

## IOL Calcs I: Basics

- Quick, down-and-dirty estimate of IOL needed for emmetropia:  $Power = \boxed{\#} + (\boxed{\#} \times pre\text{-}op \boxed{abb.})$



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- Two types of IOL calculation formulae:
  - : Based on linear regression of refractive data
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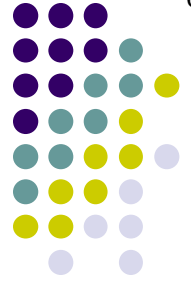


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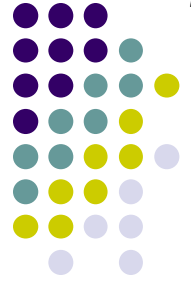
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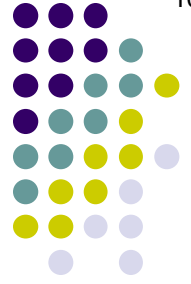
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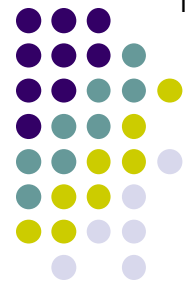
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*With regard to accurate IOL selection, which is the single most important biometric component?*

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--For *shorter* eyes, errors in AL measurement will result in an error  than 2.5D

--For *longer* eyes, errors in AL measurement will result in an error  than 2.5D

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In addition to increased length, what other aspect of AL measurement should raise suspicion that a staphyloma might be present?  
If there is significant variability among measurements  
  
Why do staphyloma produce variability among AL measurements?  
Because measurement signals directed at a staphyloma often vary in where along the (sloping) wall they reflect, and thus each signal will yield a different AL

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# IOL Calcs I: Basics

*What specifically is meant by stating the SRK was 'too inaccurate'?*

SRK worked well for eyes of average length and keratometry; however, it often led to large 'refractive surprises' in eyes that were significantly shorter or longer than average

*How was this inaccuracy addressed in the SRK2?*

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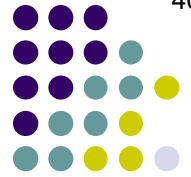
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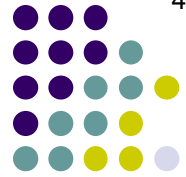
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*(Warning--Optics nerd-out right ahead)*

*More precisely, ELP is the distance between the **principal planes** of the cornea and IOL.*

The key factor is how the formula estimates the *effective lens position (ELP)* --**the distance between the cornea and the IOL**. Remember, the eye is a two-lens system, with the cornea being the first lens. As with any two-lens system, the total refractive power of the eye is exquisitely sensitive to the distance between the 'lenses' (the cornea and the IOL). Increased accuracy in IOL calc formulae are due to improvements in ELP estimation.

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*Which step in phaco surgery is most critical in determining actual ELP (i.e., where the IOL will be seated within the eye)?*

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Assuming capsular bag placement, the most critical step is the **capsulorrhexis**. A continuous, centered rhexis that covers the entire optic will hold the IOL in the location where the IOL calc formula 'expects' it to be. In this way, estimated ELP and actual ELP stand the greatest chance of being equivalent—and thus the intended post-op refraction and the obtained post-op refraction are more likely to be equivalent as well.

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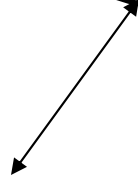
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# IOL Calcs II: Theoretic Formulae



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*Does this mean these formulae employ **no** empirical information?*





# IOL Calcs II: Theoretic Formulae



*Does this mean these formulae employ **no** empirical information?*

No—all of these will rely on study-based estimates of certain anatomic considerations (eg, axial length). What makes them 'theoretic' is their inclusion of non-empirical factors.



# IOL Calcs II: Theoretic Formulae

- 1<sup>st</sup> generation theoretic formula
  - Assumed ELP was  mm for all patients



# IOL Calcs II: Theoretic Formulae

- 1<sup>st</sup> generation theoretic formula
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## IOL Calcs II: Theoretic Formulae

- 1<sup>st</sup> generation theoretic formula
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## IOL Calcs II: Theoretic Formulae

- **1<sup>st</sup> generation theoretic formula**
  - As These are of **historic interest only**—no one uses them anymore
- **2<sup>nd</sup> generation 1-variable theoretic formula**
  - *Binkhorst*: Measured **axial length (AL)** to estimate ELP





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  - *Holladay I*
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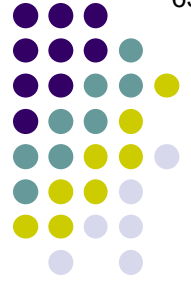
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- Measure specific variable(s) to estimate ELP



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Measure both AL and keratometry to estimate ELP



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Measure both AL and keratometry to estimate ELP
- 4<sup>th</sup> generation multi-variable theoretic formulae





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Measure both AL and keratometry to estimate ELP
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Measure specific variable, as well as several other factors +/- variables used by the 3<sup>rd</sup> generation formulae above, to estimate ELP



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*Why don't these formulae work for eyes outside these values?*

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As stated previously, the key to accurate IOL calcs is estimation of ELP. Built in to these three formulae is the assumption that ELP is proportional to AL and corneal power; i.e., long eyes and steep-K eyes are assumed to have longer-than-average ELP, whereas short eyes and flat-K eyes are assumed to have shorter-than-average ELP. However, we now know that this assumption is incorrect—most extra-long and extra-short eyes have normal-sized anterior segments, and therefore normal-length ELP. The incorrect coupling of AL and K to ELP renders these formulae inaccurate when applied to most eyes of unusual length and/or corneal power.

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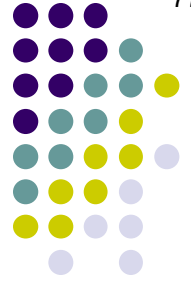
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✓ Both *Holladay II* and *Haigis* work very well for these eyes

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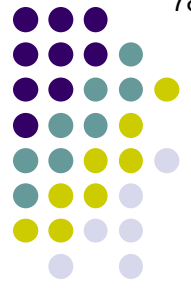


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  - *Binkhorst*: Measured axial length (AL) to estimate ELP
- 3<sup>rd</sup> generation 2-variable theoretic formulae
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Measure both AL and keratometry to estimate ELP
- 4<sup>th</sup> generation multi-variable theoretic formulae
  - *Holladay II*
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Measure anterior chamber depth (ACD), as well as several other factors +/- variables used by the 3<sup>rd</sup> generation formulae above, to estimate ELP
- 5<sup>th</sup> generation multi-variable theoretic formula
  - *Hoffer H-5* Equivalent to Holladay II, except employs demographic factor 1 and demographic factor 2-specific averages for AL, corneal power, etc.



## IOL Calcs II: Theoretic Formulae

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# IOL Calcs III: s/p Keratorefractive Surgery



*Note—topic shift*

# IOL Calcs III: s/p Keratorefractive Surgery

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The problem lies with manual keratometry. To perform reliable IOL calcs, we need an accurate measure of central corneal power. However, contrary to popular belief, manual keratometers do **not** measure central corneal power.

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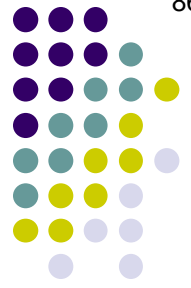


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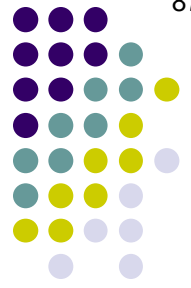
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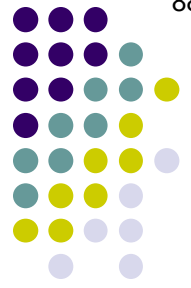
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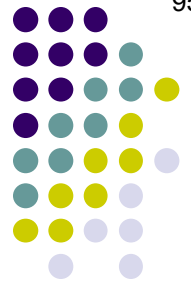
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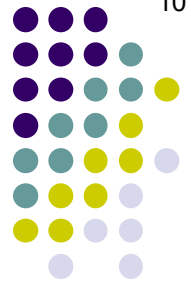
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**Hard CL overrefraction method:** A plano hard contact lens is used to restore the cornea to its pre-surgical configuration. The CL will vault over the flattened central cornea, and the tear film will fill in the portion altered by the refractive surgery. The patient is refracted with and without the CL in place, and the difference between these refractions equals the change in the cornea owing to the refractive surgery. This change is then added to the base curve of the CL to yield an estimate of the central corneal power. This technique may be too unreliable, however.



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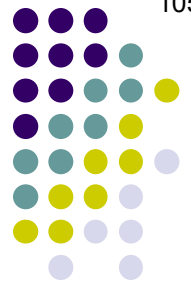
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**Automated keratometry/topography:** These devices can do a fair job of estimating anterior corneal power (though adjustments and modifications are frequently needed). Thus they can yield reasonably accurate estimates of corneal power in post-RK and post-hyperopic ablative corneas, because these surgeries do not alter the relationship between the anterior and posterior corneal curvatures. However, because myopic ablative procedures alter the relationship between the anterior and posterior corneal curvatures, keratometry/topography techniques will **not** produce accurate estimates of true central corneal power s/p myopic keratoablative surgery.

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pr A plethora of techniques have been developed specifically for estimating central K power wi after myopic ablative surgery. Some of them make use of historical data (e.g., the ov refractive surgery Ks); these include the *Masket method* and the *corneal bypass method*. an

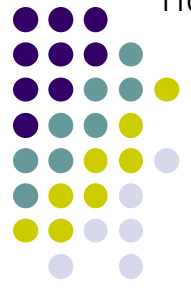
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*Why is estimation of ELP problematic after keratorefractive surgery?*

The problem is with the 3<sup>rd</sup> generation 2-variable (3G2V) theoretic formulae (SRK/T, Hoffer Q and Holladay I) so popular with surgeons. Recall that these formulae rely in part upon corneal power in estimating ELP. Recall also that we now know the assumptions built in to these formulae regarding the relationship b/t corneal power and ELP are **incorrect**.

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Consider an eye with pre-RK keratometry of 45D and post-RK keratometry of 38D. We know that RK does not affect where an IOL will sit within the eye, and thus will have no effect on ELP. However, 3G2V formulae will yield very different ELP estimates based on a 38D cornea than they would for a 45D cornea because of the erroneous assumptions relating ELP and corneal power.



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Consider that RK c ELP. How than they power.

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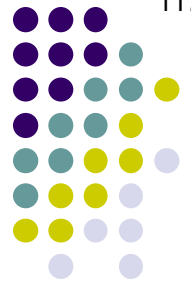
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The most popular technique is probably the **double K method** developed by Aramberri. In this approach, the pre-refractive-surgery Ks are used to determine IOL *position* (i.e., ELP estimation), but the **post-refractive-surgery Ks** are used to determine IOL *power*.

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- Prior keratometry calcs differ

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*How do these formulae deal with the problem of ELP estimation with post-keratorefractive surgery corneas?*

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The problem is with the 3<sup>rd</sup> generation 2-variable (3G2V) theoretic formulae (SRK/T, Hoffer Q and Holladay I) so popular with surgeons. Recall that these formulae rely in part upon corneal power in the form of a 2-variable formulae.

Consider that RK of the eye changes the ELP. However, the ELP is not known until after the surgery. Thus, the ELP is not known until after the surgery. Thus, the ELP is not known until after the surgery.

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*How do these formulae deal with the problem of ELP estimation with post-keratorefractive surgery corneas?*  
 If pre-surgical Ks are available, the Holladay II employs them (in addition to AC depth and other factors). If they are not available, Holladay II uses a default K power of about 44D in calculating ELP. On the other hand, the **Haigis does not use K values in estimating ELP**, so this is a non-issue for Haigis users.

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