ASCRS ♦ ASOA Symposium & Congress

Technicians & Nurses Program

April 17-21, 2015 – San Diego, California

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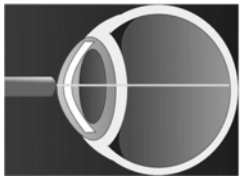
JOINT COMMISSION ON ALLIED HEALTH PERSONNEL IN OPHTHALMOLOGY®



Update on Post-Refractive Surgery IOL Calculations

ASCRS Technicians and Nurses Program
April 18th, 2015

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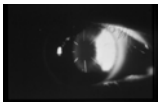
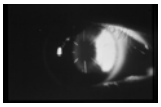
The Post-Refractive Surgery Keratometry Challenge



- Central cornea flattened for myopic correction, steepened for hyperopic correction
- Changes shape of cornea and refractive index of stroma unless RK
- Standard formulas using anterior corneal measurements assume a predictable relationship between front and back surfaces
- After LASIK, only the anterior surface is reshaped

The Post-Refractive Surgery Keratometry Challenge



- Different machines measure different areas of the cornea, producing different results
- Flattened or steepened K's cause invalid assumptions of ELP in our calculations formulas unless Double K modification used
- Using standard keratometry readings results in over-estimation of corneal curvature in the previous myope due to reading a larger area than desired, resulting in a hyperopic surprise (-3.0 D to + 6.0 D)
- In the previous hyperope, results in an under-estimation due to reading a smaller area, and a myopic surprise

Warn the Patient!

- These patients are at a higher risk of an imperfect result which could require yet another procedure for desired target refraction, i.e. more refractive surgery, an IOL exchange, a piggyback lens
- Tell them to expect two procedures from the beginning?

Clinical History Method

Koch, et al AJO 1989; 108:676-82

- Previously considered "Gold Standard", but now one of least favored methods
- Requires records, no sign of cataract at time of refractive surgery and post-op
- Need three numbers:
  1. Pre-Op MR (sph eq)
  2. Pre-Op K's (average)
  3. Post-Op MR (sph eq)

Clinical History Method

Koch, et al AJO 1989; 108:676-82

- Determine how much correction took place, then

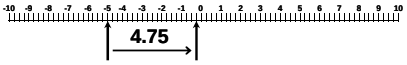
K = Pre-Op Avg. K – change in MR

Clinical History Method

Koch, et al AJO 1989; 108:676-82

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**



What If's

- *What if patient had enhancements or multiple types of procedures?*
- *The stable post-op refraction is the spherical equivalent after LAST PROCEDURE*

What If's

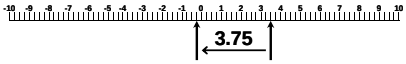
- *What if the patient had refractive surgery to correct hyperopia instead of myopia?*
- *ADD the amount of correction from original K rather than subtract due to corneal steepening*

Clinical History Method

Koch, et al AJO 1989; 108:676-82

For example:

- *Average K pre-Lasik = 42.75 D*
- *+ 3.50 D hyperope pre-Lasik*
- *- 0.25 D myope post-Lasik*
- *Change in MR = 3.75 D*
- *K = 42.75 D + (3.75 D) =* **46.50 D**



The Most Reliable Methods Today

Shammas PL For Myopic LASIK

Shammas, et al AJO 2003; 136:426-32

- *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

Shammas, et al J Cataract Ref Surg 2013; 39:739-744

- *Measure K's post-op, average, and adjust with formula:*

$$K_C = 1.0457\ (K_{post\text{-}op}) - 1.9538$$

Wang-Koch-Maloney Method

Wang, Booth, Koch. Ophthalmol 2004; 111(10):1825-1831

For myopic LASIK patients:

- *Obtain topography post-op, then*

$$K = 1.114\ (Ccp) - 6.1$$

Where Ccp is the central corneal power with cursor at the exact center of the Axial Map Recommend using Atlas topographer

Masket Method

Masket S, Masket SE. JCRS 2006; 32:430-434

- *Best performance in some 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 Adjustment = LSE x (-.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 X (-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 X (-0.326) + 0.101 = - 0.877*
- *+22.0 – 1.0 = +21.0 D Final IOL Power*

Modified Masket Method

Warren Hill's data produced a slightly different regression formula when working to validate the Masket Method:

IOL Adjustment = LSE x (-0.4385) + 0.0295

Modified Masket Method

Calculated IOL power = +15.26 D
Stable SE correction after LASIK = -5.0 D

Masket Method:
(-5.0 X -0.326) + 0.101 = +1.73 D, so
+15.26 D + 1.73 D = +16.99 D

Modified Masket Method:
(-5.0 X -0.4385) + 0.0295 = +2.22 D, so
+15.26 D + 2.22 D = +17.48 D

Haigis L

- ***For both myopic and hyperopic LASIK on recent versions of IOL Master***
- ***Older versions have neither***
- ***Semi-older versions have myopic only***
- ***Use IOLM or immersion biometry, but IOLM K's only!***

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***

Aramberri Double K

Aramberri. JCRS 2003; 29(11):2063-2068

- ***Formulas actually use K's twice: once regarding amount of power of cornea to bend light, the other to help predict ELP***
- ***With double-K modification, an avg K is inserted into the formula where ELP is predicted, adjusted K where corneal power is used***
- ***Axis II and Sonomed have double K***

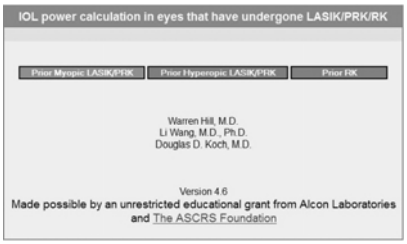
Holladay II Double K Correction

- ***Check the box in Holladay II for "Prev RK, PRK, LASIK" and it automatically puts avg K (43.9 D unless you provide historical information, then will use that) in ELP prediction***

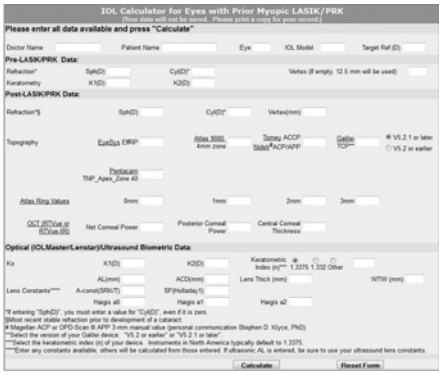
ASCRS Post-Refractive Surgery IOL Calculator

www.ASCRS.org

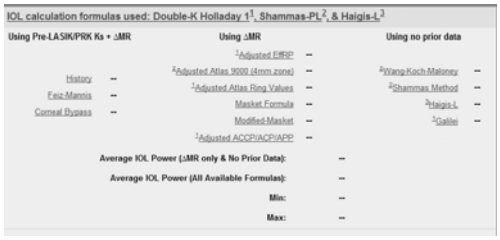
(link on home page)



Prior Myopic LASIK/PRK

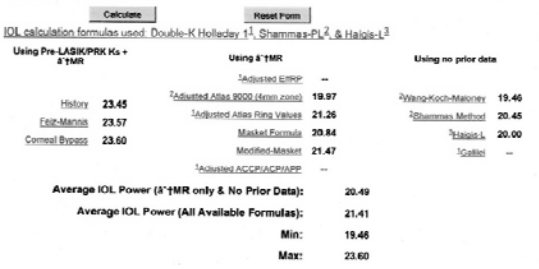


Prior Myopic LASIK/PRK Previous Calculator Version



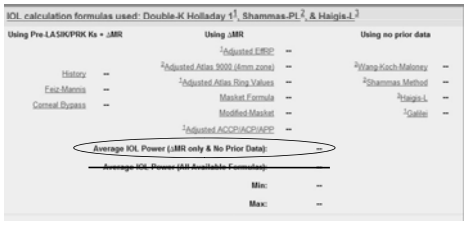
Prior Myopic LASIK/PRK Previous Calculator Version

- ***Typically first column much stronger than second and third***



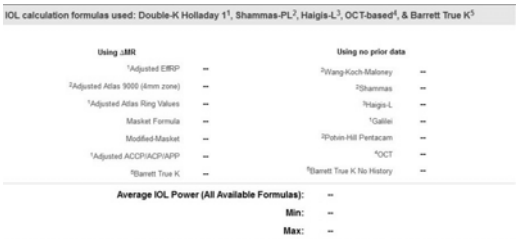
Prior Myopic LASIK/PRK Previous Calculator Version

- ***Research showed repeatedly that methods in second and third columns perform better than those of the first column***
- ***Calculator had average of 2nd and 3rd columns only above average from entire calculator***



Prior Myopic LASIK/PRK New Version

- ***Best results from Masket, Shammas, Haigis-L, and Wang-Koch-Maloney, Potvin-Hill, Barrett***
- ***Completely eliminated first column!***



Potvin-Hill Pentacam Method

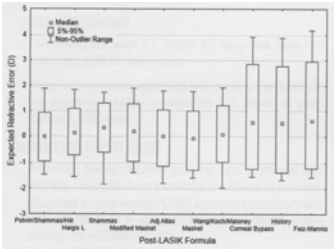
Potvin, R and Hill, W. J Cat Refract Surg 2015: 41:339-347

- *For myopic LASIK only*
- *Directly determines the corneal power by measuring both the anterior and posterior surfaces with the Pentacam rotating Scheimpflug camera*
- *Best results were found to be from using the true net power measurements in the 4.0 mm zone centered on the corneal apex (TNP_Apex_Zone_40), used in Shammas formula*

Potvin-Hill Pentacam Method

Potvin, R and Hill, W. J Cat Refract Surg 2015: 41:339-347

- *Produced calcs similar to those obtained from existing formulas on the ASCRS website*



Potvin-Hill Pentacam Method

Potvin, R and Hill, W. J Cat Refract Surg 2015: 41:339-347

- *Results compared to other methods on ASCRS website*

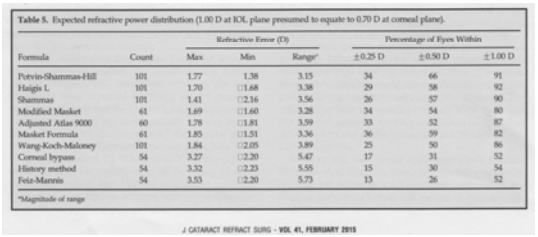


Table 5. Expected refractive power distribution (1.00 D at IOL plane presumed to equate to 0.70 D at corneal plane).

Formula	Count	Refractive Error (D) Max	Min	Range*	Percentage of Eyes Within ±0.25 D	±0.50 D	±1.00 D
Potvin-Shammas-Hill	101	1.77	1.38	3.15	34	66	91
Haigis L	101	1.70	□1.68	3.38	29	58	92
Shammas	101	1.41	□2.16	3.56	26	57	90
Modified Masket	61	1.69	□1.60	3.28	34	54	80
Adjusted Atlas 9000	60	1.78	□1.81	3.59	33	52	87
Masket Formula	61	1.85	□1.51	3.36	36	59	82
Wang-Koch-Maloney	101	1.84	□2.05	3.89	25	50	86
Corneal bypass	54	3.27	□2.20	5.47	17	31	52
History method	54	3.32	□2.23	5.55	15	30	54
Feiz-Mannis	54	3.53	□2.20	5.73	13	26	52

*Magnitude of range

J CATARACT REFRACT SURG - VOL 41, FEBRUARY 2015

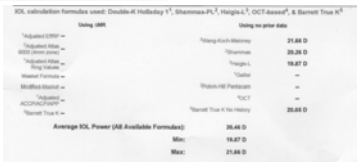
Barrett True K Method

Barrett GD. True-K formula: New Approach to biometry after LASIK. Presented at ASCRS 2009

- *For myopic LASIK, hyperopic LASIK, and RK*
- *Based on Barrett Universal II formula*
- *Calculates a modified K value for post-refractive patients*
- *Requires optical Ks as measured and the pre- and post-refractive surgery refractions for maximum accuracy*
- *Can also be run when no history available*

Barrett True K Method

Barrett GD. True-K formula: New Approach to biometry after LASIK. Presented at ASCRS 2009

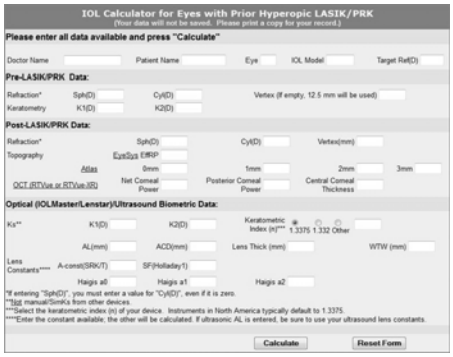


OCT-Based Method

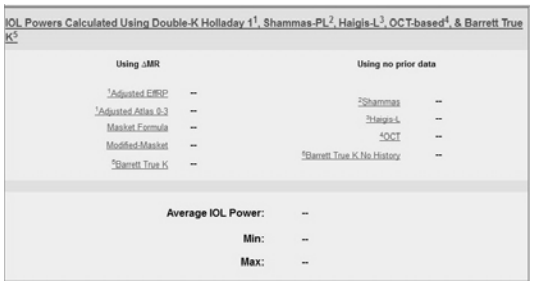
Huang D et al. Transactions of the American Ophthalmological Society, 2013: 111:57-68

- *For myopic LASIK, hyperopic LASIK, and RK*
- *Net corneal power, posterior corneal power, and central corneal thickness are obtained from RTVue or RTVue-XR (Optovue Inc)*
- *Axial length and ACD from IOL Master*
- *Recommended to perform three OCT scans and use the median net and posterior corneal power*

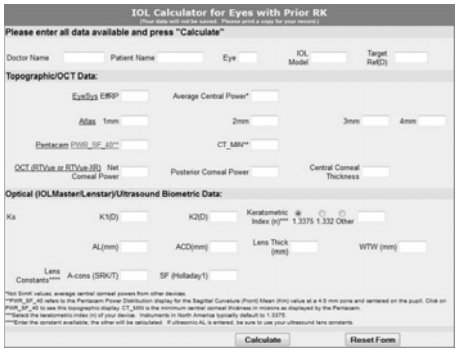
Prior Hyperopic LASIK/PRK



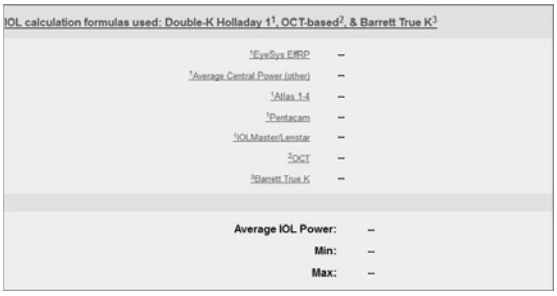
Prior Hyperopic LASIK/PRK



Prior RK



Prior RK



RK Patients

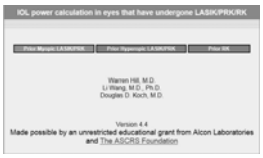
- ***History method not as good for post-RK due to unstable post-op refraction***
- ***Measure them in morning rather than afternoon – K's flatter in the am, steeper in pm***
- ***Make them plano in the am, myopic in pm – not hyperopic am, plano pm!***

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!***

Disadvantages of ASCRS Calculator

- ***No power ranges from which to choose***
- ***Can only run for one IOL on the page, so must run multiple times for different IOLs***



Emory Protocol for Post-Refractive Patients

- ***Run ASCRS Calculator, but also:***
- ***Adjust K's with Shammas Method manually and enter into Holladay II formula as "Surgeon entered adjusted K"***
- ***Check box that patient had prior refractive surgery so it functions as a double K formula!***

Emory Protocol for Post-Refractive Patients

- ***Now docs have all four lenses calculated on the page***
- ***Now they have power ranges from which to choose***
- ***Holladay II may differ a little from ASCRS calculator of same method because more of the eye anatomy being considered than Holladay I formula being used in calculator***

Emory Protocol for Myopic LASIK Patients

- ***AEL: 26.46 OD by immersion***
- ***IOLM K's: 40.66/41.26 OD***
- ***Targeted plano OD***

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

Using Pre-LASIK/PRK Ks + â^†MR		Using â^†MR		Using no prior data	
		[1]Adjusted ERRP	--		
History	19.46	[2]Adjusted Atlas 9000 (4mm zone)	16.90	[2]Wang-Koch-Maloney	15.94
Feiz-Mannis	19.50	[1]Adjusted Atlas Ring Values	17.94	[2]Shammas Method	17.18
Corneal Bypass	20.13	Masket Formula	17.66	[3]Haigis-L	16.50
		Modified-Masket	18.46	[1]Galilei	--
		[1]Adjusted ACCP/ACP/APP	--		

Average IOL Power (â^†MR only & No Prior Data):	17.23
Average IOL Power (All Available Formulas):	17.97
Min:	15.94
Max:	20.13

Emory Protocol for Myopic LASIK Patients

For Holladay II:

- ***Manually calculate Ks by Shammas PL***
- ***IOLM K's: 40.66/41.26***
- ***Average those Ks (add them together, then divide by 2)***
- ***Avg K = 40.96***
- ***Shammas PL = 1.14 (40.96) – 6.8***
- ***Adj K for calcs = 39.89***

Emory Protocol for Myopic LASIK Patients

- ***Adjusted K of 39.89 entered into H II***
- ***Checked box that patient had prior refractive surgery***
- ***IOL Power = 17.50 D***
- ***Post-Op outcome: -0.75 + 0.50 x 176 = 20/20***

Emory Protocol for Hyperopic LASIK Patients

- *AEL: 22.26 OS by optical*
- *IOLM K's: 46.18/47.02 OS*
- *Targeted plano OS*

IOL Powers Calculated Using Double-K Holladay 1 Formula

Using Pre-LASIK/PRK Ks + Â*†MR	Using Â*†MR	Using no prior data
Clinical History --	Adjusted EffRP --	
Feiz-Mannis --	Adjusted Atlas 0-3 --	Haigis-L 20.00
Corneal Bypass --	Masket Formula --	
	Modified-Masket --	
	Average IOL Power: 20.00	CHOSEN LENS:
	Min: 20.00	Model:_____ Power:___
	Max: 20.00	

Emory Protocol for Hyperopic LASIK Patients

For Holladay II:

- *Manually calculate K's with Shammas PHL*
- *IOLM K's: 46.18/47.02*
- *Average those Ks (add them together, then divide by 2)*
- *Avg K = 46.60*
- *Shammas PHL = 1.0457 (46.60) – 1.9538*
- *Adj K for calcs = 46.77*

Emory Protocol for Hyperopic LASIK Patients

- *Adjusted K of 46.77 entered into H II*
- *Checked box that patient had prior refractive surgery*
- *IOL Power = 20.0 D*
- *Post-Op outcome: plano = 20/20*

Emory Protocol for RK Patients

- *Run ASCRS Calculator, but also:*
- *Just use average optical K from IOLM or LS (which formula does automatically)*
- *Check box that patient had prior refractive surgery*

Emory Protocol for RK Patients

- *AEL: 22.99 OD, 22.79 OS*
- *IOLM K's: 43.55/44.35 OD*
  44.41/44.88 OS
- *Target -0.75 OU*

OD

EvoOpt EffRP	--
Average Central Power (other)	--
Hemiphony Atlas 1-4	22.35
Average IOL Power:	22.35
Min:	22.35
Max:	22.35

OS

EvoOpt EffRP	--
Average Central Power (other)	--
Hemiphony Atlas 1-4	22.34
Average IOL Power:	22.34
Min:	22.34
Max:	22.34

Emory Protocol for RK Patients

For Holladay II:

- *Enter as normal so program will average*
- *IOLM K's OD: 43.55/44.35 (avg 43.95)*
- *IOLM K's OS: 44.41/44.88 (avg 44.65)*
- *Check box that patient had prior refr sx*
- *IOL Power = 22.5 D OU*
- *Post-Op outcome:*
  OD: -1.00 + 1.00 x 175 = 20/20
  OS: -0.50 = 20/15-1

Patient Unsure

- ***Patient had LASIK OU, wasn't sure what type***
- ***Asked if she was nearsighted or farsighted beforehand***
- ***Her answer was "both"***

		OD Right eye		OS Left eye	
Measuring mode	Mode	Phakic		Phakic	
Axial length	AL	26.64 mm	±0.007 mm	26.51 mm	±0.008 mm
Cornea thickness	CCT	398 µm	±6.0 µm	359 µm	±1.2 µm
Aqueous depth	AD	3.02 mm	±0.010 mm	3.46 mm	±0.007 mm
Anterior chamber depth incl..	ACD	3.42 mm	±0.006 mm	3.82 mm	±0.007 mm
Lens thickness	LT	3.90 mm	±0.230 mm	3.15 mm	±0.020 mm
Retina thickness	RT	200** µm	±0.0 µm	200** µm	±0.0 µm
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	

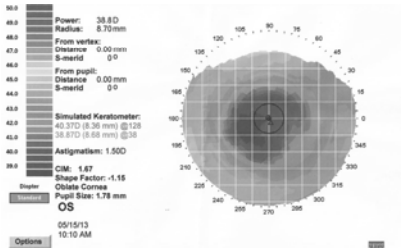
Patient Unsure

- ***Patient had LASIK OS only for monovision purposes***
- ***Was plano OU beforehand***
- ***Would that be myopic or hyperopic LASIK?***

		OD Right eye		OS Left eye	
Measuring mode	Mode	Phakic		Phakic	
Axial length	AL	23.05 mm	±0.007 mm	23.44 mm	±0.009 mm
Cornea thickness	CCT	581 µm	±2.1 µm	588 µm	±4.3 µm
Aqueous depth	AD	2.32 mm	±0.011 mm	2.25 mm	±0.009 mm
Anterior chamber depth incl..	ACD	2.90 mm	±0.009 mm	2.83 mm	±0.005 mm
Lens thickness	LT	4.45 mm	±0.285 mm	4.73 mm	±0.005 mm
Retina thickness	RT	200** µm	±0.0 µm	200** µm	±0.0 µm
Flat meridian	K1	42.59 D @ 49°	±0.072 D	43.86 D @ ----°	±0.052 D
Steep meridian	K2	42.74 D @ 139°	±0.106 D	43.86 D @ ---°	±0.052 D
Astigmatism	AST	0.15 D @ 139°	±3.0°	0.00 D @ ---°	----°
Keratometric index	n	1.3375		1.3375	

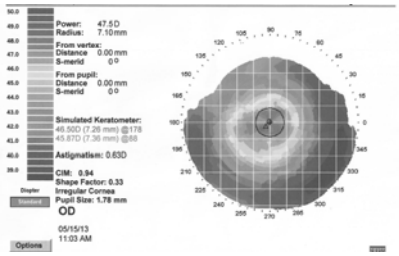
Topography Myopic LASIK

- ***Flat zone centrally***



Topography Hyperopic LASIK

- ***Steep zone centrally***

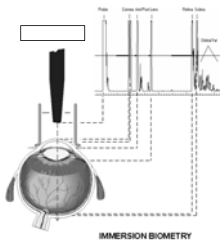


CAUTION!!!

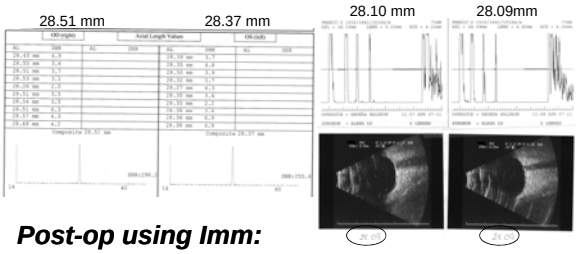
- ***ALL methods require good data in!***
- ***If measurements are not accurate, none of the methods work!***
- ***Must use ultrasound for long eyes!***

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***



Long Eye: Optical vs. Ultrasound



Post-op using Imm:

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

Wang, et al, J Cataract Refract Surg 2011; 37:2018-2027

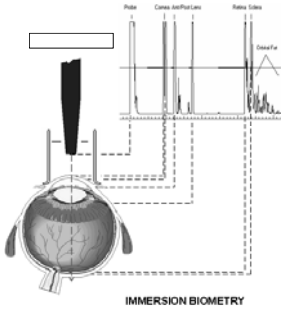
- ***Holladay I formula:***
  0.8814 x AL(IOLM) + 2.8701 = Adjusted AL
- ***Haigis formula:***
  0.9621 x AL(IOLM) + 0.6763 = Adjusted AL
- ***SRK/T formula:***
  0.8981 x AL(IOLM) + 2.5637 = Adjusted AL
- ***Hoffer Q formula:***
  0.8776 x AL(IOLM) + 2.9269 = Adjusted AL

Optimizing Axial Length in Long Eyes

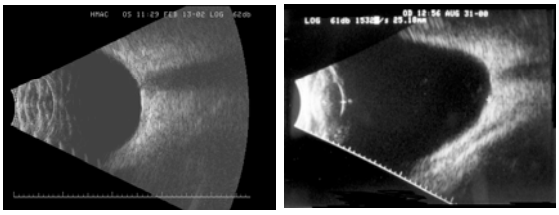
- ***The problem with using an optimization equation is that sometimes optical gets it right!***
- ***Adjusting a measurement that didn't need adjusting will still lead to a post-op surprise***
- ***The best way to measure the high myope is with ultrasound so you know it is correct***

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***

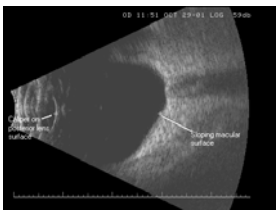


Why High Myopes are Harder to Measure



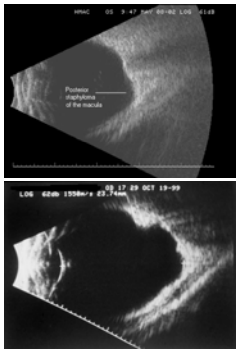
Why High Myopes are Harder to Measure

- ***The eye is misshapen, oval or elongated rather than round***
- ***Macula on a "slope"***
- ***Perpendicularity impossible***



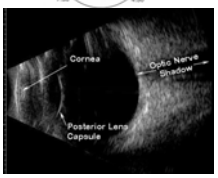
Posterior Staphyloma

- ***Uvea bulging into thin, stretched sclera***
- ***Commonly in posterior pole***
- ***Perpendicularity impossible***
- ***Measurements vary greatly***

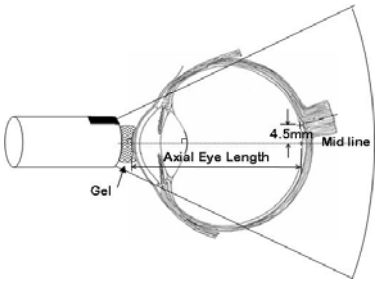


B-Biometry Technique

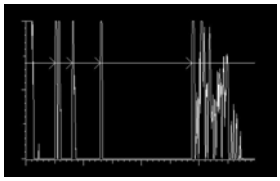
- ***Align B-scan with "HMAC" position (probe on corneal vertex, marker nasal) with 4 or 5 mm of gel on probe tip***
- ***Corneal vertex and posterior lens surface centered on left, macula centered on right inferior to optic nerve***
- ***Macula ~4.5 mm down from center of optic disc***
- ***Place one caliper on front of cornea, move the other through the center of the lens to macular surface***



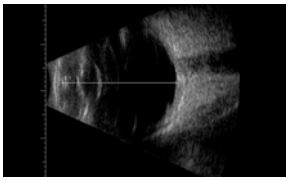
If you don't see the cornea, you aren't using enough gel!



B-Biometry Technique Comparison to Good Immersion

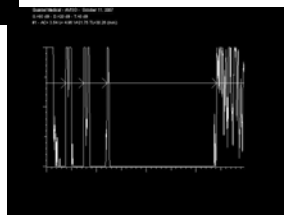


23.78 on A-scan



23.80 on B-scan

B-biometry = 30.34mm



A-scan = 30.03, 30.26, 30.0, 30.20, 30.15, 29.98

Conclusion

- ***Records will continue to be difficult to obtain, research emphasis being placed on methods that don't require history***
- ***Keep up with the latest methods***
- ***Use ASCRS calculator***
- ***Know which methods are most reliable***
- ***Don't forget to get ultrasound measurements on the long eyes!***
- ***Do NOT measure the cornea after an eye exam!***
- ***ALL methods require good data in!***