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MEDICAL CENTER

How to Improve Your Refractive Outcomes in Cataract Surgery ?

Adi Abulafia, MD

Modern Cataract surgery =

Cataract extraction + Refractive surgery

Accuracy of Intraocular Lens Calculation Formulas

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

Purpose: To compare the accuracy of intraocular lens (IOL) calculation formulas (Barrett Universal II, Haigis, Hoffer Q, Holladay 1, Holladay 2, Olsen, and SRK/T) in the prediction of postoperative refraction using a single optical biometry device.

Design: Retrospective consecutive case series.

Participants: A total of 13 301 cataract operations with an AcrySof SN60WF implant and 5200 operations with a SA60AT implant (Alcon Laboratories, Inc., Fort Worth, TX).

Table 3. SN60WF Outcomes, Sorted by Standard Deviation

	Mean	SD	Mean AE	Median AE	Percentage of Eyes within Diopter Range Indicated			
					±0.25 D	±0.50 D	±0.75 D	±1.00 D
Barrett	0.000	0.404	0.311	0.252	49.8%	80.8%	93.7%	97.8%
$Olsen_{H-S}$	0.000	0.424	0.325	0.258	48.8%	78.7%	92.5%	97.4%
Haigis	0.000	0.437	0.338	0.275	46.1%	77.1%	91.9%	97.3%

Conclusions: Overall, the Barrett Universal II formula had the lowest prediction error for the 2 IOL models studied. *Ophthalmology 2018;125:169-178*


1 out of 5 !

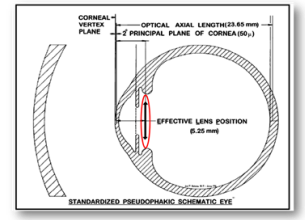
Sources of errors in IOL power prediction

Measurements

Formula

Other

(i.e. Post op refraction, IOL Manufacturing tolerance/labeling, etc.)



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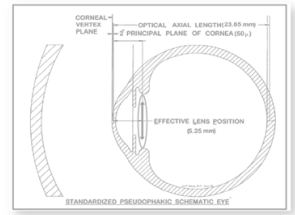



TOMEY


ALADDIN


LENSTAR
OD


NIDEK

LENSTAR LS 900 Calibration

Weekly nullification - - - - - - - - - - - - - - - - SUCCESSFUL

Keratometry

Ocular surface (improvement necessary?) - - - - - - NORMAL
K_1 & K_2 SD (maximum value, each eye) - - - - - - - - - - ±0.25 D
Avg K power difference (between eyes) - - - - - - < 1.25 D
Avg K power (each eye) - - - - - - > 40.00 D and < 48.00 D
Steep meridian SD (maximum value, each eye) - - - - ± 3.5°
AST (maximum value, each eye) - - - - - - - - - - - - - - - < 4.25 D
Reflected LED images (all meridians) - - - GOOD QUALITY

T-cone Topography

Calibration -
All measurements - - - - - - - - - CO
Topo maps (AC, T, E & Rings) -
K_1, K_2 & A1 (all five me

Additio / Studies

Phakic ACD 4 mm or < 1.8 mm - - - - MD CONFIRMS
OD / OS AL difference > 0.33 mm - - - - MD CONFIRMS
OD / OS avg K power > 1.25 D - - - - - - MD CONFIRMS
AST > 4.25 D (KCN?) - - - - - - TOPOGRAPHIC AXIAL MAP
Avg K power > 48.00 D or < 40.00 D - - - MD CONFIRMS

Axial Measurements

Measurement mode (phakic, silicone oil, etc.) - - CORRECT
Fixation light (visualization by patient) - - - - - - - - - - - STEADY
5 consistent measurements - - - - - - - - - - CONFIRMED
Caliper placement (cornea, lens & retina) - CORRECT
CCT (prior myopic LASIK?) - - - - - - - - < 620 µm
Phakic ACD (each eye) - - - < 4.4 mm
Lens thickness (ea and < 6.2 mm
OD & OS a - - - WITHIN 0.33 mm
AL x SphEq - - - - - CONFIRMED
- DELETE & REPEAT

to White

Limbus ring - - - - - - - - - - - - - - - - ADJUST AS REQUIRED
Avg WTW (unusual Ks, ACD or AL?) - - - > 10.0 and < 13.0 mm
Avg WTW (each eye) - - - - - - - - - - - - - - - - - WITHIN 0.1 mm
Avg WTW (between eyes) - - - - - - - - - - - - - - WITHIN 0.2 mm

Additional Validation / Studies

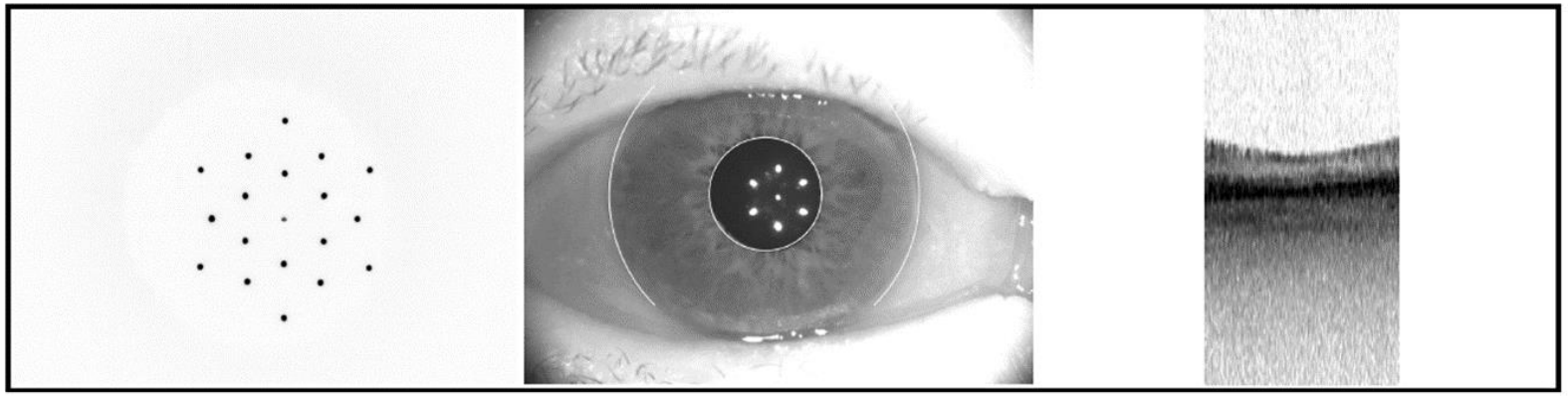
Phakic ACD > 4.4 mm or < 1.8 mm - - - - MD CONFIRMS
OD / OS AL difference > 0.33 mm - - - - MD CONFIRMS
OD / OS avg K power > 1.25 D - - - - - - MD CONFIRMS
AST > 4.25 D (KCN?) - - - - - - TOPOGRAPHIC AXIAL MAP
Avg K power > 48.00 D or < 40.00 D - - - MD CONFIRMS

Warren E. Hill, MD - LENSTAR LS 900

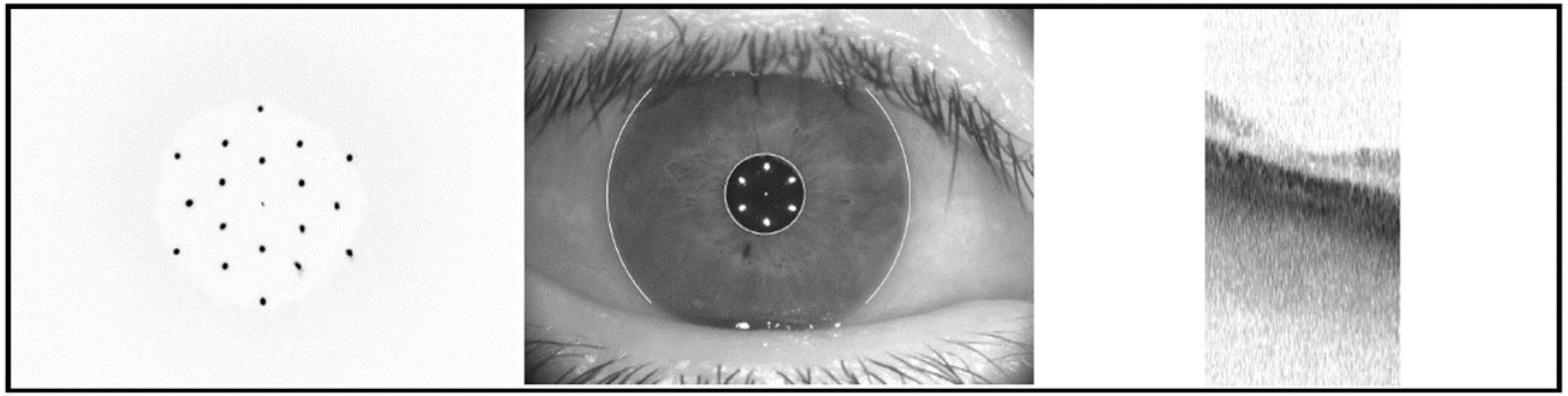
Use Validation Criteria!

http://www.doctor-hill.com

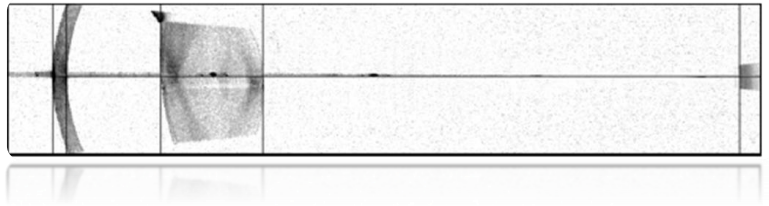
Enhanced evaluation of measurements quality



X



Axial length



SDs ~ 0.010 mm for an OLCR and a SS-OCT devices → < 0.05 D[1]

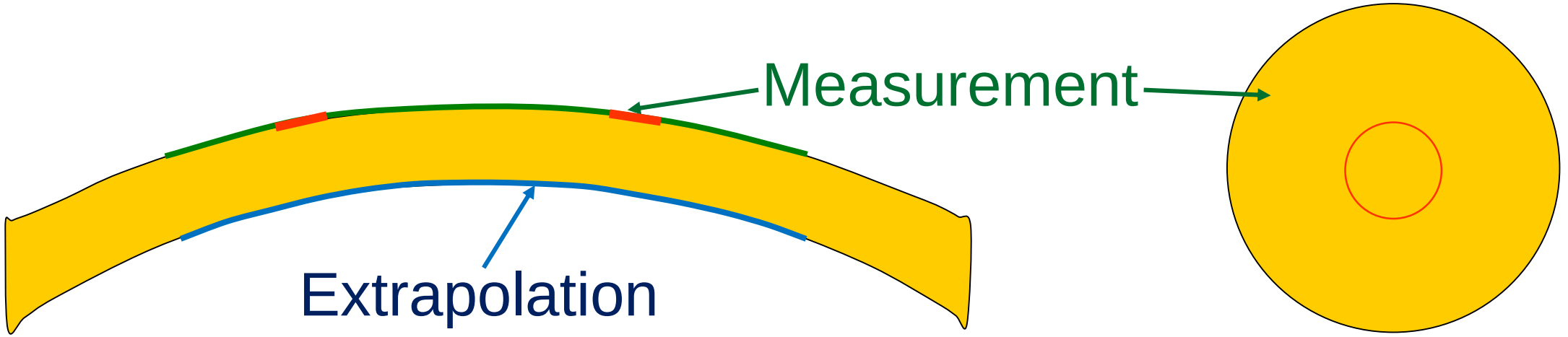
Higher success rates in measuring AL with SS-OCT:

- SS_OCT (96%) Vs OLCR (79%) Vs PCI (77%) [2]
- SS-OCT (96%) Vs OLCR (79%) [3]

[1]Koch DD. Am J Ophthalmol. 2016; 171: xv–xxx ; [2]Shammas HJ et al. JCRS 2016; 42:50–61 ; [3]Kurian M et al. JCRS 2016; 42:577–581

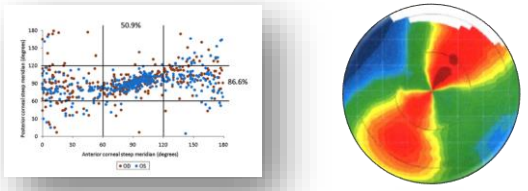
Keratometry

- ❑ **Measure the anterior cornea (in limited zones)**
- ❑ **Extrapolate posterior corneal curvature**
  - Use population average P/A ratio
  - To calculate the estimated total cornea power



Errors from extrapolating posterior corneal power by a fixed ratio:

Toric IOL calculations - posterior corneal astigmatism



Atypical corneas - P/A ratio no longer valid:

Variability of the P/A ratio in "Normal" corneas (~0.50 D)!

Koch DD. Am J Ophthalmol. 2016; 171: xv–xxx

Solutions for measuring the total corneal power:

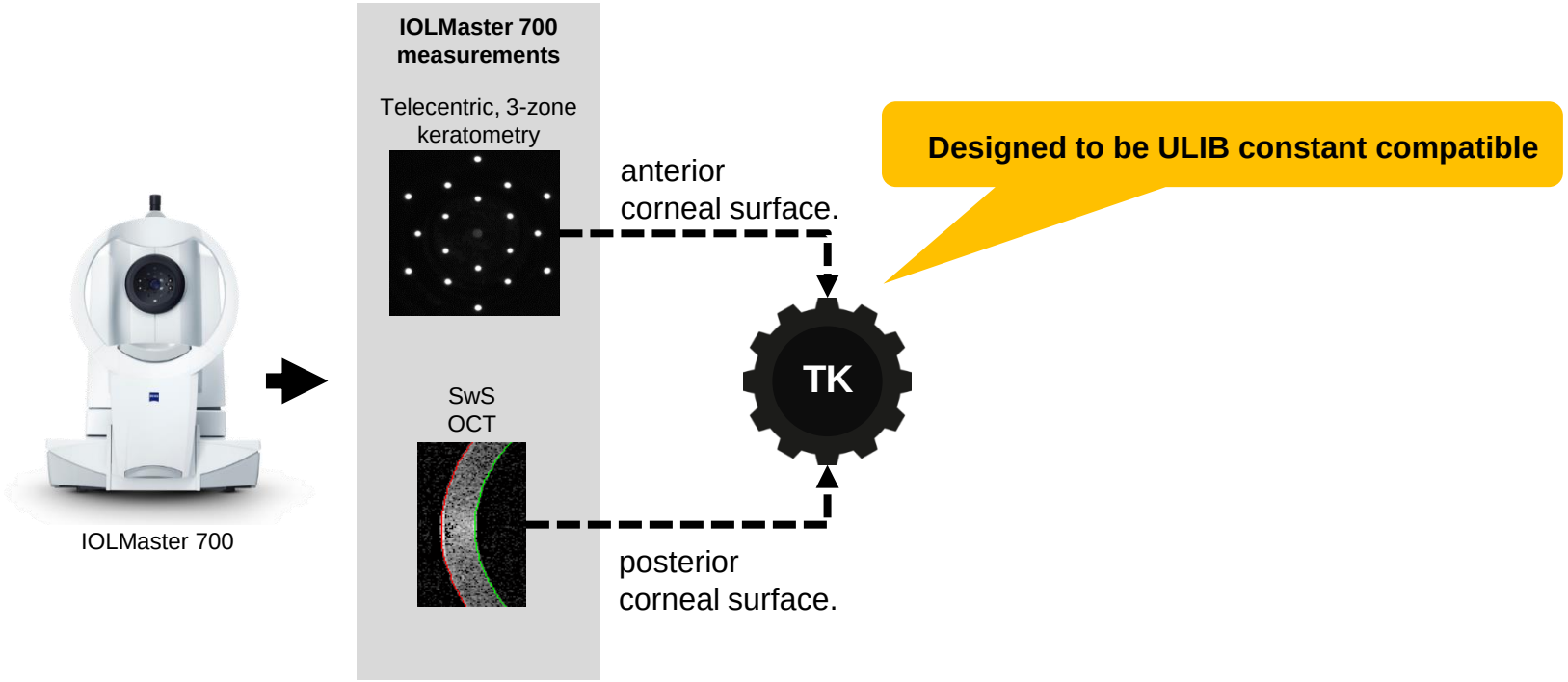
Scheimpflug

SS-OCT

Color-LED

Intraoperative Refractive Biometry

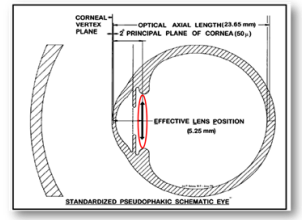
The IOLMaster 700 - Total Keratometry (TK)



Sources of errors in IOL power prediction

- Measurements
- **Formula**
- Other

  (i.e. Post op refraction, IOL Manufacturing tolerance/labeling, configuration of the capsulorhexis, etc.)



2 Variables Vergence Formulas

Incorrect assumptions

The ant & post segments of the eye are mostly proportional

Keratometry and ACD are always related.

SRK®/T

A-const: 119.10

IOL (D)	REF (D)
21.5	-1.56
21.0	-1.23
20.5	-0.90
20.0	**-0.58**
19.5	-0.25
19.0	0.06
18.5	0.38

Emme. IOL: 19.10

Holladay

SF: 1.80

IOL (D)	REF (D)
21.0	-1.60
20.5	-1.26
20.0	-0.93
19.5	**-0.60**
19.0	-0.27
18.5	0.05
18.0	0.37

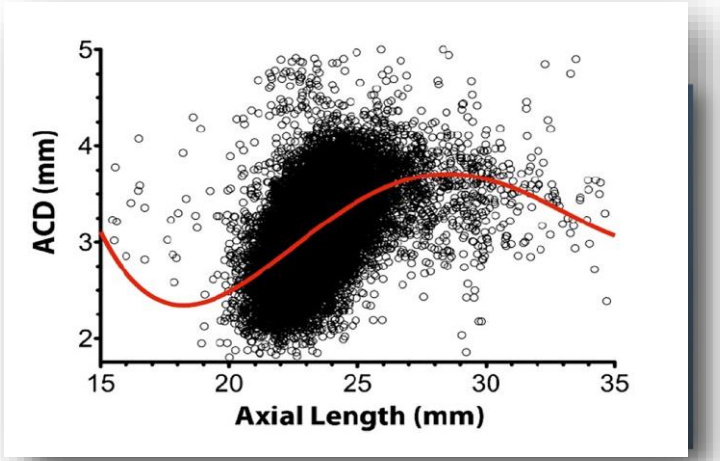
Emme. IOL: 18.58

HofferQ

pACD const: 5.61

IOL (D)	REF (D)
20.5	-1.4
20.0	-1.1
19.5	-0.8
19.0	**-0.4**
18.5	-0.1
18.0	0.2
17.5	0.5

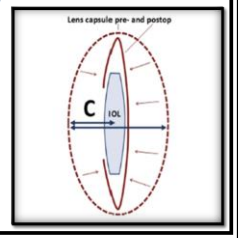
Emme. IOL: 18.33



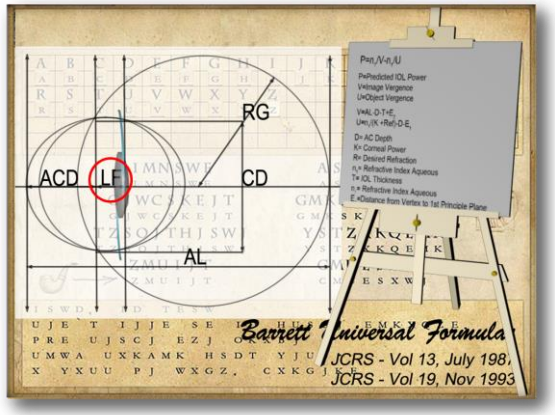
New IOL Power Calculation Formulas

The Olsen Formula

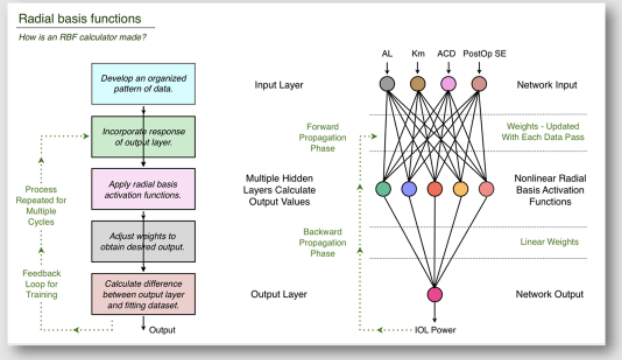
- Uses ray tracing to correct for spherical aberrations of the cornea and the IOL
- C-constant – to estimate the physical IOL position by using the pre-operative ACD and LT measurements

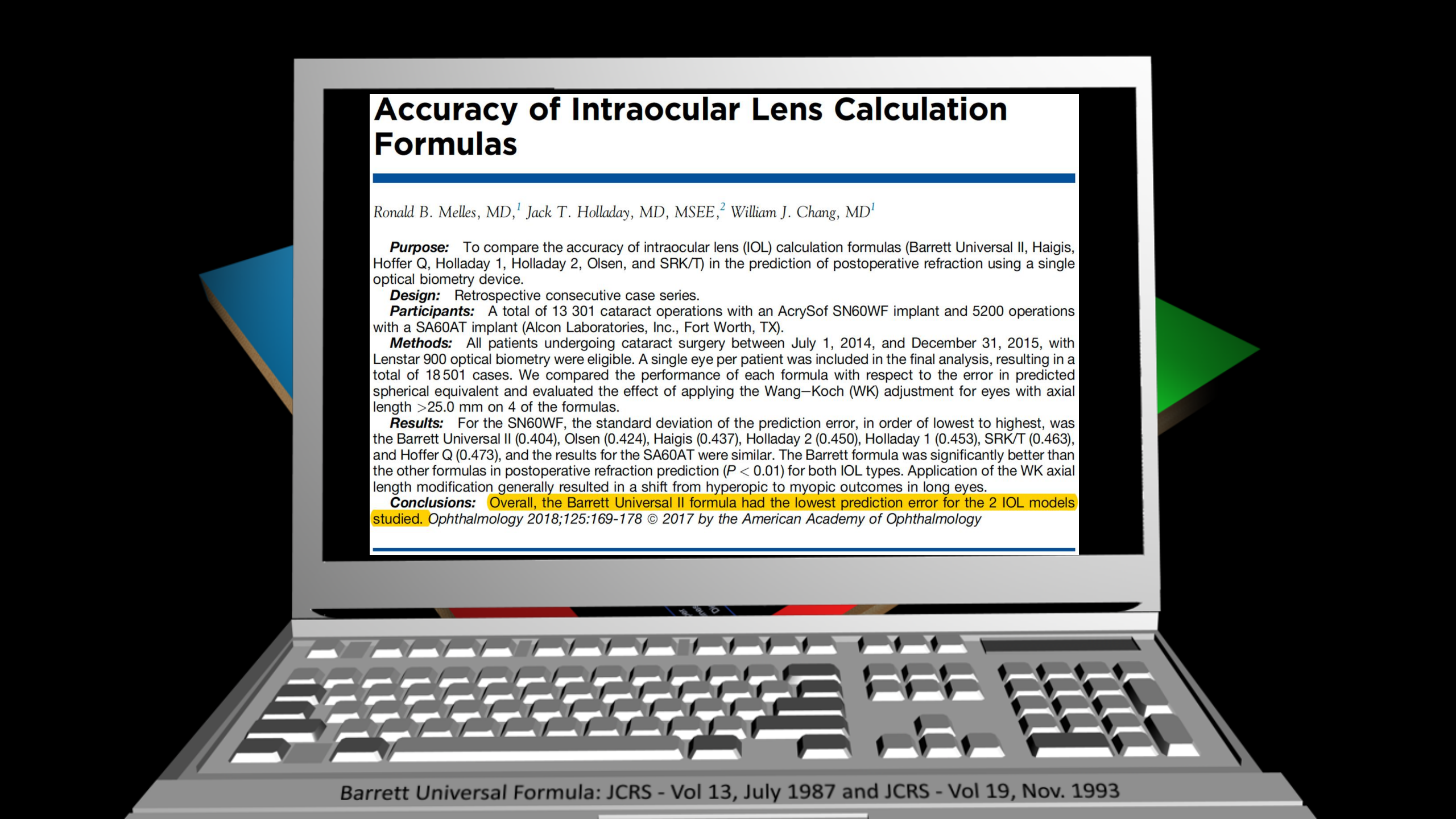


The Barrett Universal II formula



Hill RBF Calculator

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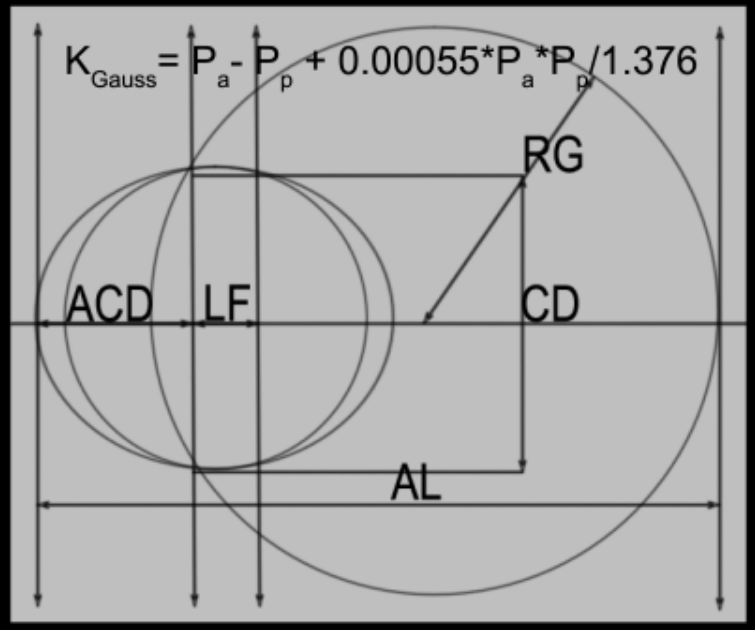
Design: Retrospective consecutive case series.
Participants: A total of 13 301 cataract operations with an AcrySof SN60WF implant and 5200 operations with a SA60AT implant (Alcon Laboratories, Inc., Fort Worth, TX).
Methods: All patients undergoing cataract surgery between July 1, 2014, and December 31, 2015, with Lenstar 900 optical biometry were eligible. A single eye per patient was included in the final analysis, resulting in a total of 18 501 cases. We compared the performance of each formula with respect to the error in predicted spherical equivalent and evaluated the effect of applying the Wang–Koch (WK) adjustment for eyes with axial length >25.0 mm on 4 of the formulas.
Results: For the SN60WF, the standard deviation of the prediction error, in order of lowest to highest, was the Barrett Universal II (0.404), Olsen (0.424), Haigis (0.437), Holladay 2 (0.450), Holladay 1 (0.453), SRK/T (0.463), and Hoffer Q (0.473), and the results for the SA60AT were similar. The Barrett formula was significantly better than the other formulas in postoperative refraction prediction (P < 0.01) for both IOL types. Application of the WK axial length modification generally resulted in a shift from hyperopic to myopic outcomes in long eyes.
Conclusions: Overall, the Barrett Universal II formula had the lowest prediction error for the 2 IOL models studied. Ophthalmology 2018;125:169-178 © 2017 by the American Academy of Ophthalmology
Barrett Universal Formula: JCRS - Vol 13, July 1987 and JCRS - Vol 19, Nov. 1993

Barrett Universal II

$$K_{Gauss} = P_a - P_p + 0.00055 * P_a * P_p / 1.376$$



ELP
Prediction

AL, Ks, ACD, LT, WTW

Barrett Universal Formula: JCRS - Vol 13, July 1987 and JCRS - Vol 19, Nov. 1993

	Barrett Universal II	Barrett TK Universal II
Mean Error (D)	0.00	0.00
STDev (D)	0.38	0.35
MAE (D)	0.30	0.29
Median AE (D)	0.27	0.26
≤ 0.50 D	85.2%	88.9%
≤ 0.75 D	94.4%	96.3%
≤ 1.00 D	97.2%	99.1%

N = 108

Barrett, ESCRS Lisbon 2017

How can we improve our refractive outcomes in cataract surgery?

Validate our measurements

Advanced IOL power calculation formulas

New biometry devices

- **Accurate**
- **Robust**
- **± Posterior cornea**

Thank you.