The quest for perfection ….in Intraocular lens power prediction

Elisabeth Patsoura MRCOphth

Egyptian Ophthalmological Society Meeting, Cairo 27-29/03/2019

No financial disclosures

30 years ago!

Benchmark standards for refractive outcomes after NHS cataract surgery

Postoperative SE 85% within 1D & 55% within 0,50D → Obsolete ?

Risk factors for refractive error after cataract surgery: Analysis of 282 811 cataract extractions reported to the European Registry of Quality Outcomes for cataract and refractive surgery

72,7 % within 0,50D
93% within 1,0D

Elimination sources or error

biometry + IOL formulae → perfection

Devices & technology

A-scan ultrasonography

Partial Coherence interferometry (IOL Master)

Optical low coherence reflectometry (Lenstar)

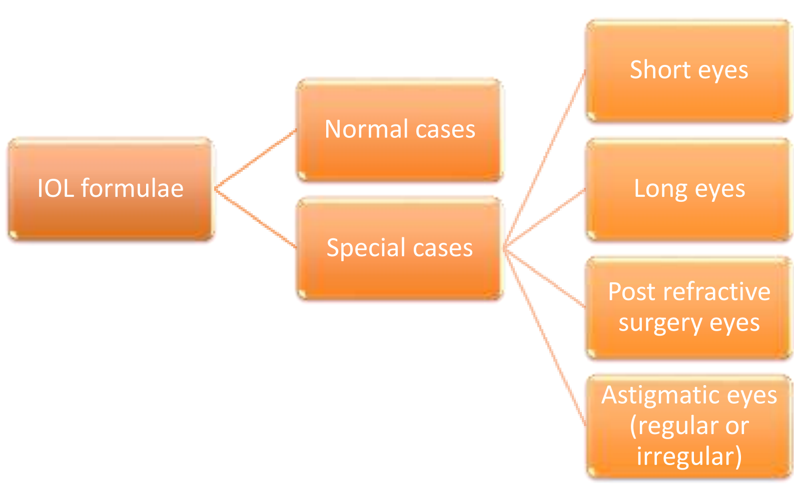
Swept –Source Optical Coherence Tomography (IOL Master 700, OA-2000-Tomey)

Intraoperative aberrometry (ORA, Alcon)

IOL calculation formulas

- **First generation** SRK (*)
- **Second generation** SRKII (*)
- **Third generation** SRK-T, Hoffer Q, Holladay I (2 V)
- **Fourth generation** Holladay II (7), Haigis (3), Barrett (5), Olsen
- **Fifth generation** Hoffer 5

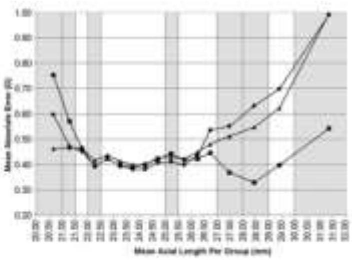
- **Newest formulas**
  - Hill-RBF formula (artificial intelligence)
  - Ladas Super formula (Haigis +2V)
  - Full Monte method (based on Monte Carlo Chain Simulator)



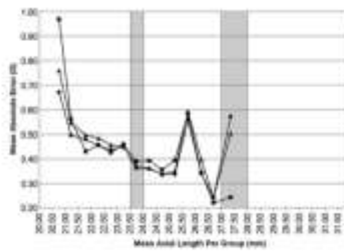
ARTICLE

Formula choice: Hoffer Q, Holladay 1, or SRK/T and refractive outcomes in 8108 eyes after cataract surgery with biometry by partial coherence interferometry

Petros Aristodemou, FRCOphth, Nathaniel E. Knox Cartwright, MRCOphth, John M. Sparrow, DPhil, FRCOphth, Robert L. Johnston, FRCOphth



IOL 1



IOL 2

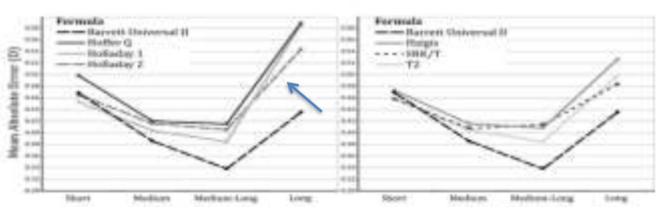
CONCLUSIONS: The Hoffer Q performed best for ALs from 20.00 to 20.99 mm, the Hoffer Q and Holladay 1 for ALs from 21.00 to 21.49 mm, and the SRK/T for ALs of 27.00 mm or longer. Using optimized constants, refractive outcomes of 40%, 75%, and 95% within ±0.25 diopter (D), ±0.50 D, and ±1.00 D, respectively, were achievable.

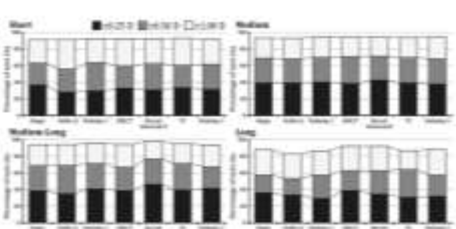
ARTICLE

Intraocular lens power formula accuracy: Comparison of 7 formulas

Jack X. Kane, MB BS, Anton Van Heerden, MB ChB, FRANZCO, Aly Atik, MB BS, Constantinos Petsoglou, MB BS, MMed(Clin Epi), FRANZCO

PURPOSE: To assess the accuracy of 7 intraocular lens (IOL) power formulas (Barrett Universal II, Haigis, Hoffer Q, Holladay 1, Holladay 2, SRK/T, and T2) using IOLMaster biometry and optimized lens constants.





- **Holladay II** not very accurate if lens thickness is not used
- **Barrett II** performed better over the full range

ARTICLE

Comparison of 9 intraocular lens power calculation formulas

David L. Cooke, MD, Timothy L. Cooke, BA

Two biometry devices : PCI, OLCR   Two versions of Olsen formula

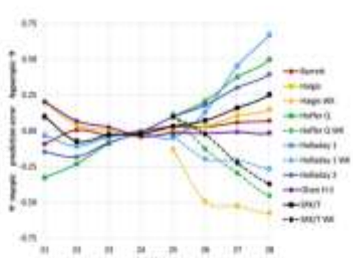
CONCLUSIONS: The formulas gave different results depending on which machine measurements were used. The Olsen formula was the most accurate with OLCR measurements, significantly better than the best formula with PCI measurements. The Olsen was better, regardless of AL. If only PCI measurements (without lens thickness) were available, the Barrett Universal II performed the best and the Olsen formula performed the worst. The preinstalled version of Olsen was not as good as the standalone version. The Holladay 2 formula performed better when the preoperative refraction was excluded.

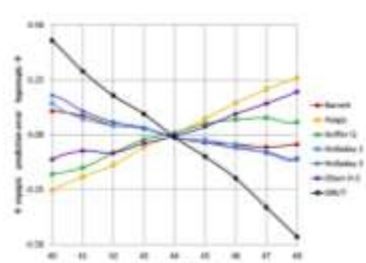
AMERICAN ACADEMY OF OPHTHALMOLOGY

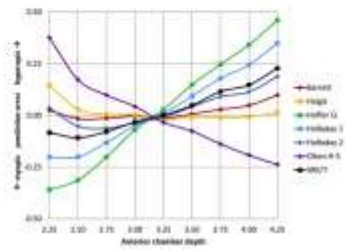
Accuracy of Intraocular Lens Calculation Formulas

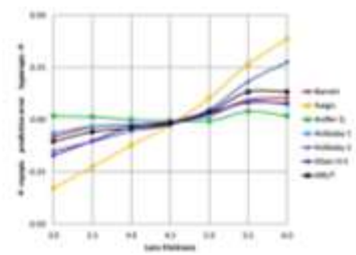
Ronald B. Melles, MD,[1] Jack T. Holladay, MD, MSEE,[2] William J. Chang, MD[1]

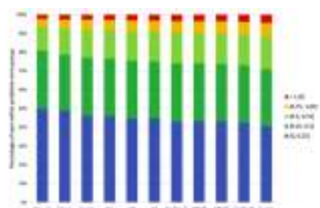
Barrett II, Haigis, Hoffer Q, Olsen, Holladay I, Holladay II, SRK-T   One device OLCR

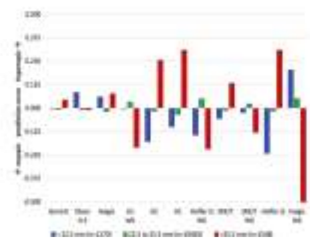












ARTICLE

Accuracy of 3 new methods for intraocular lens power selection

Jack X. Kane, MB BS, Anton Van Heerden, MB ChB, FRANZCO, Alp Atik, MB BS, Constantinos Petsoglou, MB BS, MMed(Clin Epi), FRANZCO

Hill-RBF, Ladas Super Formula, Full Monte VS Barrett II, Holladay I

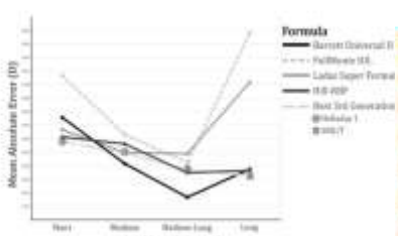
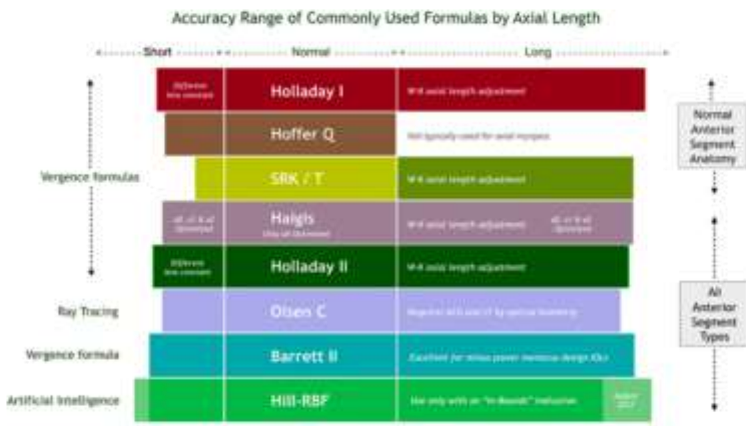


Table 1. Prediction errors over the entire AL range for each formula (n = 3122).

Formula	MAE (D)	MedAE (D)	ME (D)	Prediction Error (% of Eyes) ≤0.50 D	≤1.00 D
Haigis	0.409	0.334	-0.08	69.2	93.6
Hoffer Q	0.417	0.344	-0.02	67.9	93.2
Holladay 1	0.396	0.321	-0.01	70.1	94.3
Holladay 2	0.410	0.327	-0.01	68.2	94.4
SRK/T	0.402	0.330	-0.01	70.4	94.4
Barrett Universal II	0.391	0.300	-0.28	72.6	94.6
T2	0.398	0.330	-0.03	70.8	94.4
Ladas Super Formula	0.403	0.327	-0.04	68.6	94.2
FullMonteIOL	0.408	0.331	-0.11	68.8	93.0
HillRBF	0.407	0.330	-0.13	68.8	94.3

New methods no more accurate for the clinical practice to be changed



www.doctor-hill.com

Wang L, Koch DD. Modified axial length adjustment formulas in long eyes. JCRS 2018; 44:1396-1397.

Special cases

- Short eyes
  - Higher optical power gives more weight to any error in the predicted IOL position
  - Steep cornea & shallow AC
  - Labeled power
- Long eyes
  - Flat corneas
  - Deep AC

One can reliably depend on the Haigis, HofferQ, Holladay 2 & Barret II for short eyes , Barrett II, Haigis, Olsen , SRK-T for long eyes

Hoffer K., Savini G . Asia-Pacific Journal ophthalmol 2017

ARTICLE

Intraocular lens power calculations in short eyes using 7 formulas

Sabite E. Gökce, MD, John H. Zeiter, MS, Mitchell P. Weikert, MD, Douglas D. Koch, MD, Warren Hill, MD, Li Wang, MD, PhD

Table 5. Summary of studies on formula choice in short eyes.

Study	Number of Eyes	AL (mm)	Formulas Used	Results
Gavin	41	<22.0	Hoffer Q, SRK T	Hoffer Q formula significantly more accurate than SRK T
Narvaez	11	<22.0	Hoffer Q, Holladay 1, Holladay 2, SRK/T	No difference in accuracy of IOL power prediction with Hoffer Q, Holladay 1, Holladay 2, SRK/T
Terzi	19	<22.0	Haigis, Holladay 2, Hoffer Q, SRK/T	No statistically significant difference in MAE values between formulas
MacLaren	76	<22.95 (1 eye >22.0)	Haigis, Hoffer Q, Holladay 1, SRK/T	Best MAE and MPE with Haigis formula
Eom	75	<20.0	Haigis, Hoffer Q	No significant difference between MedAE of Hoffer Q and Haigis when ACD >2.4 mm; when ACD < 2.4 mm, more hyperopic correction with Hoffer Q
Roh	25	<22.0	Haigis, Hoffer Q, SRK II, SRK/T	No statistically significant difference between formulas except Haigis vs SRK II
Wang	33	<22.0	Haigis, Hoffer Q, Holladay 1, SRK/T	Comparable results with Haigis and Hoffer Q (both better than Holladay 1 and SRK/T formulas
Aristodemou	497	<22.0	Hoffer Q, Holladay 1, SRK/T	Hoffer Q best for ALs from 20.00 to 20.99 mm; Hoffer Q and Holladay 1 best for ALs from 21.00 to 21.49 mm
Carifi	28	<20.0	Haigis, Hoffer Q, Holladay 1, Holladay 2, SRK/T and SRK II	Not statistically significant trend toward better results with Holladay 2, Haigis, Hoffer Q formulas
Cooke	41	≤22.0	Barrett, T2, Haigis, Hoffer Q, Holladay 1, Holladay 2, SRK/T, Super Formula, Olsen	No formula performed as well for short eyes as for other eyes; MPE far from zero for most
Kane	100	<22.0	Holladay 1, Holladay 2, Barrett Universal II, Haigis, Hoffer Q, SRK/T, T2	No statistically significant difference in MAE and MedAE between 7 formulas in eyes with short AL
Current study	86	≤22.0	Barrett Universal II, Haigis, Hill-RBF, Hoffer Q, Holladay 1, Holladay 2, Olsen	When mean numerical RPE adjusted to zero, no significant difference in MedAEs between 7 formulas

Hoffer Q & Holladay II Slightly myopic

Olsen Slightly hyperopic

Overall formulae perform worse than in normal eyes

Primary Polypseudophakia

- Extremely hyperopic small eyes
- Implantation of two lenses is needed
- Preferably one in the bag , one in the sulcus
- Caution ! Calculation for total power and then subtract for the second lens and adjust for sulcus placement

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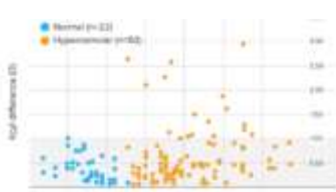
Recommendations for long eyes

- Target moderate amount of myopia (X)
- Use optical biometry IOL adjustment by Wang and Koch (Wang L et al. optimizing IOL power calculations in eyes with axial length over 25.0mm JSCRS 2011 – newer version 2018)
- Barrett II formula (no adjustments)
- Hill- RBF method version 2.0 for IOL power down to -5,00 with an in bound indication

Regular astigmatism
Toric IOLs

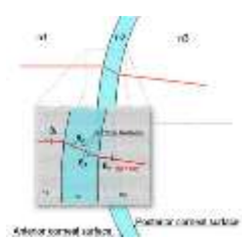
Accurate keratometry



Epitropoulos study

Beware of irregular corneas!

Posterior astigmatism




Correcting astigmatism with toric intraocular lenses: Effect of posterior corneal astigmatism

Underestimate against the rule and overestimate with the rule astigmatism

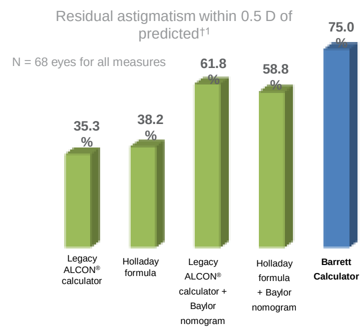
- Regression formulae better
  - Baylor nomogram (based on population average)
  - Abufalia –Koch
  - Koch

  80% ± 0,50 D
- ELP+mathematical estimation of PCS
  - Barrett
  - Post refractive Barrett toric IOL calculation

www.ascrs.org/barrett-tori-calculator

www.apacrs.org

On line calculators



1. Abulafia A, et al. *J Cataract Refract Surg*. 2015; 41(5):936-944

Irregular astigmatism

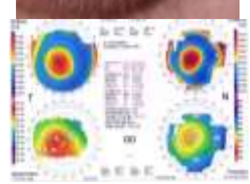
Review Article

Intraocular lens calculations in atypical eyes

Aazim A Siddiqui, Uday Devgan[1]

Indian Journal of ophthalmology 2017

- Paucity of studies
- Suboptimal measurements of AL & keratometry➔ calculation of ELP
- True corneal power measured by corneal tomography
- Use the lowest corneal power readings in the center pupil zone
- Use newer formulas such as Barrett II , Hill RBF rather than traditional ones
- Err towards mild myopia



Toric IOLs?

Post cornea refractive surgery
Sources of error

	Radius error	Keratometry index error	Formula error
Myopic ablation	+/-	+	++
Hyperopic ablation	+/-	+	++
Radial keratotomy	+	-	++

Myopic ablation ➔ hyperopic surprise

Hyperopic ablation ➔ myopic surprise

RK ➔ variable

IOL formulas

- **Use preoperative and postoperative data**
  - Clinical history method (Eifferman & Holladay)

  The effective keratometry value is calculating from substracting the refractive change induced by the treatment from the preoperative mean keratometry values
- **Use change in refraction**
  - Adjusted effective refractive power (EffRP)
  - Adjusted atlas 9000 (4mm)
  - Masket
  - Savini

  Apply a correction to the keratometric value based on the corrected refractive power. A value based on a regression formula deriving the change in refraction was added to the standard calculated IOL power

  Risk of index myopia related errors
- **No history methods**
  - Contact lens overefraction
  - Haigis –L
  - Shammas, Shammas post Lasik
  - Barrett true K
  - OCT based
  - Ray tracing

Web and app base calculators

- ASCRS post refractive calculator (www.iolcalc.org)
- Hoffer-Savini LASIK IOL power calculation tool (www.iolpowerclub.org)
- APACRS Barret true K formula (www.apacrs.org)
- OcularMD Post-LASIK IOL Calculator (www.iol.OcularMD.com)
- McCarthy post refractive IOL calculator
- EyePro application

- Intraoperative aberrometry
  Measurements influenced by viscoelastic, tight speculum, air in A/C, RK etc

- 50-60% within 0,50D of prediction error, up to 70% when ray tracing and intraoperative aberrometry is used

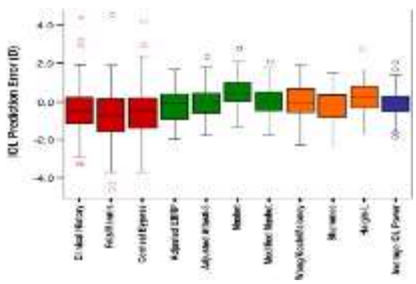
Savini G, Hoffer K. IOL power calculationin eyes with corneal refractive surgery. Eye and Vision 2018

Frain NR, Masket S, Wang L.Comparison of intraoperative aberrometry, OCT based IOL formula, Haigis-L and Masket formula for IOL power calculations after laser vision correction. Ophthalmology 2015

ARTICLE

Evaluation of intraocular lens power prediction methods using the American Society of Cataract and Refractive Surgeons Post-Keratorefractive Intraocular Lens Power Calculator

Li Wang, MD, PhD, Warren E. Hill, MD, Douglas D. Koch, MD



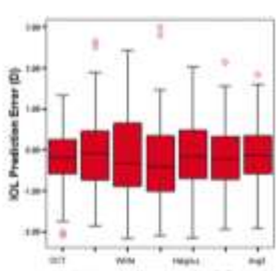
JSCRS 2010

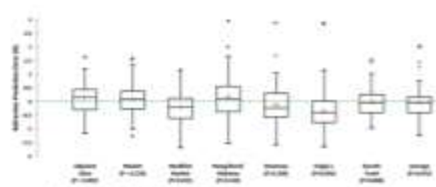
Metaanalysis of intraocular lens power calculation after laser refractive surgery in myopic eyes

For the post myopic laser
- Masket
- Shammas, Shammas post Lasik
- Haigis-L
- Double K methods

Comparison of Newer Intraocular Lens Power Calculation Methods for Eyes after Corneal Refractive Surgery

Accuracy of the Barrett True-K formula for intraocular lens power prediction after laser in situ keratomileusis or photorefractive keratectomy for myopia





Based on this study OCT based & Barrett true-K formulae were included in the ASCRS calculator

Validation and comparison of formulas for RK

Clinical Ophthalmology

ORIGINAL RESEARCH

Evaluation of the American Society of Cataract and Refractive Surgery intraocular lens calculator for eyes with prior radial keratotomy (2011)

↓

ASCRS calculator accurate in IOL prediction in RK eyes, add 1-1,50D to the recommended power

Special Issue

Comparison of Newer IOL Power Calculation Methods for Eyes With Previous Radial Keratotomy

Jack X. Ma, Maolong Tang, Li Wang, Mitchell P. Weikert, David Huang, and Douglas D. Koch

↓

OCT based and Barrett true K was equally good with Holladay Double K, average power can be used

In summary…

- Better IOL power prediction with new formulae but there is still space for improvement
- Current formulae work better in “normal” cases
- Barrett II formula appears to give consistently good results across a wide range of axial lengths
- Refractive surprises are to be expected in atypical eyes

Thank you!