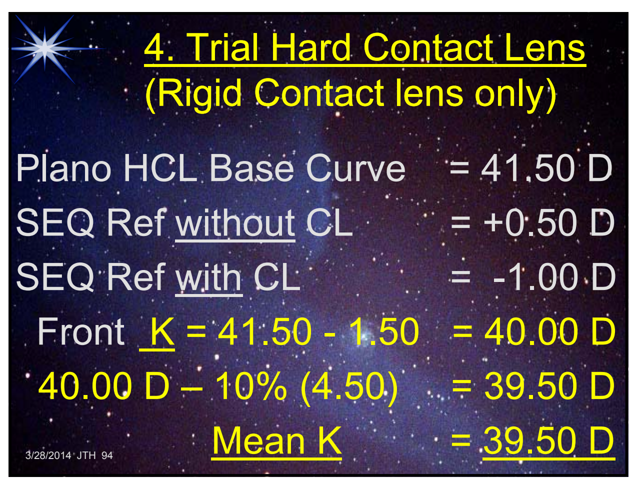

3/28/2014 JTH 89

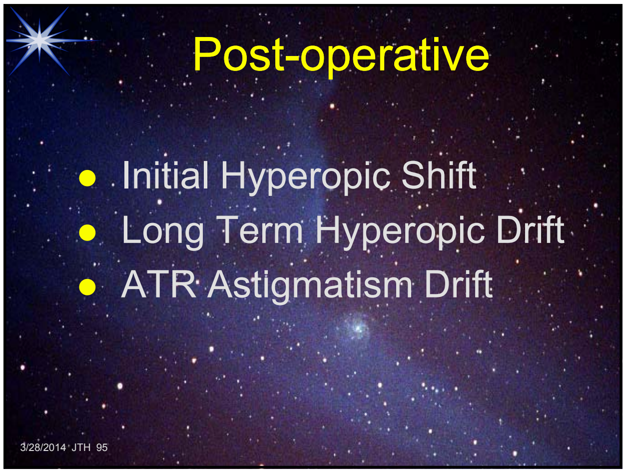

1. Calculation from Prior Data
(Pre K & Δ MR known)
Pre KR Mean K = 44.00 D
Change in SEQ Ref = -4.50 D
Calc Mean K = 39.50 D
3/28/2014 JTH 90

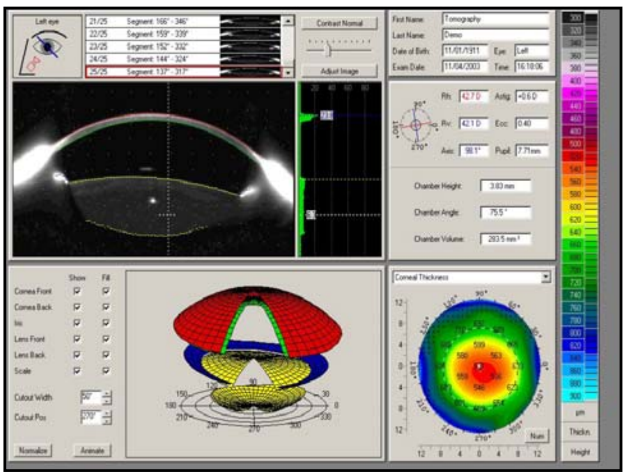

2. Calculation from Prior Data
(Post Std. K's & Δ MR only)
Post Mean K = 40.58 D
Change in SEQ Ref = -4.50 D
STD K's: -0.24 * SEQ = -1.08
Calc Mean K = 39.50 D
3/28/2014 JTH 91

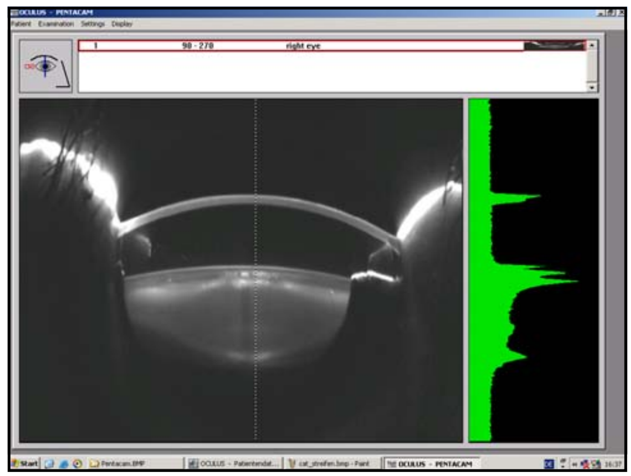

3. Calculation from Prior Data
(Post Ctr Top Power & Δ MR only)
Post Mean K = 40.27 D
Change in SEQ Ref = -4.50 D
Ctr Top: -0.15 * SEQ = -0.77
Calc Mean K = 39.50 D
3/28/2014 JTH 92

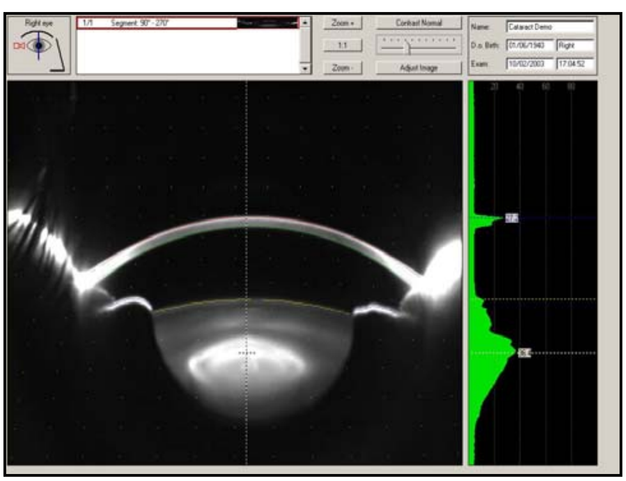

Holladay Diagnostic Summary 2000
Refractive Map
Local ROC (Radius) Map
Profile Difference Map
Distortion Map
Corneal Parameters for 3mm pupil
Print
Options
Done

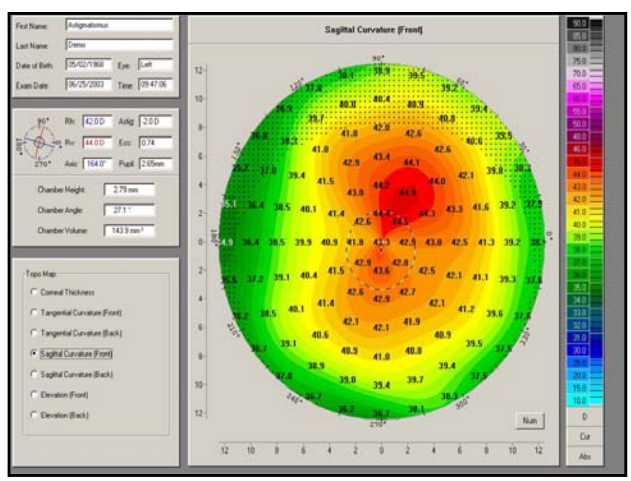

4. Trial Hard Contact Lens
(Rigid Contact lens only)
Plano HCL Base Curve = 41.50 D
SEQ Ref without CL = +0.50 D
SEQ Ref with CL = -1.00 D
Front K = 41.50 - 1.50 = 40.00 D
40.00 D – 10% (4.50) = 39.50 D
Mean K = 39.50 D
3/28/2014 JTH 94

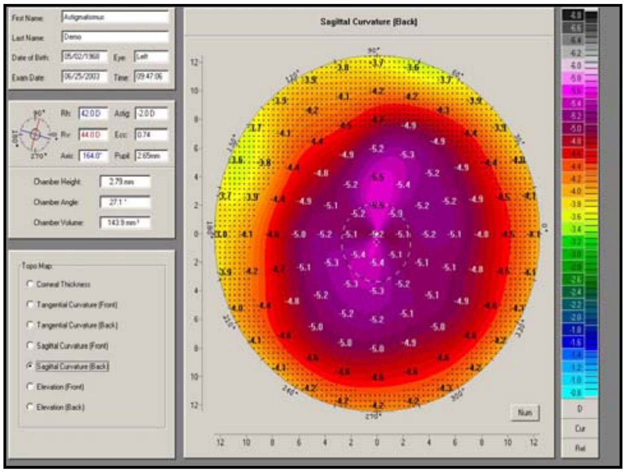

Post-operative
Initial Hyperopic Shift
Long Term Hyperopic Drift
ATR Astigmatism Drift
3/28/2014 JTH 95









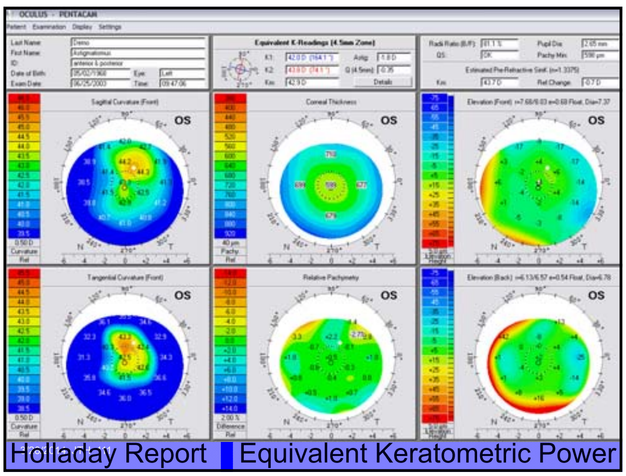


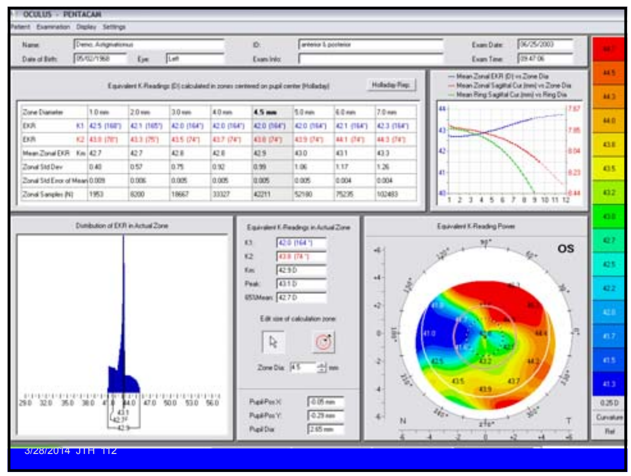
Accuracy of EKR

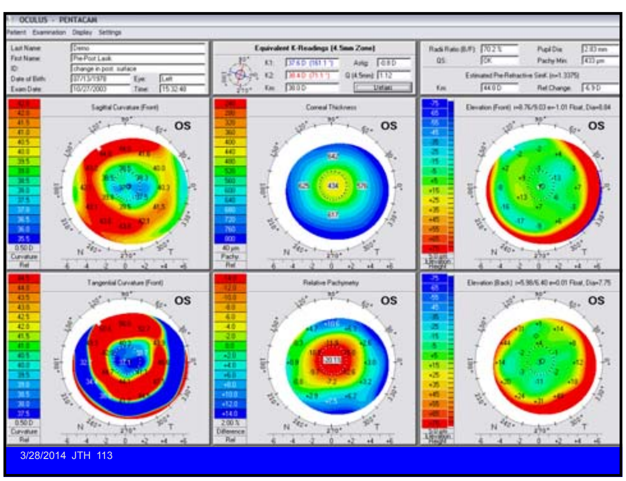
Prior Sx	STD 4.5 (D)
LASIK	0.56
RK	0.94

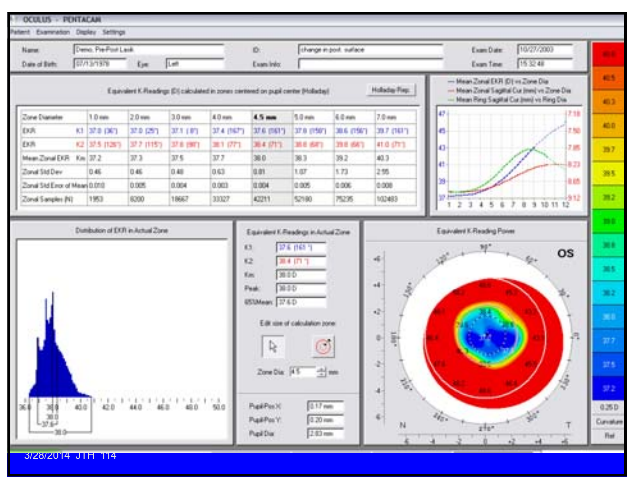
Holladay JT, Hill WE, Steinmueller A. Corneal Power Measurements Using Scheimpfl ug Imaging in Eyes With Prior Corneal Refractive Surgery. J Refractive Surgery 2009:25:862-868. (October 2009 Issue of J Refr Surgery)

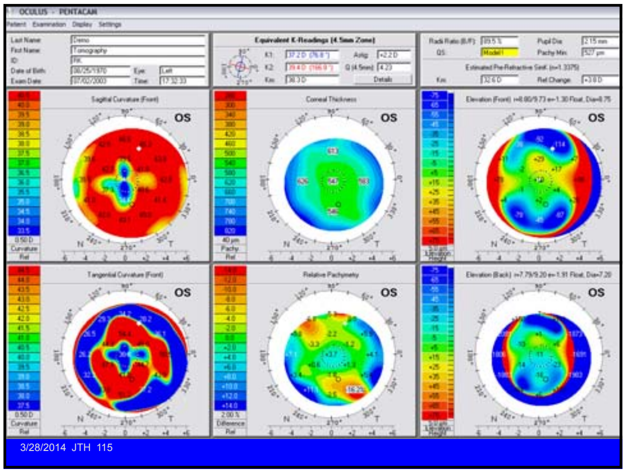
3/28/2014 JTH 106

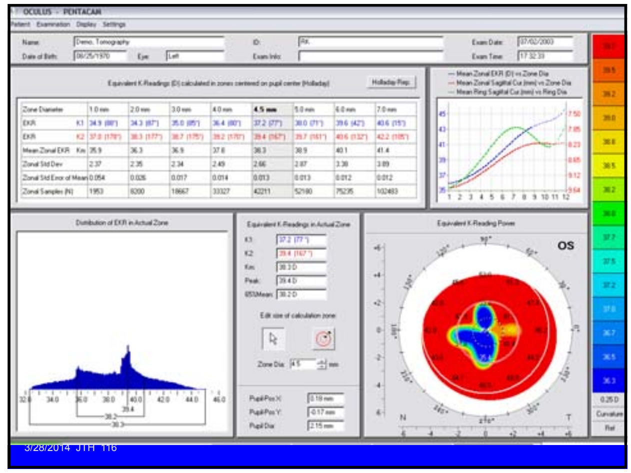


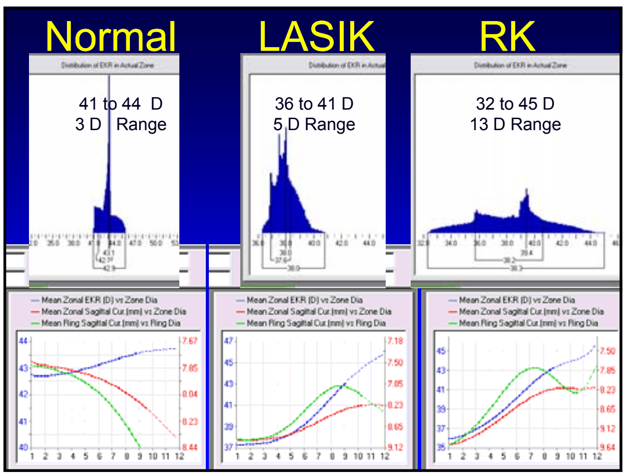












Summary

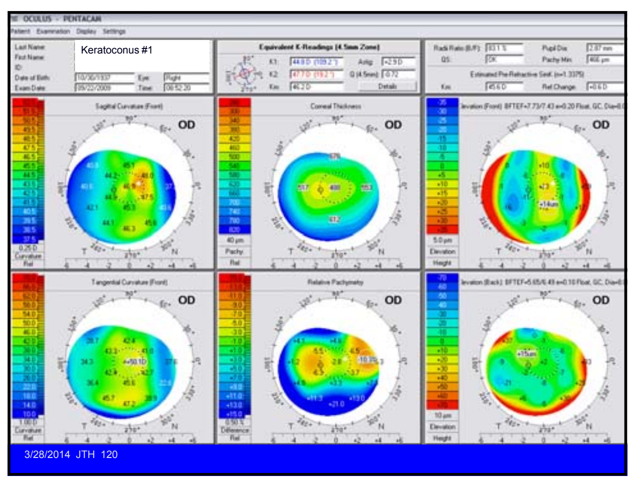
- Optimal Zone
  - LASIK: 4.5 mm
  - RK: 5.0 mm
  - Customize for small/large pupils
- Accuracy
  - LASIK: ± 0.56 D
  - RK: ± 0.94 D
- Error on MYOPIC side

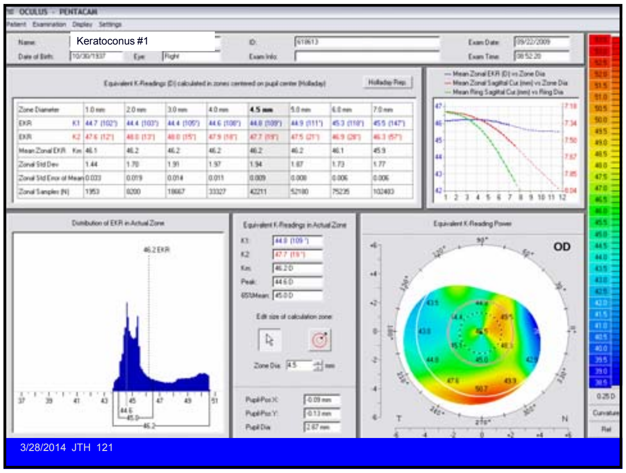
3/28/2014 JTH 118

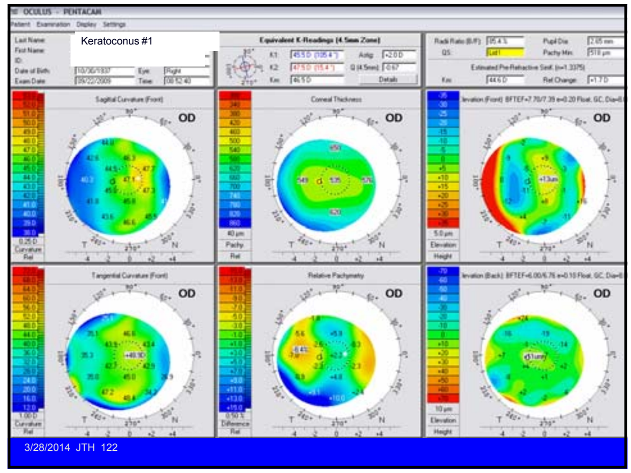
IOL CALCS in Keratoconus

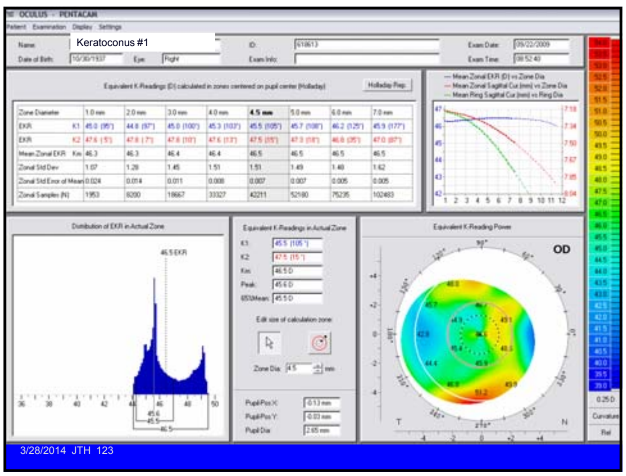
- Corneal is Bifocal
- Patient does not look through cone for distance (may use at 10 cm as magnifier
- Look at Power Distribution
- Use Paracentral Power (65% Mean Power)

3/28/2014 JTH 119









Keratoconus Calculation #1 OS

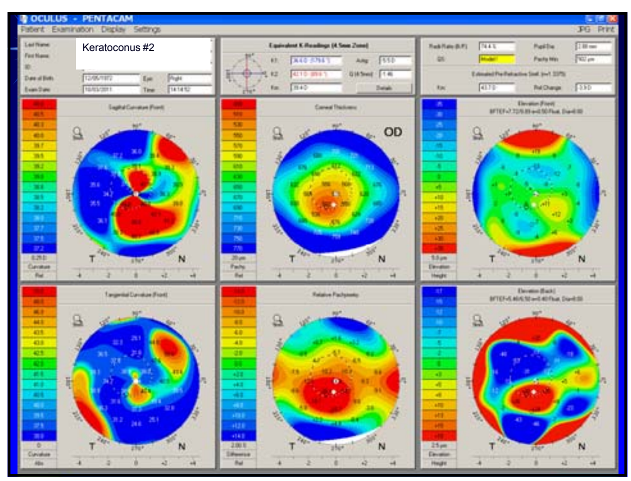
- Used Km = 46.5 D => +1.00 D
- Should have used 65% Mean
  - 45.5 D => plano
  - should have targeted -0.50 D (-0.50 always better than +0.50)

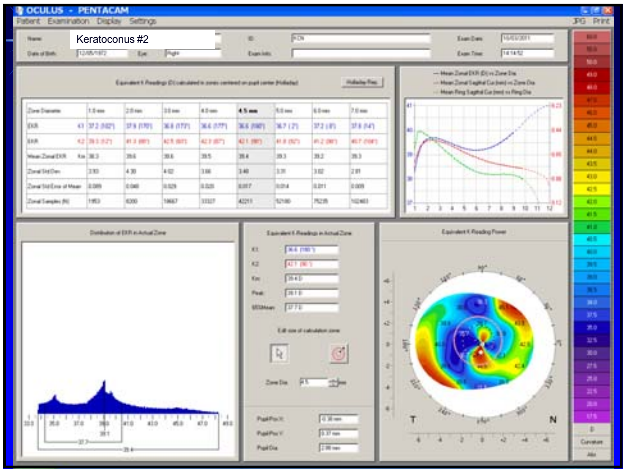
3/28/2014 JTH 124

Keratoconus Calculation #2

Dear Dr. Holladay,
> Will you please review this case and give me some insight. A KKC with Intacs patient undewent ECCE/IOL the doc targeted -4.OO so as to not make him anisometropic. I used the Pentacam 3.0mm zone EKR and the Holladay II formula. The patient came out PI -0.75x 135= 20/30! UCVA = 20/40. Patient is very very happy. But, this was an unintended outcome. How does one measure the central corneal power in an Intacs pt?. Can you determine the cause of this outcome?. It appears that the cornea must be flatter than what the instruments measured? Is that a correct assumption. The suggested IOL power was 26.0D. for a target 0f -4.00. When I click the keratoconous box (after the fact) for the same target the suggested IOL power was 27.50.?????? What should I have done differently!
>
> Please Advise! THANK YOU 1000x
> Yvonne

3/28/2014 JTH 125





Keratoconus Calculation #2

- Used Km = 39.60 D => Plano, but targeted for -4.00 D
- Should have used 65% Mean
  - 37.7 D => +2.00 D
  - If had ✓ KKC => +0.50 D

(not ✓ will use steeper K to size eye)

3/28/2014 JTH 128

Keratoconus Case #3

- Dear Dr. Holladay,

I am so pleased and excited to tell you about a very successful outcome involving IOL calcs on KCN patient and the assistance Holladay distribution scale on the Pentacam. I thought you might find this case interesting and gratifying at the least.

Pre Op Refraction: +5.75 -8.00x 075= 20/40 IOLM ks 47/54.17 x 91

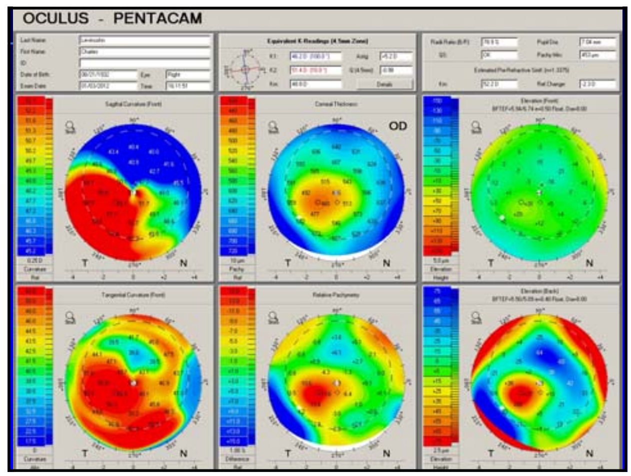
1wk Post-Op Refraction : -0.50-3.25X65 = 20/50 The surgeon placed a temporal suture. Will this 1 suture significantly impact the astigmatism?

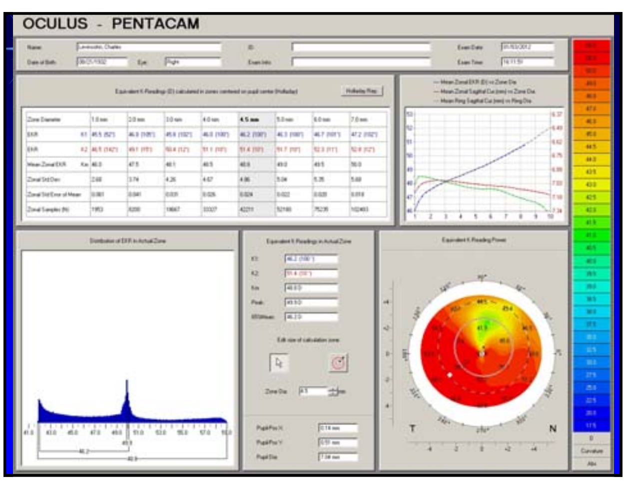
I ran IOL calcs based on instructions you gave me on a similar case ,previously. You instructed me to use the Ks from a paracentral region derived from the EKR Distribution scale on Holladay report. I used the Ks from the smaller peak which I approximated to be about 44D. With those Ks and Holladay consultant we obtained the above results. I think this case demonstrates the invaluable utility of the Holldaday report when calculating IOL power in pts with KCN.

I attached the screenshots of Pentacam and IOL calcs. The technician who perfromed the IOL Master was unable to get ACD with IOLM and failed to get ACD with Immersion ultrasound- thats the reason that field is blank.

Yvonne

3/28/2014 JTH 129





Keratoconus Calculation

- K_{mean} = 48.8 D
- Used 44 D => SEQ = -2.12 D

  (-0.50-3.25X65 = 20/50)
- 65% mean = 46.2 D => +0.08 D
- Always ✓ KKC
- Use 65% mean K

3/28/2014 JTH 132

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

3/28/2014 JTH 133

Axial Length Measurements

- Phakia AL_{1555}
- Aphakia AL_{1532}
- Pseudophakia
  - PMMA $AL_{1532} + 0.4$
  - Silicone $AL_{1532} - 0.6$
  - Acrylic $AL_{1532} + 0.2$

3/28/2014 JTH 134

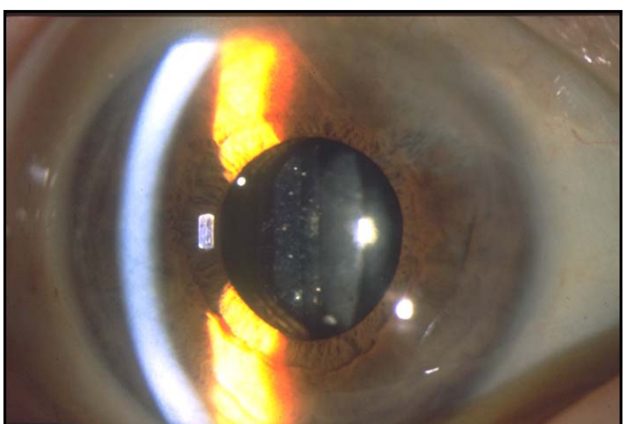
Primary Piggy-Back IOL's

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

3/28/2014 JTH 135

Primary PIGGY-BACK INTRAOCULAR LENSES

3/28/2014 JTH 136

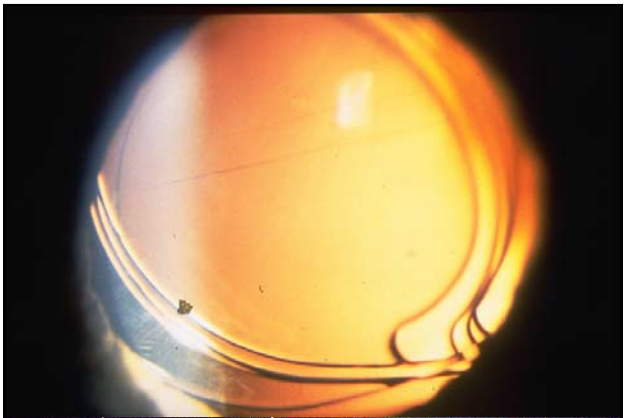


3/28/2014 JTH 137

Polypseudophakia

Up to 4 IOL's

3/28/2014 JTH 138



3/28/2014 JTH 139

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."
Ophthalmology Journal: Vol. 103. July 1996 Blue Journal"

3/28/2014 JTH 144

Primary Piggy-Back Complications

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

Silicone
- Interlenticular membrane
- Flat Spot

3/28/2014 JTH 148

Minimizing Prediction Error

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

3/28/2014 JTH 153

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

3/28/2014 JTH 158

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

3/28/2014 JTH 160

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)

3/28/2014 JTH 161

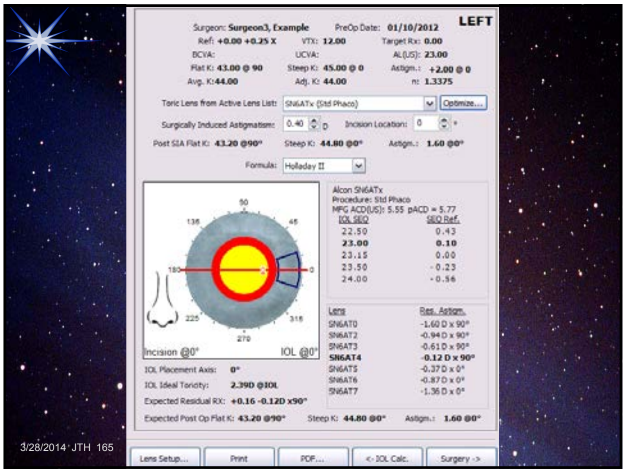
Ratio and Power of IOL Cylinder to Corneal Cylinder

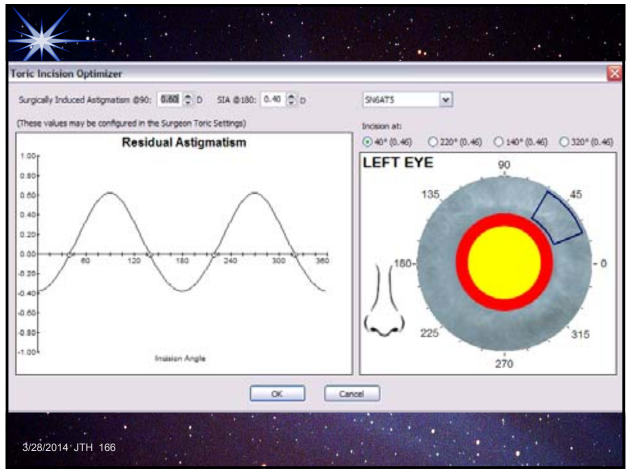
TABLE 1

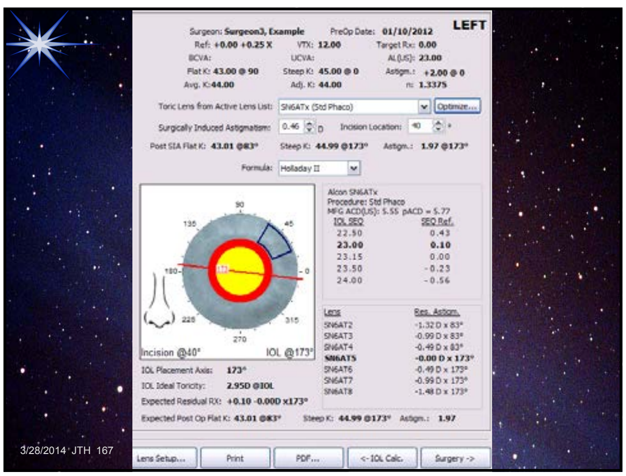
	Effective Lens Position (ELP)					
A-constant—>	116.346	117.203	118.059	118.916	119.773	120.630
Surgeon Factor—>	0.287	0.772	1.257	1.742	2.227	2.713
ELP—>	4.000	4.500	5.000	5.500	6.000	6.500
IOL POWER	*Resulting Ratio of IOL Toricity to 2 D of Corneal Astigmatism*					
10	1.359	1.424	1.494	1.571	1.654	1.745
22	1.277	1.330	1.387	1.450	1.519	1.595
34	1.198	1.239	1.284	1.334	1.390	1.452
46	1.121	1.151	1.185	1.223	1.267	1.316

TABLE 2

	Effective Lens Position (ELP)					
A-constant(D) —>	116.346	117.203	118.059	118.916	119.773	120.630
Surgeon Factor(mm) —>	0.287	0.772	1.257	1.742	2.227	2.713
ELP(mm) —>	4.000	4.500	5.000	5.500	6.000	6.500
IOL POWER	*Required IOL Toricity for 2 D of Corneal Astigmatism*					
10	2.718	2.848	2.988	3.141	3.308	3.490
22	2.554	2.659	2.774	2.900	3.038	3.190
34	2.396	2.477	2.568	2.668	2.780	2.904
46	2.242	2.302	2.369	2.446	2.533	2.631





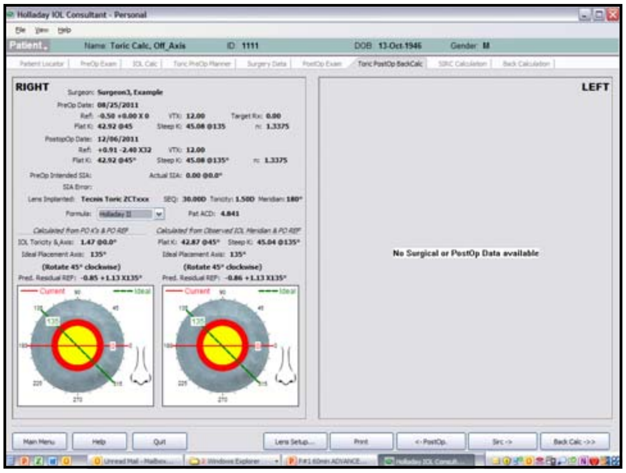


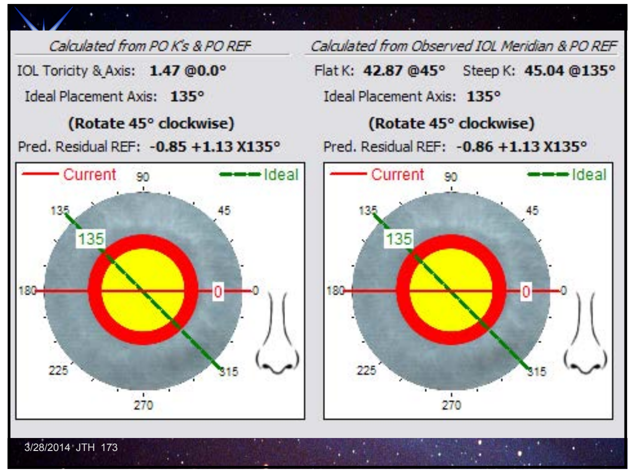
Dioptric Error vs. Angular Error for a 1.00 D of astigmatism

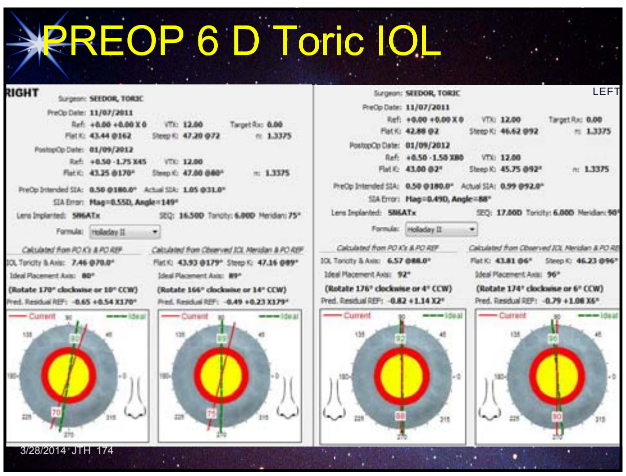
Angle Error (°)	Dioptric Error (D)	% Error
0°	0.00	0%
15°	0.52	52%
30°	1.00	100%
45°	1.41	141%
60°	1.73	173%
75°	1.93	193%
90°	2.00	200%

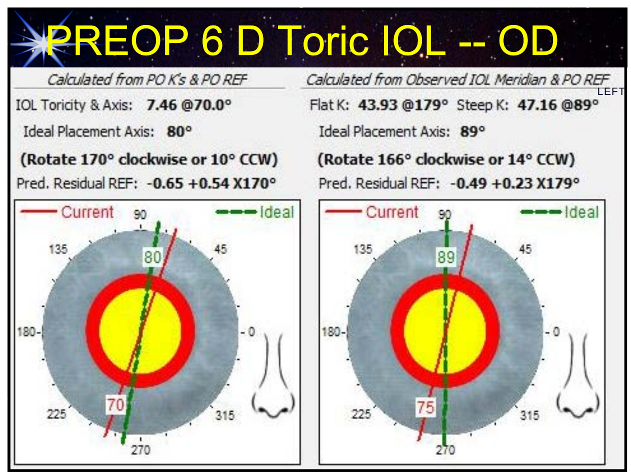
Dioptric Error = 2 * Cyl * sin (angular error)

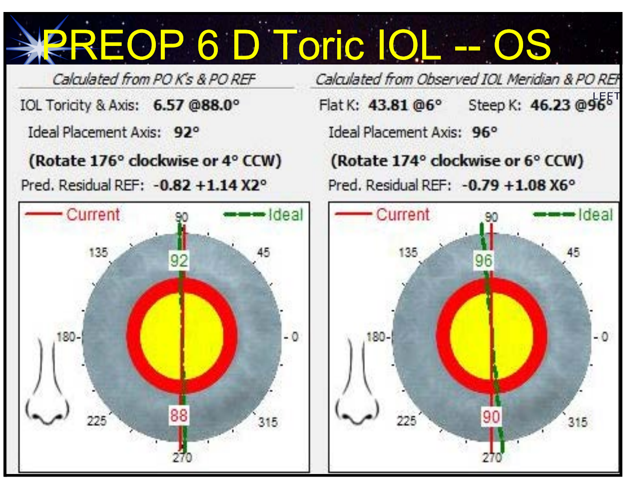
3/28/2014 Jack T. Holladay, M.D. 168

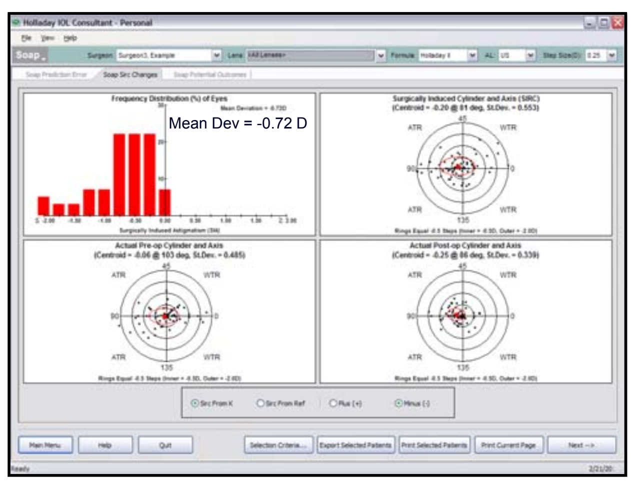

Holladay IOL Consultant - Personal
RIGHT
LEFT
No Surgical or PostOp Data available

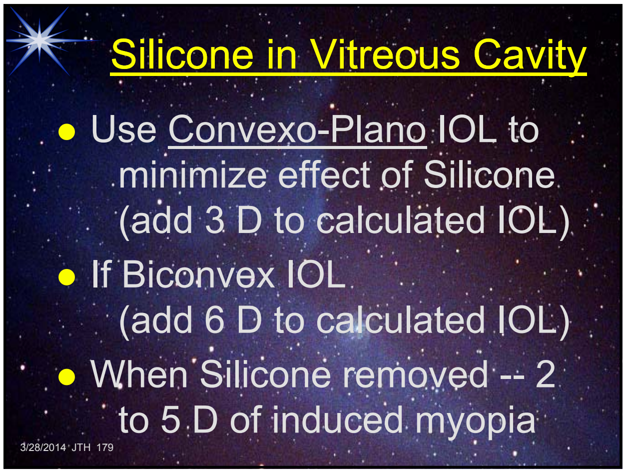

Calculated from PO K's & PO REF
IOL Toricity & Axis: 1.47 @0.0°
Ideal Placement Axis: 135°
(Rotate 45° clockwise)
Pred. Residual REF: -0.85 +1.13 X135°
Calculated from Observed IOL Meridian & PO REF
Flat K: 42.87 @45° Steep K: 45.04 @135°
Ideal Placement Axis: 135°
(Rotate 45° clockwise)
Pred. Residual REF: -0.86 +1.13 X135°
Current
Ideal
3/28/2014 JTH 173

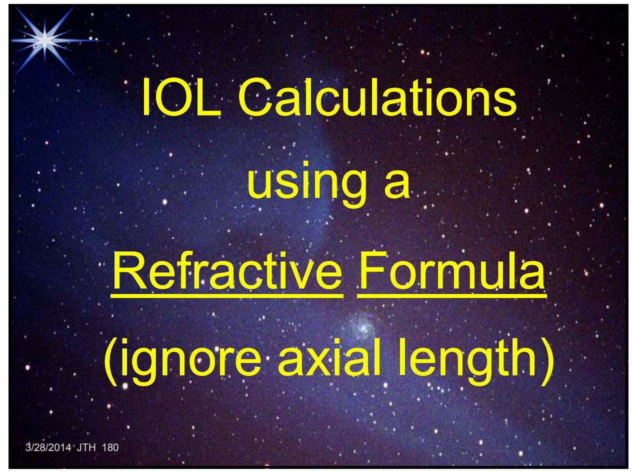

PREOP 6 D Toric IOL
RIGHT
LEFT
3/28/2014 JTH 174

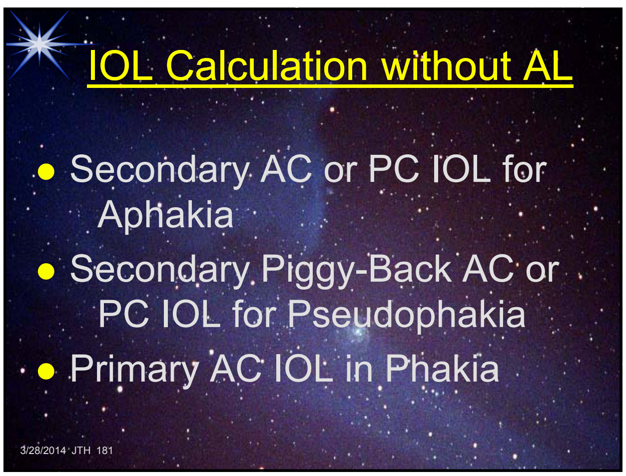

PREOP 6 D Toric IOL -- OD
Calculated from PO K's & PO REF
IOL Toricity & Axis: 7.46 @70.0°
Ideal Placement Axis: 80°
(Rotate 170° clockwise or 10° CCW)
Pred. Residual REF: -0.65 +0.54 X170°
Calculated from Observed IOL Meridian & PO REF
Flat K: 43.93 @179° Steep K: 47.16 @89°
Ideal Placement Axis: 89°
(Rotate 166° clockwise or 14° CCW)
Pred. Residual REF: -0.49 +0.23 X179°
Current
Ideal

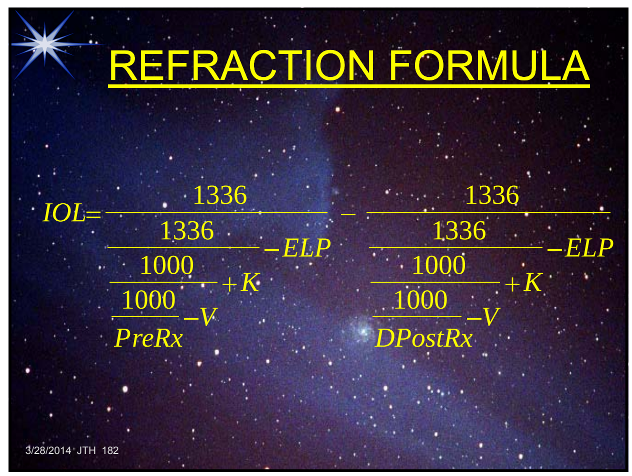

PREOP 6 D Toric IOL -- OS
Calculated from PO K's & PO REF
IOL Toricity & Axis: 6.57 @88.0°
Ideal Placement Axis: 92°
(Rotate 176° clockwise or 4° CCW)
Pred. Residual REF: -0.82 +1.14 X2°
Calculated from Observed IOL Meridian & PO REF
Flat K: 43.81 @6° Steep K: 46.23 @96°
Ideal Placement Axis: 96°
(Rotate 174° clockwise or 6° CCW)
Pred. Residual REF: -0.79 +1.08 X6°
Current
Ideal

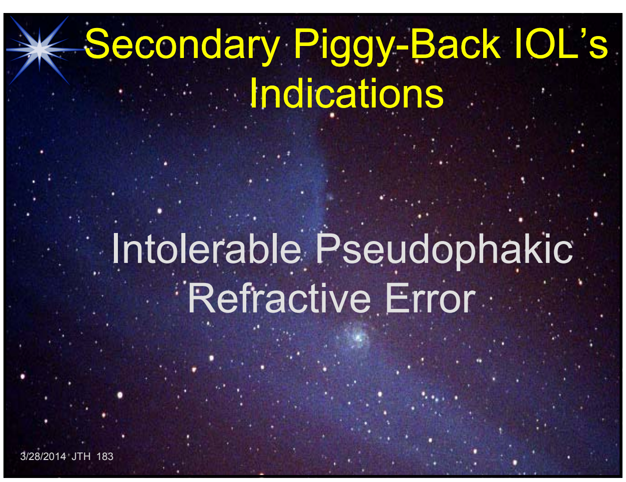

Holladay IOL Consultant - Personal
Mean Dev = -0.72 D


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
3/28/2014 JTH 179


IOL Calculations
using a
Refractive Formula
(ignore axial length)
3/28/2014 JTH 180

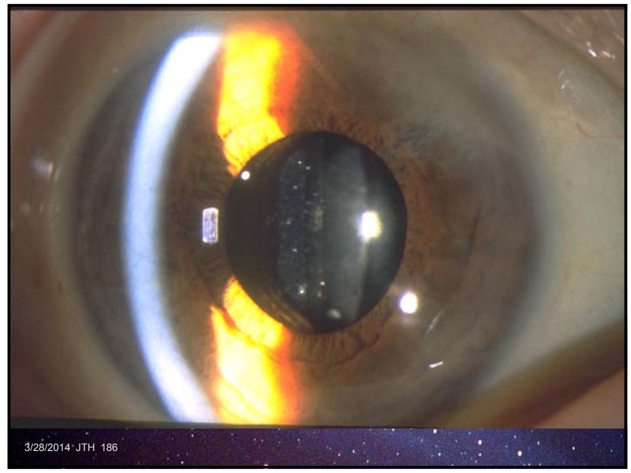

IOL Calculation without AL
Secondary AC or PC IOL for Aphakia
Secondary Piggy-Back AC or PC IOL for Pseudophakia
Primary AC IOL in Phakia
3/28/2014 JTH 181

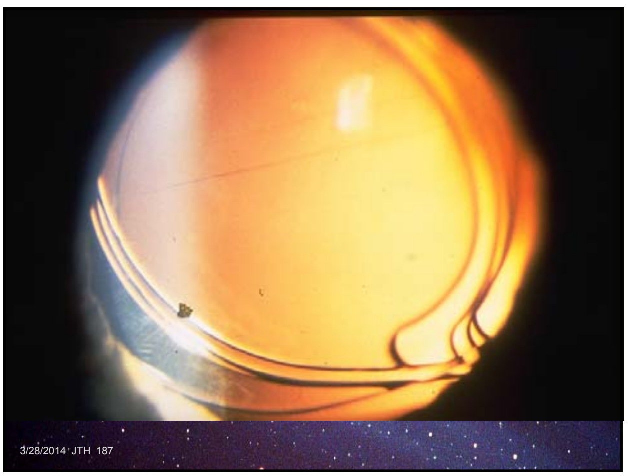

REFRACTION FORMULA
$IOL=\frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{PreRx}-V}+K}-ELP}-\frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{DPostRx}-V}+K}-ELP}$
3/28/2014 JTH 182


Secondary Piggy-Back IOL's Indications
Intolerable Pseudophakic Refractive Error
3/28/2014 JTH 183


Refractive Surprises
❶ Previous RK, PRK, LASIK
❷ Bad axial length - short/long
❸ Mislabeled IOL
❹ Axially displaced
❺ Misc.
3/28/2014 JTH 184

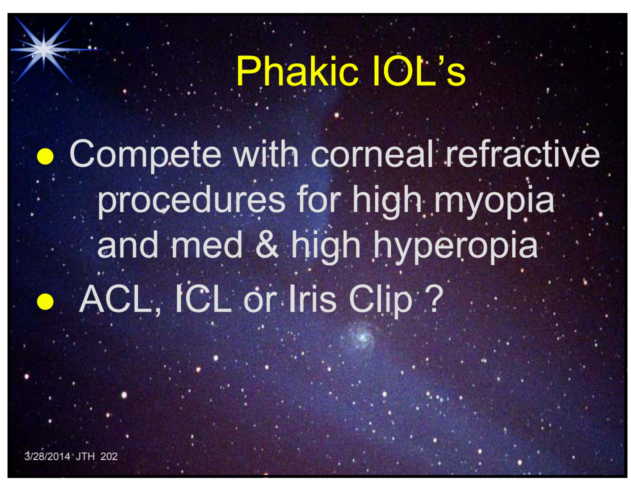

Secondary Piggy-Back Calc
Advantages over Exchange
❶ Mislabeled IOL irrelevant
❷ Less risk to capsule or zonules
❸ Mismeasured AL irrelevant
❹ No AP shift of existing IOL
❺ Fewer unknown variables
3/28/2014 JTH 185

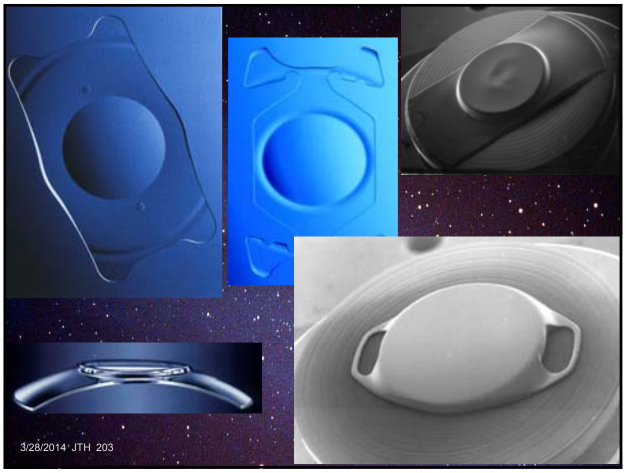

3/28/2014 JTH 186


3/28/2014 JTH 187

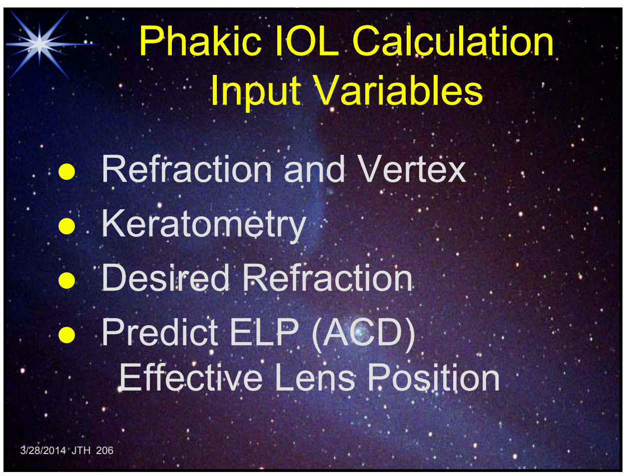

Phakic IOL's

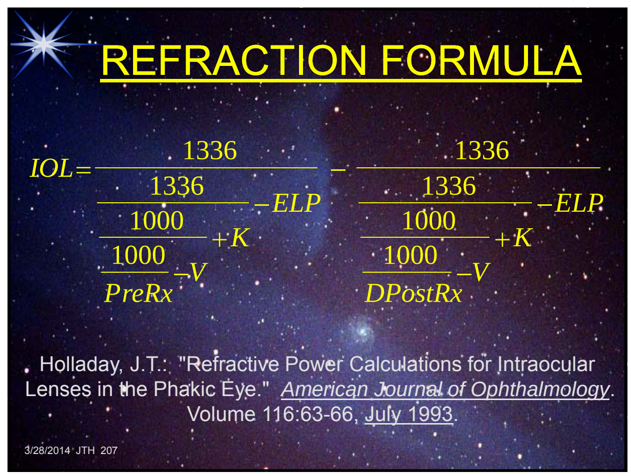

IOL Power Calcs for Phakic IOLs
(2º Piggy-Back & IOL Exchange after
Refractive Surprise)
Jack T. Holladay, MD, MSEE, FACS
Clinical Professor of Ophthalmology
Baylor College of Medicine
Houston, Tx

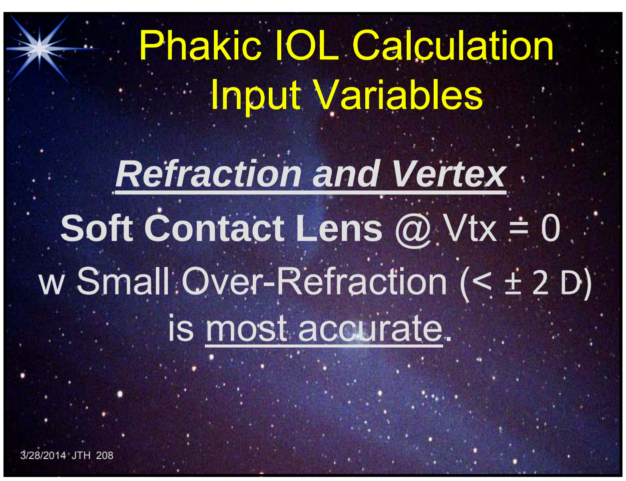

Phakic IOL's
● Compete with corneal refractive procedures for high myopia and med & high hyperopia
● ACL, ICL or Iris Clip ?
3/28/2014 JTH 202

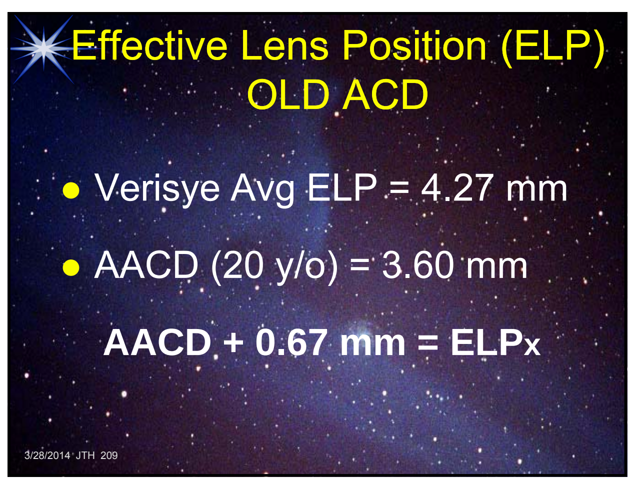

3/28/2014 JTH 203

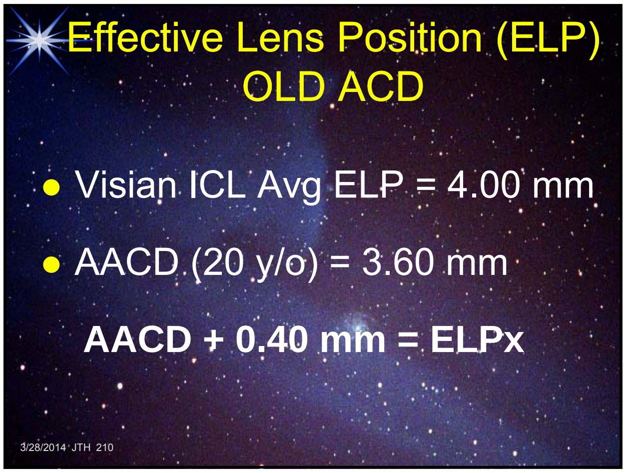

Phakic IOL's
(Secondary Piggy Back IOL's)
Refraction
Formula
3/28/2014 JTH 204


Phakic IOL Calculation
Input Variables
Refraction and Vertex
Keratometry
Desired Refraction
Predict ELP (ACD)
Effective Lens Position
3/28/2014 JTH 206


REFRACTION FORMULA
$$IOL=\frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{PreRx}-V}+K}-ELP}-\frac{1336}{\frac{1336}{\frac{1000}{\frac{1000}{DPostRx}-V}+K}-ELP}$$
Holladay, J.T.: "Refractive Power Calculations for Intraocular Lenses in the Phakic Eye." American Journal of Ophthalmology. Volume 116:63-66, July 1993.
3/28/2014 JTH 207


Phakic IOL Calculation
Input Variables
Refraction and Vertex
Soft Contact Lens @ Vtx = 0
w Small Over-Refraction (< ± 2 D)
is most accurate.
3/28/2014 JTH 208


Effective Lens Position (ELP)
OLD ACD
Verisye Avg ELP = 4.27 mm
AACD (20 y/o) = 3.60 mm
AACD + 0.67 mm = ELPx
3/28/2014 JTH 209



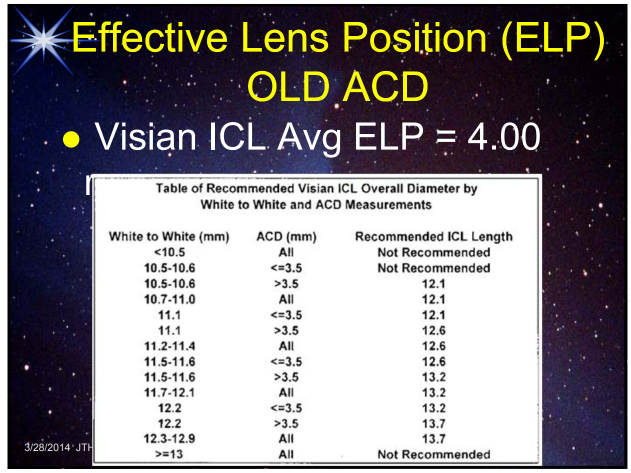
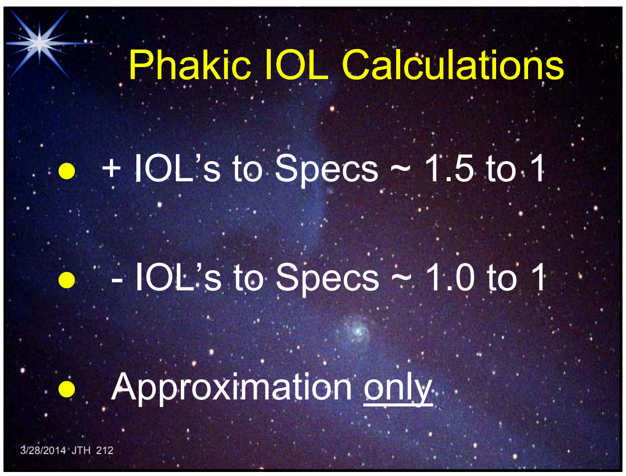
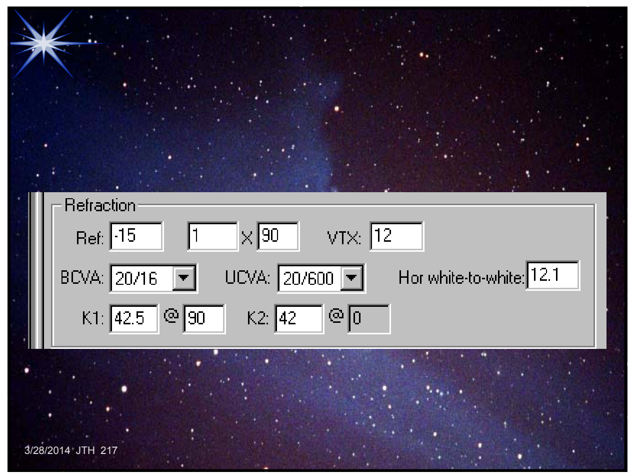
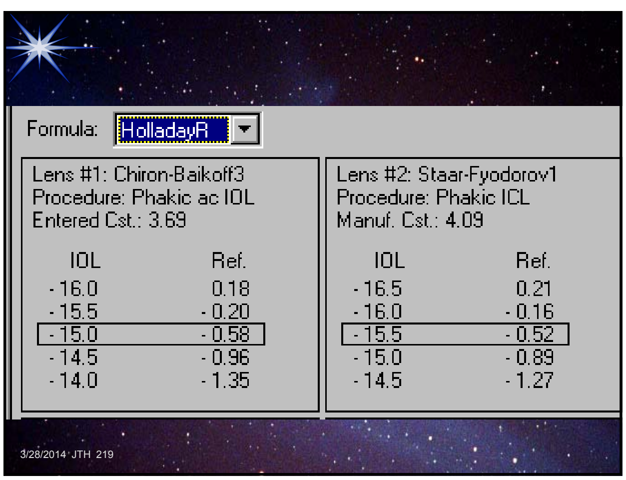


Table of Recommended Visian ICL Overall Diameter by White to White and ACD Measurements

White to White (mm)	ACD (mm)	Recommended ICL Length
<10.5	All	Not Recommended
10.5-10.6	<=3.5	Not Recommended
10.5-10.6	>3.5	12.1
10.7-11.0	All	12.1
11.1	<=3.5	12.1
11.1	>3.5	12.6
11.2-11.4	All	12.6
11.5-11.6	<=3.5	12.6
11.5-11.6	>3.5	13.2
11.7-12.1	All	13.2
12.2	<=3.5	13.2
12.2	>3.5	13.7
12.3-12.9	All	13.7
>=13	All	Not Recommended







Pediatric IOL Calculations

- Ideal Refraction: plano to -1 D
- Expect average of 4 D myopic shift from age 2 to 20
- Much easier to correct myopia at age 20 than amblyopia

3/28/2014 JTH 223

Minimizing Prediction Error

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

3/28/2014 JTH 224

Surgically Induced Refractive Change SIRC

- From Keratometry
  - Cataract & Clear Lensectomy
  - Keratorefractive Sx.
- From Refraction
  - Keratorefractive Sx.

3/28/2014 JTH 225

Outcome Analysis

- Prediction Error (50% < 0.50 D)
- Formula Comparisons
- Induced Astigmastism (SIRC)
- Visual Acuity
  - Best Corrected
  - Uncorrected

3/28/2014 JTH 226

Back-Calculations

- Helpful in determining cause of refractive surprise
  - Back-calculated K, AL and IOL power compared to pre-op & to post-op remeasured values
  - Back-calculated ELP compared to preoperative prediction by formula

3/28/2014 JTH 227