History of IOL Formulas

Empirical Formulas		
	Benefits	**Drawbacks**
Sanders-Retzlaff-Kraff (SRK) (1980) $P = A - 2.5L - 0.9K$	Most accurate at the time; best for axial lengths (L) between 22.00-24.50 mm	Inaccurate; doesn't consider ELP
SRKII (~1989) $P = A - 2.5L - 0.9K + C$	Better than SRK for longer and shorter eyes (A-constant correction factors added)	Still too inaccurate; doesn't consider ELP
VRF (2017)	Better than the other empirical formulas; considers AL, Ks, ACD, and K diameter to estimate ELP	

Theoretical Formulas		
	Benefits	**Drawbacks**
1st Generation Theoretical Fyodorov (1967) Colenbrander (1973) Van der Heijde (1975) Thijssen (1980)	Accounted for ELP; for ACIOLs; reduced to: $P = \frac{n}{L - c} - \frac{nK}{n - cK}$ *n* for refractive index of the aqueous and vitreous	Assumed ELP was always 4.0 mm; mainly for ACIOLs
2nd Generation Theoretical Binkhorst (1975) Hoffer (1975)	Adjusted ELP based on Axial length	Still not accurate enough
3rd Generation Theoretical SRK/T (T=theoretical) (1990) Holladay I (1988) Hoffer Q (~1993) T2 (~2010)	Measure both AL and Ks to estimate ELP	Best for "normal" ALs between ~22-~26 and "normal" Ks between ~41D-~46D
4th Generation Theoretical Holladay II (1992) Barrett II Universal (2010) Haigis (~2014) $\mathrm{ELP} = a_0 + a_1 AC + a_2 AL$	Measure ACD and other variables to estimate ELP; better for "abnormal" ALs and Ks; Haigis has an added benefit of not relying on Ks (good for post-LASIK)	
5th Generation Theoretical Hoffer H-5 (2014)	Incorporates race and gender data	
AI/Machine Learning Kane (2017) Hill RBF (2016) PEARL-DGS (2021)	Uses a combination of theoretical/empirical optics and/or components of AI/machine learning	
Ray Tracing Olsen (2013) Okulix (2017) Naeser 2 (2019) VRF-G (2020)	Simulates whole pseudophakic eye and accounts for aberrations	
Combination Ladas Super Formula (2019)	Combines the most accurate portions of other formulas to make a "super formula" based on patient measurements; also uses AI	
Other Vergence-Based Formulas Emmetropia Verifying Optical (EVO) 2.0 (2019) – Thick lens formula, considers geometry of IOL Cooke K6 (2020) – Uses multiple refractive indices for various media in the eye Castrop (2021) - Pseudophakic eye model with 4 refractive surfaces and 3 formula constants		
IOL Formula Adjustments Wayne-Koch Adjustment – Applied to some third- and fourth-generation IOL formulas to optimize the calculation for AL >25 mm; great for Holladay II		

History of IOL Formulas

IOL Calculation Terms and Concepts:
Empirical Formulas: Linear regression of refractive data
Theoretical Formulas: Based on formal optics and model eye
Ray-Tracing: Calculates the exact and paraxial rays through refractive elements of the eye to calculate postoperative ELP
Vergence: Based on principle of theoretical refractive vergence to predict what IOL power would refract an image on the retina
Thin Lens: Approximate the IOL as a thin lens; ELP is considered the distance from anterior corneal surface to infinitely thin IOL plane
Thick Lens: ELP(T) (T for "thick") is considered the distance between the principle image plane of the cornea and principle object plane of the IOL; differentiates between the IOL's physical and optical position

A = A-constant (from manufacturer)
P = Emmetropic power
L or AL = Axial Length
AC = Phakic AC depth
K = Corneal Power
C = Correction factor
n = Refractive index
c = Estimated post-op lens position
a = Other constants

SRK II Correction Values for *C*	
If $L \leq 20$	3
If $L \geq 20$ and < 21	2
If $L \geq 21$ and < 22	1
If $L \geq 22$ and < 24.5	0
If $L \geq 24.5$	-0.5