# What's The Kraze with Total Keratometry?

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KAMRAN M. RIAZ, MD
CLINICAL ASSOCIATE PROFESSOR
DIRECTOR OF MEDICAL STUDENT RESEARCH
CATARACT, CORNEA, EXTERNAL DISEASE AND REFRACTIVE SURGERY
DEAN MCGEE EYE INSTITUTE, UNIVERSITY OF OKLAHOMA
KAMRAN-RIAZ@DMEI.ORG

## Financial Disclosures

- I have no financial interests in this lecture or any information discussed therein
- Unrelated Disclosures:
  Bausch & Lomb – Speaker
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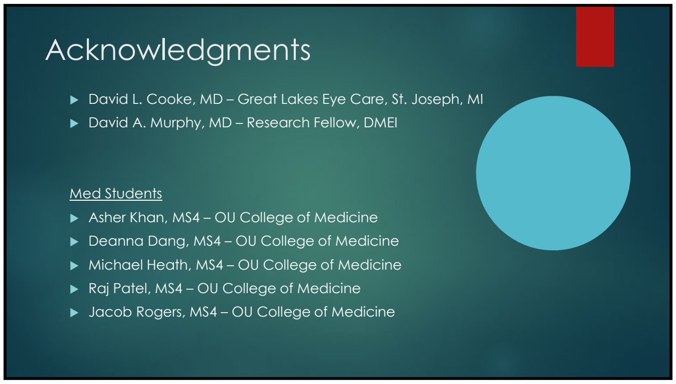

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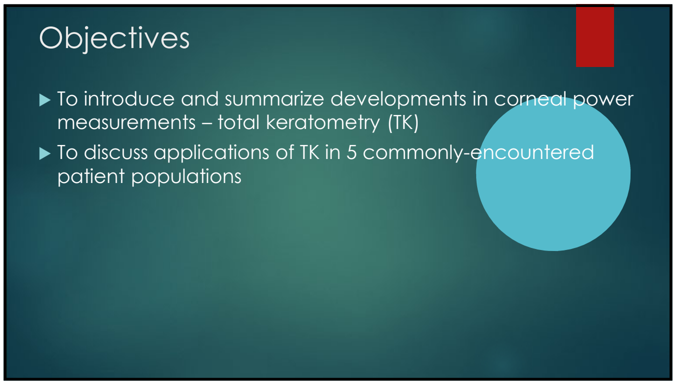
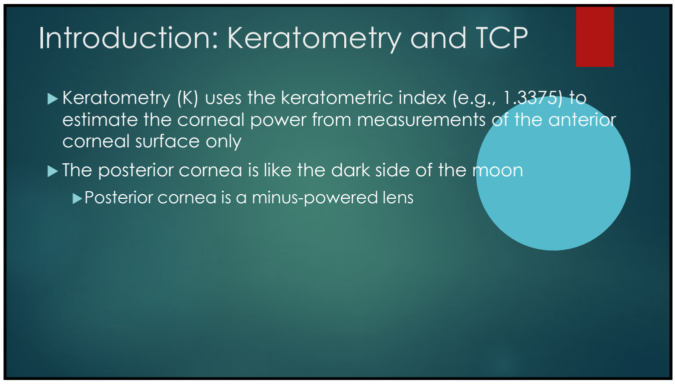


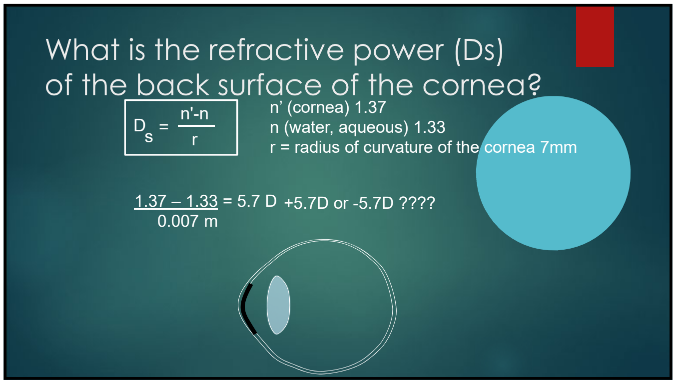
## Objectives

- To introduce and summarize developments in corneal power measurements – total keratometry (TK)
- To discuss applications of TK in 5 commonly-encountered patient populations



## Introduction: Keratometry and TCP

- Keratometry (K) uses the keratometric index (e.g., 1.3375) to estimate the corneal power from measurements of the anterior corneal surface only
- The posterior cornea is like the dark side of the moon
  - Posterior cornea is a minus-powered lens

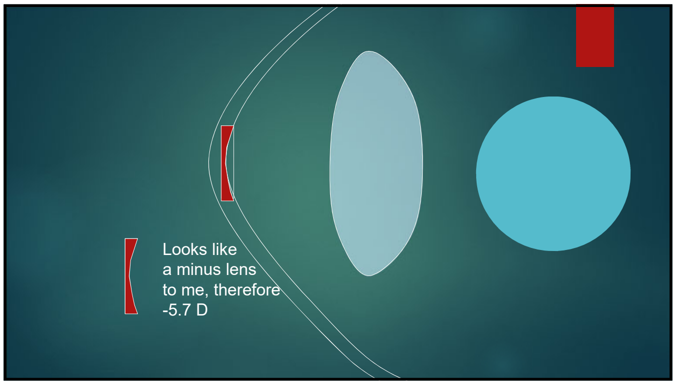


## What is the refractive power (Ds) of the back surface of the cornea?

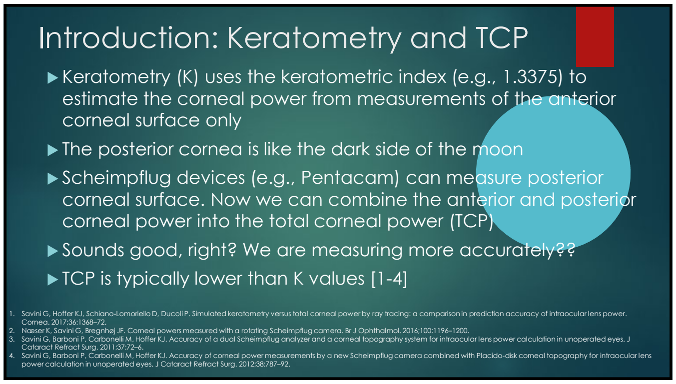
$$\boxed{D_s = \frac{n'-n}{r}}$$

n' (cornea) 1.37
n (water, aqueous) 1.33
r = radius of curvature of the cornea 7mm

$$\frac{1.37 - 1.33}{0.007 \text{ m}} = 5.7 \text{ D}$$ +5.7D or -5.7D ????



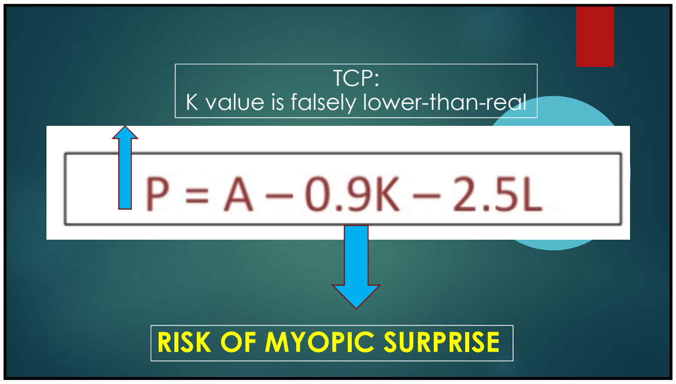
Looks like a minus lens to me, therefore -5.7 D



## Introduction: Keratometry and TCP

- Keratometry (K) uses the keratometric index (e.g., 1.3375) to estimate the corneal power from measurements of the anterior corneal surface only
- The posterior cornea is like the dark side of the moon
- Scheimpflug devices (e.g., Pentacam) can measure posterior corneal surface. Now we can combine the anterior and posterior corneal power into the total corneal power (TCP)
- Sounds good, right? We are measuring more accurately??
- TCP is typically lower than K values [1-4]

1. Savini G, Hoffer KJ, Schiano-Lomoriello D, Ducoli P. Simulated keratometry versus total corneal power by ray tracing: a comparison in prediction accuracy of intraocular lens power. Cornea. 2017;36:1368–72.
2. Næser K, Savini G, Bregnhøj JF. Corneal powers measured with a rotating Scheimpflug camera. Br J Ophthalmol. 2016;100:1196–1200.
3. Savini G, Barboni P, Carbonelli M, Hoffer KJ. Accuracy of a dual Scheimpflug analyzer and a corneal topography system for intraocular lens power calculation in unoperated eyes. J Cataract Refract Surg. 2011;37:72–6.
4. Savini G, Barboni P, Carbonelli M, Hoffer KJ. Accuracy of corneal power measurements by a new Scheimpflug camera combined with Placido-disk corneal topography for intraocular lens power calculation in unoperated eyes. J Cataract Refract Surg. 2012;38:787–92.



TCP:
K value is falsely lower-than-real

$$P = A - 0.9K - 2.5L$$

RISK OF MYOPIC SURPRISE

# Corneal Power Measurements with Optical Biometry

- Corneal Power Measurements: Assumed measurement of posterior cornea based on Gullstrand ratio → more "inaccuracy" in steep/flat K eyes, which often occur independently and concurrently with short/long AXL eyes
- Posterior corneal astigmatism: usually contributes ATR astigmatism
  - Range from -0.26 to -0.78D[1]
  - How does ATR contribute to the measured corneal astigmatism?
    - Negative: may decrease the WTR of the total corneal astigmatism
    - Poor: if we measure oblique astigmatism
    - Additive: may add to the ATR of the total corneal astigmatism
- How to measure posterior corneal curvature?
  - Indirect measurements: Nomograms (Baylor, Abulafia-Koch) vs IOL Formulas (online, Barrett, etc.)
  - Direct measurement: Scheimpflug device, Purkinje Images, SS-OCT (Total K on IOL Master 700)

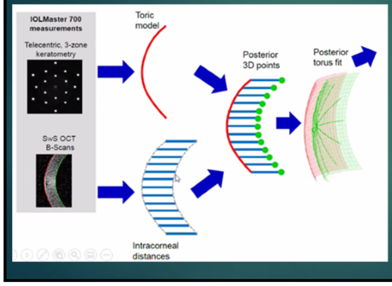
1. Koch DD, et al. Contribution of posterior corneal astigmatism to total corneal astigmatism. JCRS 2012; 38: 2080-7

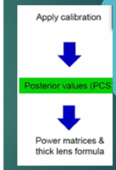
# Total Keratometry (TK)

- The IOL Master 700 (Carl Zeiss Meditec AG, Jena, Germany) is a swept-source OCT (SS-OCT) biometer that uses
  - Telecentric keratometry for anterior keratometry measurements
  - SS-OCT acquired pachymetry to define a toric posterior surface model for posterior corneal measurements
  - The resulting total keratometry (TK) value offers the surgeon a measurement of the anterior and posterior corneal radii that can potentially be used for more accurate IOL calculations
- TK does not differ from standard K in most normal K range unoperated eyes and post-excimer laser surgery eyes.
  - But TK and TCA values are NOT interchangeable [1]
- Allows surgeons to use TK values compatible with established IOL formula constants

Savini, G., Taroni, L., Schiano-Lomoriello, D. *et al.* Repeatability of total Keratometry and standard Keratometry by the IOLMaster 700 and comparison to total corneal astigmatism by Scheimpflug imaging. *Eye* **35**, 307–315 (2021)

# TK on IOL Master 700





Some evidence that TK works well for post-refractive eyes, but still unclear for virgin eyes, especially for extreme flat/steep Ks

## Is TK Better? Well…

- Depends on the study and what it looked at

Regular Eyes

- Conventional K and TK similar; trend towards better outcomes with TK (60 eyes) [8]
- TK works better with formulas optimized for it, such as Barrett TK [9]

Presbyopia-Correcting IOLs

- TK may help improve outcomes of toric tri-focal IOLs [1]
- However, conventional K is better than TK in MFIOLs [2]

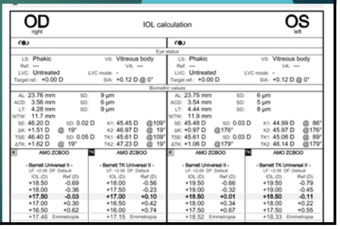
Post-Laser Vision Correction

- TK can help better measure corneal power in post-SMILE patients [3]
- TK doesn't make existing post-LASIK formulas (ASCRS website) better; Barrett True-K with conventional K worked best. (*IOA did not improve results!*). [4] TK makes Haigis better.[5]
- TK used with customized post-LASIK formulas (ie, BTK with TK) is superior (Barrett is author)[6]
- TK can make some existing formulas (not optimized for post-LASIK) better, such as Evo and Haigis (author was developer of Evo)[7]

- Bottom line: we're not sure how much TK helps and in which eyes it helps

## Where Can TK Potentially Help?

- At this time, no convincing evidence that TK helps improve outcomes in "normal" eyes
  - Normal range AL
  - Normal range Ks (especially without previous laser vision correction)
- For ~90% of most cataract surgeries, TK values may not help "that" much
- Approximately 0.25D difference on most eyes between K and TK values
- Barrett TK Universal II (built into IOLM): requires no additional surgeon effort
- Not worth inputting TK values manually into online-formula websites for "normal" eyes



OD right

IOL calculation

OS left

Eye status

| OD | | OS | |
|---|---|---|---|
| LS: Phakic | VS: Vitreous body | LS: Phakic | VS: Vitreous body |
| Ref: --- | VA: --- | Ref: --- | VA: --- |
| LVC: Untreated | LVC mode: - | LVC: Untreated | LVC mode: - |
| Target ref.: +0.00 D | SIA: +0.12 D @ 0° | Target ref.: +0.00 D | SIA: +0.12 D @ 0° |

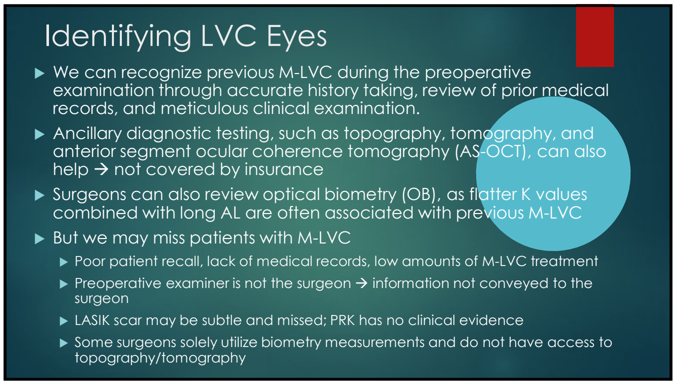
Biometric values

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AL: 23.76 mm | SD: 9 µm | | | AL: 23.75 mm | SD: 6 µm | | |
| ACD: 3.56 mm | SD: 6 µm | | | ACD: 3.54 mm | SD: 5 µm | | |
| LT: 4.28 mm | SD: 9 µm | | | LT: 4.44 mm | SD: 8 µm | | |
| WTW: 11.7 mm | | | | WTW: 11.9 mm | | | |
| SE: 46.20 D | SD: 0.02 D | K1: 45.45 D | @109° | SE: 45.48 D | SD: 0.03 D | K1: 44.99 D | @ 86° |
| ΔK: +1.51 D | @ 19° | K2: 46.97 D | @ 19° | ΔK: +0.97 D | @176° | K2: 45.97 D | @176° |
| TSE: 46.40 D | SD: 0.05 D | TK1: 45.61 D | @109° | TSE: 45.61 D | SD: 0.03 D | TK1: 45.08 D | @ 89° |
| ΔTK: +1.62 D | @ 19° | TK2: 47.23 D | @ 19° | ΔTK: +1.06 D | @179° | TK2: 46.14 D | @179° |

| K AMO ZCBOO | | TK AMO ZCBOO | | K AMO ZCBOO | | TK AMO ZCBOO | |
|---|---|---|---|---|---|---|---|
| - Barrett Universal II - | | - Barrett TK Universal II - | | - Barrett Universal II - | | - Barrett TK Universal II - | |
| LF: +2.06 DF: Default | | LF: +2.06 DF: Default | | LF: +2.06 DF: Default | | LF: +2.06 DF: Default | |
| IOL (D) | Ref (D) | IOL (D) | Ref (D) | IOL (D) | Ref (D) | IOL (D) | Ref (D) |
| +18.50 | -0.69 | +18.00 | -0.56 | +19.50 | -0.66 | +19.50 | -0.79 |
| +18.00 | -0.36 | +17.50 | -0.23 | +19.00 | -0.32 | +19.00 | -0.45 |
| **+17.50** | **-0.03** | **+17.00** | **+0.10** | **+18.50** | **+0.01** | **+18.50** | **-0.11** |
| +17.00 | +0.30 | +16.50 | +0.42 | +18.00 | +0.34 | +18.00 | +0.22 |
| +16.50 | +0.62 | +16.00 | +0.74 | +17.50 | +0.67 | +17.50 | +0.55 |
| +17.46 | Emmetropia | +17.15 | Emmetropia | +18.52 | Emmetropia | +18.33 | Emmetropia |

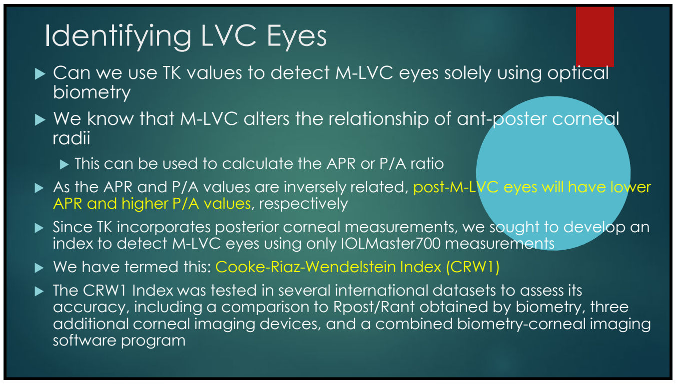
## Where Can TK Potentially Help?

1. Identifying Post-Laser Vision Correction (LVC) Eyes
2. Refractive Outcomes in Post-LVC Eyes
3. Refractive Outcomes in Keratoconus Eyes
4. Refractive Outcomes in Extreme K (non-ectatic, non LVC) Eyes
5. Refractive Outcomes in Combined Phaco-DMEK Eyes
6. Refractive Outcomes in Post Penetrating Keratoplasty Eyes



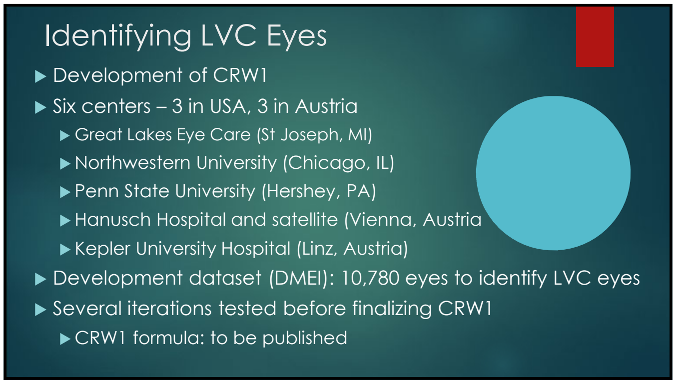
## Identifying LVC Eyes

- We can recognize previous M-LVC during the preoperative examination through accurate history taking, review of prior medical records, and meticulous clinical examination.
- Ancillary diagnostic testing, such as topography, tomography, and anterior segment ocular coherence tomography (AS-OCT), can also help → not covered by insurance
- Surgeons can also review optical biometry (OB), as flatter K values combined with long AL are often associated with previous M-LVC
- But we may miss patients with M-LVC
  - Poor patient recall, lack of medical records, low amounts of M-LVC treatment
  - Preoperative examiner is not the surgeon → information not conveyed to the surgeon
  - LASIK scar may be subtle and missed; PRK has no clinical evidence
  - Some surgeons solely utilize biometry measurements and do not have access to topography/tomography



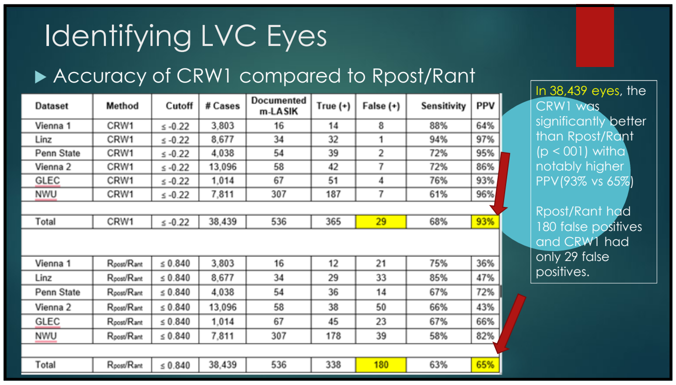
## Identifying LVC Eyes

- Can we use TK values to detect M-LVC eyes solely using optical biometry
- We know that M-LVC alters the relationship of ant-poster corneal radii
  - This can be used to calculate the APR or P/A ratio
- As the APR and P/A values are inversely related, post-M-LVC eyes will have lower APR and higher P/A values, respectively
- Since TK incorporates posterior corneal measurements, we sought to develop an index to detect M-LVC eyes using only IOLMaster700 measurements
- We have termed this: Cooke-Riaz-Wendelstein Index (CRW1)
- The CRW1 Index was tested in several international datasets to assess its accuracy, including a comparison to Rpost/Rant obtained by biometry, three additional corneal imaging devices, and a combined biometry-corneal imaging software program



## Identifying LVC Eyes

- Development of CRW1
- Six centers – 3 in USA, 3 in Austria
  - Great Lakes Eye Care (St Joseph, MI)
  - Northwestern University (Chicago, IL)
  - Penn State University (Hershey, PA)
  - Hanusch Hospital and satellite (Vienna, Austria
  - Kepler University Hospital (Linz, Austria)
- Development dataset (DMEI): 10,780 eyes to identify LVC eyes
- Several iterations tested before finalizing CRW1
  - CRW1 formula: to be published



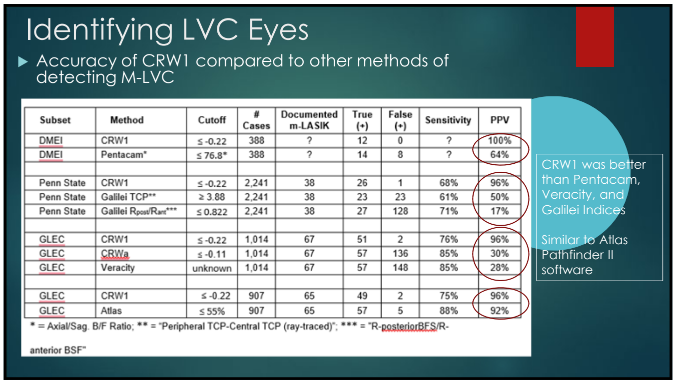
# Identifying LVC Eyes

- Accuracy of CRW1 compared to Rpost/Rant

| Dataset | Method | Cutoff | # Cases | Documented m-LASIK | True (+) | False (+) | Sensitivity | PPV |
|---|---|---|---|---|---|---|---|---|
| Vienna 1 | CRW1 | ≤ -0.22 | 3,803 | 16 | 14 | 8 | 88% | 64% |
| Linz | CRW1 | ≤ -0.22 | 8,677 | 34 | 32 | 1 | 94% | 97% |
| Penn State | CRW1 | ≤ -0.22 | 4,038 | 54 | 39 | 2 | 72% | 95% |
| Vienna 2 | CRW1 | ≤ -0.22 | 13,096 | 58 | 42 | 7 | 72% | 86% |
| GLEC | CRW1 | ≤ -0.22 | 1,014 | 67 | 51 | 4 | 76% | 93% |
| NWU | CRW1 | ≤ -0.22 | 7,811 | 307 | 187 | 7 | 61% | 96% |
| | | | | | | | | |
| Total | CRW1 | ≤ -0.22 | 38,439 | 536 | 365 | 29 | 68% | 93% |
| | | | | | | | | |
| Vienna 1 | $R_{post}/R_{ant}$ | ≤ 0.840 | 3,803 | 16 | 12 | 21 | 75% | 36% |
| Linz | $R_{post}/R_{ant}$ | ≤ 0.840 | 8,677 | 34 | 29 | 33 | 85% | 47% |
| Penn State | $R_{post}/R_{ant}$ | ≤ 0.840 | 4,038 | 54 | 36 | 14 | 67% | 72% |
| Vienna 2 | $R_{post}/R_{ant}$ | ≤ 0.840 | 13,096 | 58 | 38 | 50 | 66% | 43% |
| GLEC | $R_{post}/R_{ant}$ | ≤ 0.840 | 1,014 | 67 | 45 | 23 | 67% | 66% |
| NWU | $R_{post}/R_{ant}$ | ≤ 0.840 | 7,811 | 307 | 178 | 39 | 58% | 82% |
| | | | | | | | | |
| Total | $R_{post}/R_{ant}$ | ≤ 0.840 | 38,439 | 536 | 338 | 180 | 63% | 65% |

In 38,439 eyes, the CRW1 was significantly better than Rpost/Rant (p < 001) witha notably higher PPV(93% vs 65%)

Rpost/Rant had 180 false positives and CRW1 had only 29 false positives.



# Identifying LVC Eyes

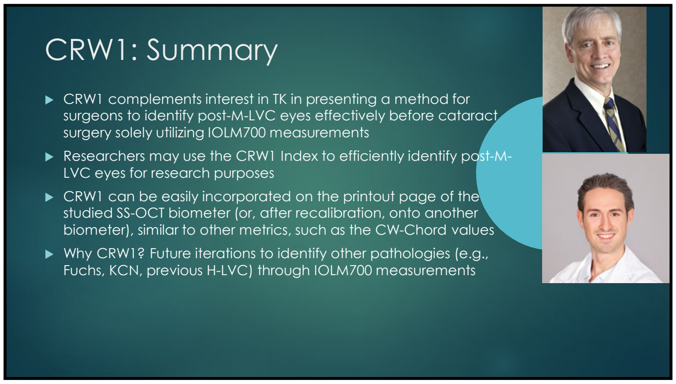
- Accuracy of CRW1 compared to other methods of detecting M-LVC

| Subset | Method | Cutoff | # Cases | Documented m-LASIK | True (+) | False (+) | Sensitivity | PPV |
|---|---|---|---|---|---|---|---|---|
| DMEI | CRW1 | ≤ -0.22 | 388 | ? | 12 | 0 | ? | 100% |
| DMEI | Pentacam* | ≤ 76.8* | 388 | ? | 14 | 8 | ? | 64% |
| | | | | | | | | |
| Penn State | CRW1 | ≤ -0.22 | 2,241 | 38 | 26 | 1 | 68% | 96% |
| Penn State | Galilei TCP** | ≥ 3.88 | 2,241 | 38 | 23 | 23 | 61% | 50% |
| Penn State | Galilei $R_{post}/R_{ant}$*** | ≤ 0.822 | 2,241 | 38 | 27 | 128 | 71% | 17% |
| | | | | | | | | |
| GLEC | CRW1 | ≤ -0.22 | 1,014 | 67 | 51 | 2 | 76% | 96% |
| GLEC | CRWa | ≤ -0.11 | 1,014 | 67 | 57 | 136 | 85% | 30% |
| GLEC | Veracity | unknown | 1,014 | 67 | 57 | 148 | 85% | 28% |
| | | | | | | | | |
| GLEC | CRW1 | ≤ -0.22 | 907 | 65 | 49 | 2 | 75% | 96% |
| GLEC | Atlas | ≤ 55% | 907 | 65 | 57 | 5 | 88% | 92% |

* = Axial/Sag. B/F Ratio; ** = "Peripheral TCP-Central TCP (ray-traced)"; *** = "R-posteriorBFS/R-anterior BSF"

CRW1 was better than Pentacam, Veracity, and Galilei Indices

Similar to Atlas Pathfinder II software



# CRW1: Summary

- CRW1 complements interest in TK in presenting a method for surgeons to identify post-M-LVC eyes effectively before cataract surgery solely utilizing IOLM700 measurements
- Researchers may use the CRW1 Index to efficiently identify post-M-LVC eyes for research purposes
- CRW1 can be easily incorporated on the printout page of the studied SS-OCT biometer (or, after recalibration, onto another biometer), similar to other metrics, such as the CW-Chord values
- Why CRW1? Future iterations to identify other pathologies (e.g., Fuchs, KCN, previous H-LVC) through IOLM700 measurements

# Refractive Outcomes in M-LVC Eyes

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## TK in M-LVC Eyes

- Previous authors have shown that TK values can make older-generation formulas, such as Haigis, to perform as similar as post-refractive formulas[1]
- Question: Can TK values used with multivariable formulas help improve refractive accuracy in these challenging post M-LVC eyes?
- Or does simply using a formula dedicated for post M-LVC eyes with traditional K values work better?

[1] Wang L, Spektor T, de Souza RG, Koch DD. Evaluation of total keratometry and its accuracy for intraocular lens power calculation in eyes after corneal refractive surgery. *J Cataract Refract Surg*. 2019;45(10):1416-1421. doi:10.1016/j.jcrs.2019.05.020

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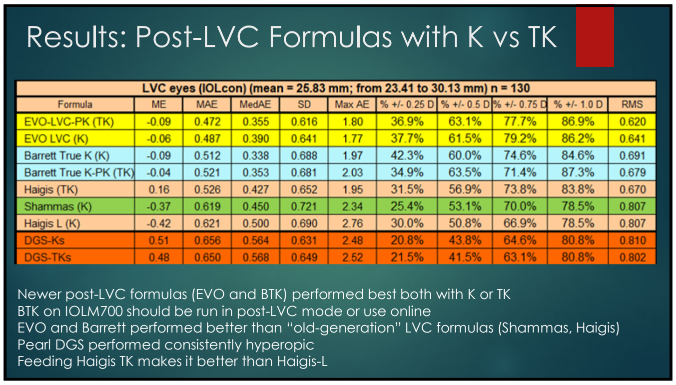
## TK in M-LVC Eyes

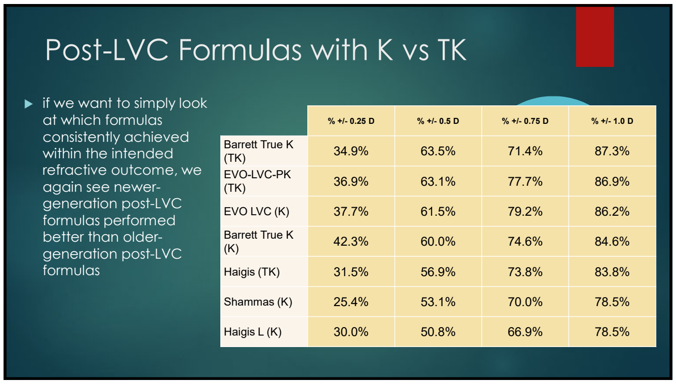
- Retrospective review of 130 eyes with previous M-LVC that were measured with SS-OCT biometer for K and TK prior to cataract surgery between 2019-2021
  - Previous hyperopic LVC and RK were excluded due to an insufficient number of eyes
  - Eyes with a history of trauma, corneal ectasia, or vision-limiting ocular pathology were excluded
- Standard K and TK values were inputted into dedicated post-refractive multivariable formulas with mechanisms for adjusted K values using no prior historical data
- TK values were applied to non-LASIK formulas
- Only IOLcon lens constants were used
- Postoperative refractive outcomes were compared to the predicted outcomes to determine predictive error and percentage of eyes within ±1.0D of targeted outcome
- Refractions done 21-90 days postoperatively with lane-length adjustments



## Results: Post-LVC Formulas with K vs TK

| LVC eyes (IOLcon) (mean = 25.83 mm; from 23.41 to 30.13 mm) n = 130 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
| EVO-LVC-PK (TK) | -0.09 | 0.472 | 0.355 | 0.616 | 1.80 | 36.9% | 63.1% | 77.7% | 86.9% | 0.620 |
| EVO LVC (K) | -0.06 | 0.487 | 0.390 | 0.641 | 1.77 | 37.7% | 61.5% | 79.2% | 86.2% | 0.641 |
| Barrett True K (K) | -0.09 | 0.512 | 0.338 | 0.688 | 1.97 | 42.3% | 60.0% | 74.6% | 84.6% | 0.691 |
| Barrett True K-PK (TK) | -0.04 | 0.521 | 0.353 | 0.681 | 2.03 | 34.9% | 63.5% | 71.4% | 87.3% | 0.679 |
| Haigis (TK) | 0.16 | 0.526 | 0.427 | 0.652 | 1.95 | 31.5% | 56.9% | 73.8% | 83.8% | 0.670 |
| Shammas (K) | -0.37 | 0.619 | 0.450 | 0.721 | 2.34 | 25.4% | 53.1% | 70.0% | 78.5% | 0.807 |
| Haigis L (K) | -0.42 | 0.621 | 0.500 | 0.690 | 2.76 | 30.0% | 50.8% | 66.9% | 78.5% | 0.807 |
| DGS-Ks | 0.51 | 0.656 | 0.564 | 0.631 | 2.48 | 20.8% | 43.8% | 64.6% | 80.8% | 0.810 |
| DGS-TKs | 0.48 | 0.650 | 0.568 | 0.649 | 2.52 | 21.5% | 41.5% | 63.1% | 80.8% | 0.802 |

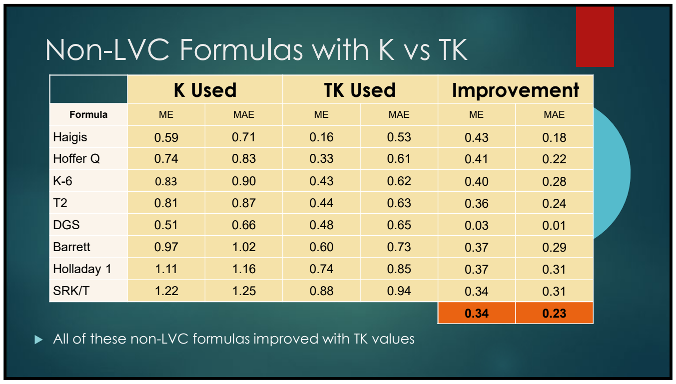
Newer post-LVC formulas (EVO and BTK) performed best both with K or TK
BTK on IOLM700 should be run in post-LVC mode or use online
EVO and Barrett performed better than "old-generation" LVC formulas (Shammas, Haigis)
Pearl DGS performed consistently hyperopic
Feeding Haigis TK makes it better than Haigis-L



## Post-LVC Formulas with K vs TK

- if we want to simply look at which formulas consistently achieved within the intended refractive outcome, we again see newer-generation post-LVC formulas performed better than older-generation post-LVC formulas

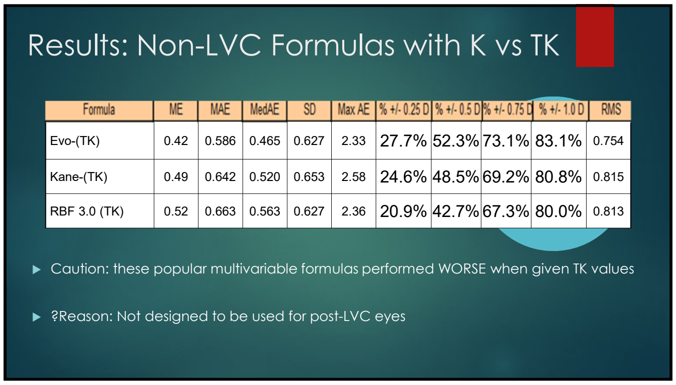
| | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D |
|---|---|---|---|---|
| Barrett True K (TK) | 34.9% | 63.5% | 71.4% | 87.3% |
| EVO-LVC-PK (TK) | 36.9% | 63.1% | 77.7% | 86.9% |
| EVO LVC (K) | 37.7% | 61.5% | 79.2% | 86.2% |
| Barrett True K (K) | 42.3% | 60.0% | 74.6% | 84.6% |
| Haigis (TK) | 31.5% | 56.9% | 73.8% | 83.8% |
| Shammas (K) | 25.4% | 53.1% | 70.0% | 78.5% |
| Haigis L (K) | 30.0% | 50.8% | 66.9% | 78.5% |



## Non-LVC Formulas with K vs TK

| | K Used | | TK Used | | Improvement | |
|---|---|---|---|---|---|---|
| Formula | ME | MAE | ME | MAE | ME | MAE |
| Haigis | 0.59 | 0.71 | 0.16 | 0.53 | 0.43 | 0.18 |
| Hoffer Q | 0.74 | 0.83 | 0.33 | 0.61 | 0.41 | 0.22 |
| K-6 | 0.83 | 0.90 | 0.43 | 0.62 | 0.40 | 0.28 |
| T2 | 0.81 | 0.87 | 0.44 | 0.63 | 0.36 | 0.24 |
| DGS | 0.51 | 0.66 | 0.48 | 0.65 | 0.03 | 0.01 |
| Barrett | 0.97 | 1.02 | 0.60 | 0.73 | 0.37 | 0.29 |
| Holladay 1 | 1.11 | 1.16 | 0.74 | 0.85 | 0.37 | 0.31 |
| SRK/T | 1.22 | 1.25 | 0.88 | 0.94 | 0.34 | 0.31 |
| | | | | | 0.34 | 0.23 |

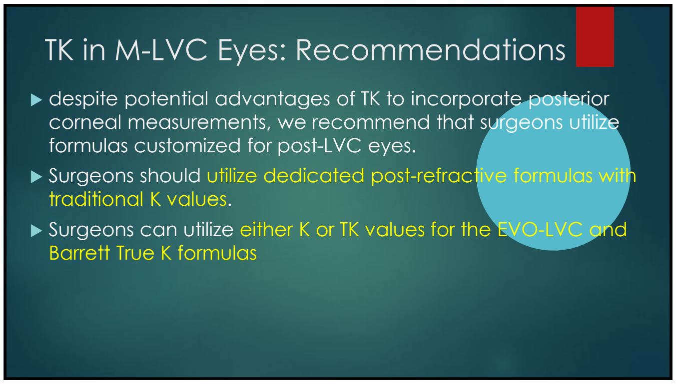
- All of these non-LVC formulas improved with TK values



## Results: Non-LVC Formulas with K vs TK

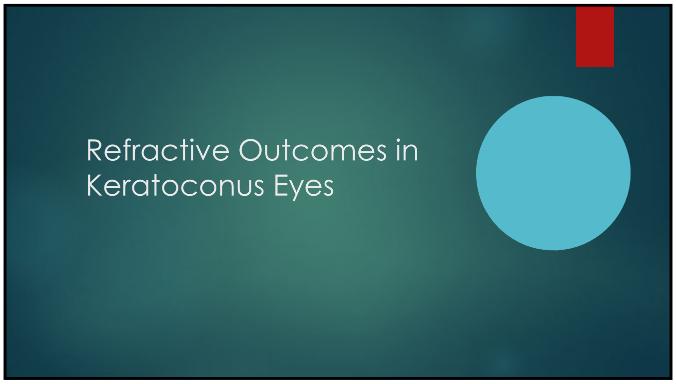
| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Evo-(TK) | 0.42 | 0.586 | 0.465 | 0.627 | 2.33 | 27.7% | 52.3% | 73.1% | 83.1% | 0.754 |
| Kane-(TK) | 0.49 | 0.642 | 0.520 | 0.653 | 2.58 | 24.6% | 48.5% | 69.2% | 80.8% | 0.815 |
| RBF 3.0 (TK) | 0.52 | 0.663 | 0.563 | 0.627 | 2.36 | 20.9% | 42.7% | 67.3% | 80.0% | 0.813 |

- Caution: these popular multivariable formulas performed WORSE when given TK values
- ?Reason: Not designed to be used for post-LVC eyes

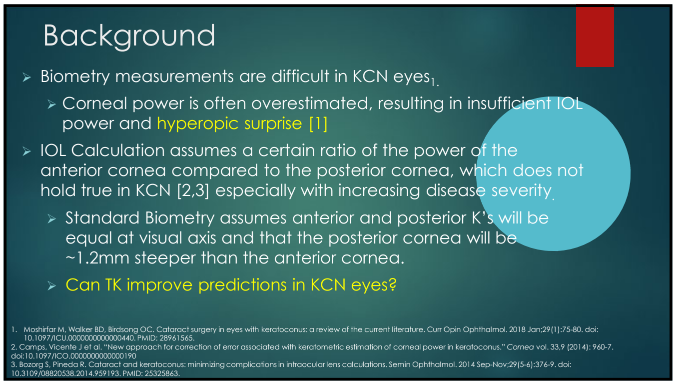


## TK in M-LVC Eyes: Recommendations

- despite potential advantages of TK to incorporate posterior corneal measurements, we recommend that surgeons utilize formulas customized for post-LVC eyes.
- Surgeons should utilize dedicated post-refractive formulas with traditional K values.
- Surgeons can utilize either K or TK values for the EVO-LVC and Barrett True K formulas



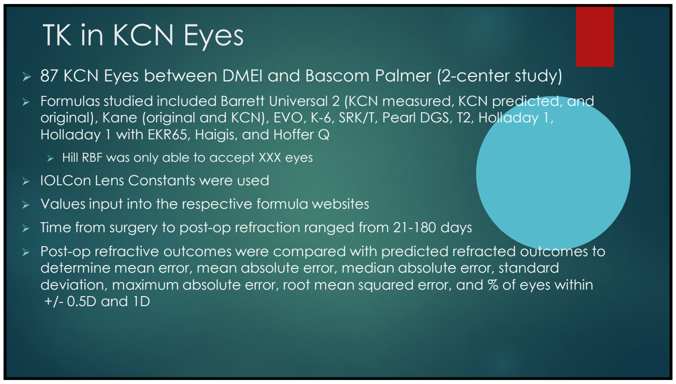
## Refractive Outcomes in Keratoconus Eyes



## Background

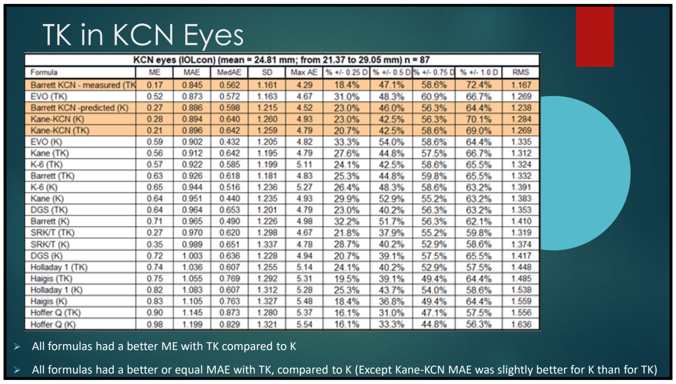
- Biometry measurements are difficult in KCN eyes[1].
  - Corneal power is often overestimated, resulting in insufficient IOL power and hyperopic surprise [1]
- IOL Calculation assumes a certain ratio of the power of the anterior cornea compared to the posterior cornea, which does not hold true in KCN [2,3] especially with increasing disease severity.
  - Standard Biometry assumes anterior and posterior K's will be equal at visual axis and that the posterior cornea will be ~1.2mm steeper than the anterior cornea.
  - Can TK improve predictions in KCN eyes?

1. Moshirfar M, Walker BD, Birdsong OC. Cataract surgery in eyes with keratoconus: a review of the current literature. Curr Opin Ophthalmol. 2018 Jan;29(1):75-80. doi: 10.1097/ICU.0000000000000440. PMID: 28961565.
2. Camps, Vicente J et al. "New approach for correction of error associated with keratometric estimation of corneal power in keratoconus." *Cornea* vol. 33,9 (2014): 960-7. doi:10.1097/ICO.0000000000000190
3. Bozorg S, Pineda R. Cataract and keratoconus: minimizing complications in intraocular lens calculations. Semin Ophthalmol. 2014 Sep-Nov;29(5-6):376-9. doi: 10.3109/08820538.2014.959193. PMID: 25325863.



## TK in KCN Eyes

- 87 KCN Eyes between DMEI and Bascom Palmer (2-center study)
- Formulas studied included Barrett Universal 2 (KCN measured, KCN predicted, and original), Kane (original and KCN), EVO, K-6, SRK/T, Pearl DGS, T2, Holladay 1, Holladay 1 with EKR65, Haigis, and Hoffer Q
  - Hill RBF was only able to accept XXX eyes
- IOLCon Lens Constants were used
- Values input into the respective formula websites
- Time from surgery to post-op refraction ranged from 21-180 days
- Post-op refractive outcomes were compared with predicted refracted outcomes to determine mean error, mean absolute error, median absolute error, standard deviation, maximum absolute error, root mean squared error, and % of eyes within +/- 0.5D and 1D

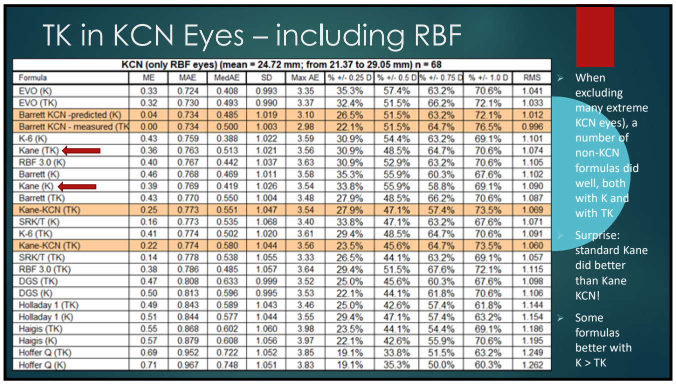


## TK in KCN Eyes

**KCN eyes (IOLcon) (mean = 24.81 mm; from 21.37 to 29.05 mm) n = 87**

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Barrett KCN - measured (TK | 0.17 | 0.845 | 0.562 | 1.161 | 4.29 | 18.4% | 47.1% | 58.6% | 72.4% | 1.167 |
| EVO (TK) | 0.52 | 0.873 | 0.572 | 1.163 | 4.67 | 31.0% | 48.3% | 60.9% | 66.7% | 1.269 |
| Barrett KCN -predicted (K) | 0.27 | 0.886 | 0.598 | 1.215 | 4.52 | 23.0% | 46.0% | 56.3% | 64.4% | 1.238 |
| Kane-KCN (K) | 0.28 | 0.894 | 0.640 | 1.260 | 4.93 | 23.0% | 42.5% | 56.3% | 70.1% | 1.284 |
| Kane-KCN (TK) | 0.21 | 0.896 | 0.642 | 1.259 | 4.79 | 20.7% | 42.5% | 58.6% | 69.0% | 1.269 |
| EVO (K) | 0.59 | 0.902 | 0.432 | 1.205 | 4.82 | 33.3% | 54.0% | 58.6% | 64.4% | 1.335 |
| Kane (TK) | 0.56 | 0.912 | 0.642 | 1.195 | 4.79 | 27.6% | 44.8% | 57.5% | 66.7% | 1.312 |
| K-6 (TK) | 0.57 | 0.922 | 0.585 | 1.199 | 5.11 | 24.1% | 42.5% | 58.6% | 65.5% | 1.324 |
| Barrett (TK) | 0.63 | 0.926 | 0.618 | 1.181 | 4.83 | 25.3% | 44.8% | 59.8% | 65.5% | 1.332 |
| K-6 (K) | 0.65 | 0.944 | 0.516 | 1.236 | 5.27 | 26.4% | 48.3% | 58.6% | 63.2% | 1.391 |
| Kane (K) | 0.64 | 0.951 | 0.440 | 1.235 | 4.93 | 29.9% | 52.9% | 55.2% | 63.2% | 1.383 |
| DGS (TK) | 0.64 | 0.964 | 0.653 | 1.201 | 4.79 | 23.0% | 40.2% | 56.3% | 63.2% | 1.353 |
| Barrett (K) | 0.71 | 0.965 | 0.490 | 1.226 | 4.98 | 32.2% | 51.7% | 56.3% | 62.1% | 1.410 |
| SRK/T (TK) | 0.27 | 0.970 | 0.620 | 1.298 | 4.67 | 21.8% | 37.9% | 55.2% | 59.8% | 1.319 |
| SRK/T (K) | 0.35 | 0.989 | 0.651 | 1.337 | 4.78 | 28.7% | 40.2% | 52.9% | 58.6% | 1.374 |
| DGS (K) | 0.72 | 1.003 | 0.636 | 1.228 | 4.94 | 20.7% | 39.1% | 57.5% | 65.5% | 1.417 |
| Holladay 1 (TK) | 0.74 | 1.036 | 0.607 | 1.255 | 5.14 | 24.1% | 40.2% | 52.9% | 57.5% | 1.448 |
| Haigis (TK) | 0.75 | 1.055 | 0.769 | 1.292 | 5.31 | 19.5% | 39.1% | 49.4% | 64.4% | 1.485 |
| Holladay 1 (K) | 0.82 | 1.083 | 0.607 | 1.312 | 5.28 | 25.3% | 43.7% | 54.0% | 58.6% | 1.538 |
| Haigis (K) | 0.83 | 1.105 | 0.763 | 1.327 | 5.48 | 18.4% | 36.8% | 49.4% | 64.4% | 1.559 |
| Hoffer Q (TK) | 0.90 | 1.145 | 0.873 | 1.280 | 5.37 | 16.1% | 31.0% | 47.1% | 57.5% | 1.556 |
| Hoffer Q (K) | 0.98 | 1.199 | 0.829 | 1.321 | 5.54 | 16.1% | 33.3% | 44.8% | 56.3% | 1.636 |

- All formulas had a better ME with TK compared to K
- All formulas had a better or equal MAE with TK, compared to K (Except Kane-KCN MAE was slightly better for K than for TK)

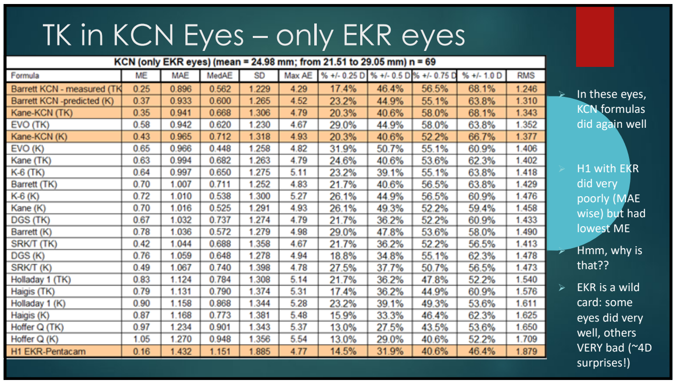


# TK in KCN Eyes – including RBF

**KCN (only RBF eyes) (mean = 24.72 mm; from 21.37 to 29.05 mm) n = 68**

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| EVO (K) | 0.33 | 0.724 | 0.408 | 0.993 | 3.35 | 35.3% | 57.4% | 63.2% | 70.6% | 1.041 |
| EVO (TK) | 0.32 | 0.730 | 0.493 | 0.990 | 3.37 | 32.4% | 51.5% | 66.2% | 72.1% | 1.033 |
| Barrett KCN -predicted (K) | 0.04 | 0.734 | 0.485 | 1.019 | 3.10 | 26.5% | 51.5% | 63.2% | 72.1% | 1.012 |
| Barrett KCN - measured (TK | 0.00 | 0.734 | 0.500 | 1.003 | 2.98 | 22.1% | 51.5% | 64.7% | 76.5% | 0.996 |
| K-6 (K) | 0.43 | 0.759 | 0.388 | 1.022 | 3.59 | 30.9% | 54.4% | 63.2% | 69.1% | 1.101 |
| Kane (TK) | 0.36 | 0.763 | 0.513 | 1.021 | 3.56 | 30.9% | 48.5% | 64.7% | 70.6% | 1.074 |
| RBF 3.0 (K) | 0.40 | 0.767 | 0.442 | 1.037 | 3.63 | 30.9% | 52.9% | 63.2% | 70.6% | 1.105 |
| Barrett (K) | 0.46 | 0.768 | 0.469 | 1.011 | 3.58 | 35.3% | 55.9% | 60.3% | 67.6% | 1.102 |
| Kane (K) | 0.39 | 0.769 | 0.419 | 1.026 | 3.54 | 33.8% | 55.9% | 58.8% | 69.1% | 1.090 |
| Barrett (TK) | 0.43 | 0.770 | 0.550 | 1.004 | 3.48 | 27.9% | 48.5% | 66.2% | 70.6% | 1.087 |
| Kane-KCN (TK) | 0.25 | 0.773 | 0.551 | 1.047 | 3.54 | 27.9% | 47.1% | 57.4% | 73.5% | 1.069 |
| SRK/T (K) | 0.16 | 0.773 | 0.535 | 1.068 | 3.40 | 33.8% | 47.1% | 63.2% | 67.6% | 1.071 |
| K-6 (TK) | 0.41 | 0.774 | 0.502 | 1.020 | 3.61 | 29.4% | 48.5% | 64.7% | 70.6% | 1.091 |
| Kane-KCN (TK) | 0.22 | 0.774 | 0.580 | 1.044 | 3.56 | 23.5% | 45.6% | 64.7% | 73.5% | 1.060 |
| SRK/T (TK) | 0.14 | 0.778 | 0.538 | 1.055 | 3.33 | 26.5% | 44.1% | 63.2% | 69.1% | 1.057 |
| RBF 3.0 (TK) | 0.38 | 0.786 | 0.485 | 1.057 | 3.64 | 29.4% | 51.5% | 67.6% | 72.1% | 1.115 |
| DGS (TK) | 0.47 | 0.808 | 0.633 | 0.999 | 3.52 | 25.0% | 45.6% | 60.3% | 67.6% | 1.098 |
| DGS (K) | 0.50 | 0.813 | 0.596 | 0.995 | 3.53 | 22.1% | 44.1% | 61.8% | 70.6% | 1.106 |
| Holladay 1 (TK) | 0.49 | 0.843 | 0.589 | 1.043 | 3.46 | 25.0% | 42.6% | 57.4% | 61.8% | 1.144 |
| Holladay 1 (K) | 0.51 | 0.844 | 0.577 | 1.044 | 3.55 | 29.4% | 47.1% | 57.4% | 63.2% | 1.154 |
| Haigis (TK) | 0.55 | 0.868 | 0.602 | 1.060 | 3.98 | 23.5% | 44.1% | 54.4% | 69.1% | 1.186 |
| Haigis (K) | 0.57 | 0.879 | 0.608 | 1.056 | 3.97 | 22.1% | 42.6% | 55.9% | 70.6% | 1.195 |
| Hoffer Q (TK) | 0.69 | 0.952 | 0.722 | 1.052 | 3.85 | 19.1% | 33.8% | 51.5% | 63.2% | 1.249 |
| Hoffer Q (K) | 0.71 | 0.967 | 0.748 | 1.051 | 3.83 | 19.1% | 35.3% | 50.0% | 60.3% | 1.262 |

- When excluding many extreme KCN eyes), a number of non-KCN formulas did well, both with K and with TK
- Surprise: standard Kane did better than Kane KCN!
- Some formulas better with K > TK

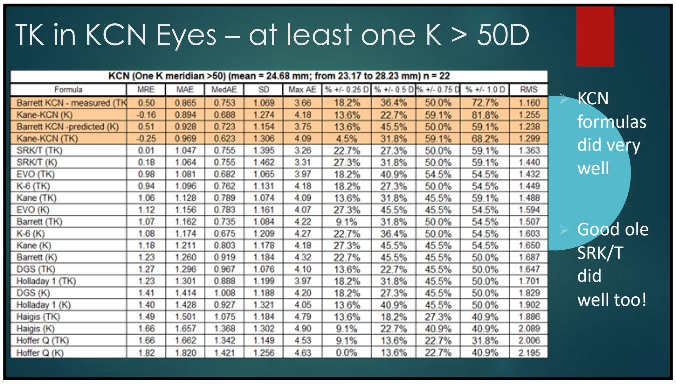


# TK in KCN Eyes – only EKR eyes

**KCN (only EKR eyes) (mean = 24.98 mm; from 21.51 to 29.05 mm) n = 69**

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Barrett KCN - measured (TK | 0.25 | 0.896 | 0.562 | 1.229 | 4.29 | 17.4% | 46.4% | 56.5% | 68.1% | 1.246 |
| Barrett KCN -predicted (K) | 0.37 | 0.933 | 0.600 | 1.265 | 4.52 | 23.2% | 44.9% | 55.1% | 63.8% | 1.310 |
| Kane-KCN (TK) | 0.35 | 0.941 | 0.668 | 1.306 | 4.79 | 20.3% | 40.6% | 58.0% | 68.1% | 1.343 |
| EVO (TK) | 0.58 | 0.942 | 0.620 | 1.230 | 4.67 | 29.0% | 44.9% | 58.0% | 63.8% | 1.352 |
| Kane-KCN (K) | 0.43 | 0.965 | 0.712 | 1.318 | 4.93 | 20.3% | 40.6% | 52.2% | 66.7% | 1.377 |
| EVO (K) | 0.65 | 0.966 | 0.448 | 1.258 | 4.82 | 31.9% | 50.7% | 55.1% | 60.9% | 1.406 |
| Kane (TK) | 0.63 | 0.994 | 0.682 | 1.263 | 4.79 | 24.6% | 40.6% | 53.6% | 62.3% | 1.402 |
| K-6 (TK) | 0.64 | 0.997 | 0.650 | 1.275 | 5.11 | 23.2% | 39.1% | 55.1% | 63.8% | 1.418 |
| Barrett (TK) | 0.70 | 1.007 | 0.711 | 1.252 | 4.83 | 21.7% | 40.6% | 56.5% | 63.8% | 1.429 |
| K-6 (K) | 0.72 | 1.010 | 0.538 | 1.300 | 5.27 | 26.1% | 44.9% | 56.5% | 60.9% | 1.476 |
| Kane (K) | 0.70 | 1.016 | 0.525 | 1.291 | 4.93 | 26.1% | 49.3% | 52.2% | 59.4% | 1.458 |
| DGS (TK) | 0.67 | 1.032 | 0.737 | 1.274 | 4.79 | 21.7% | 36.2% | 52.2% | 60.9% | 1.433 |
| Barrett (K) | 0.78 | 1.036 | 0.572 | 1.279 | 4.98 | 29.0% | 47.8% | 53.6% | 58.0% | 1.490 |
| SRK/T (TK) | 0.42 | 1.044 | 0.688 | 1.358 | 4.67 | 21.7% | 36.2% | 52.2% | 56.5% | 1.413 |
| DGS (K) | 0.76 | 1.059 | 0.648 | 1.278 | 4.94 | 18.8% | 34.8% | 55.1% | 62.3% | 1.478 |
| SRK/T (K) | 0.49 | 1.067 | 0.740 | 1.398 | 4.78 | 27.5% | 37.7% | 50.7% | 56.5% | 1.473 |
| Holladay 1 (TK) | 0.83 | 1.124 | 0.784 | 1.308 | 5.14 | 21.7% | 36.2% | 47.8% | 52.2% | 1.540 |
| Haigis (TK) | 0.79 | 1.131 | 0.790 | 1.374 | 5.31 | 17.4% | 36.2% | 44.9% | 60.9% | 1.576 |
| Holladay 1 (K) | 0.90 | 1.158 | 0.868 | 1.344 | 5.28 | 23.2% | 39.1% | 49.3% | 53.6% | 1.611 |
| Haigis (K) | 0.87 | 1.168 | 0.773 | 1.381 | 5.48 | 15.9% | 33.3% | 46.4% | 62.3% | 1.625 |
| Hoffer Q (TK) | 0.97 | 1.234 | 0.901 | 1.343 | 5.37 | 13.0% | 27.5% | 43.5% | 53.6% | 1.650 |
| Hoffer Q (K) | 1.05 | 1.270 | 0.948 | 1.356 | 5.54 | 13.0% | 29.0% | 40.6% | 52.2% | 1.709 |
| H1 EKR-Pentacam | 0.16 | 1.432 | 1.151 | 1.885 | 4.77 | 14.5% | 31.9% | 40.6% | 46.4% | 1.879 |

- In these eyes, KCN formulas did again well
- H1 with EKR did very poorly (MAE wise) but had lowest ME
- Hmm, why is that??
- EKR is a wild card: some eyes did very well, others VERY bad (~4D surprises!)

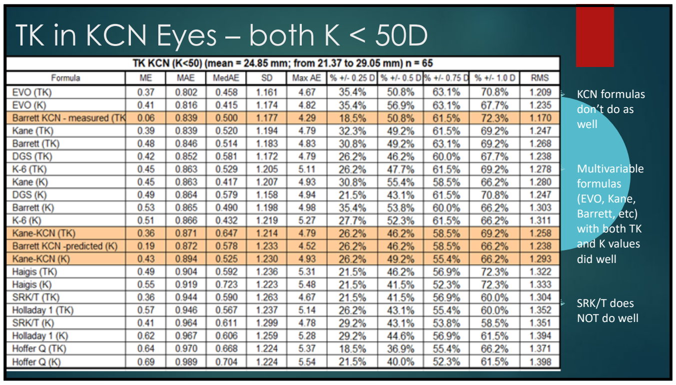


# TK in KCN Eyes – at least one K > 50D

**KCN (One K meridian >50) (mean = 24.68 mm; from 23.17 to 28.23 mm) n = 22**

| Formula | MRE | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| Barrett KCN - measured (TK | 0.50 | 0.865 | 0.753 | 1.069 | 3.66 | 18.2% | 36.4% | 50.0% | 72.7% | 1.160 |
| Kane-KCN (K) | -0.16 | 0.894 | 0.688 | 1.274 | 4.18 | 13.6% | 22.7% | 59.1% | 81.8% | 1.255 |
| Barrett KCN -predicted (K) | 0.51 | 0.928 | 0.723 | 1.154 | 3.75 | 13.6% | 45.5% | 50.0% | 59.1% | 1.238 |
| Kane-KCN (TK) | -0.25 | 0.969 | 0.623 | 1.306 | 4.09 | 4.5% | 31.8% | 59.1% | 68.2% | 1.299 |
| SRK/T (TK) | 0.01 | 1.047 | 0.755 | 1.395 | 3.26 | 22.7% | 27.3% | 50.0% | 59.1% | 1.363 |
| SRK/T (K) | 0.18 | 1.064 | 0.755 | 1.462 | 3.31 | 27.3% | 31.8% | 50.0% | 59.1% | 1.440 |
| EVO (TK) | 0.98 | 1.081 | 0.682 | 1.065 | 3.97 | 18.2% | 40.9% | 54.5% | 54.5% | 1.432 |
| K-6 (TK) | 0.94 | 1.096 | 0.762 | 1.131 | 4.18 | 18.2% | 27.3% | 50.0% | 54.5% | 1.449 |
| Kane (TK) | 1.06 | 1.128 | 0.789 | 1.074 | 4.09 | 13.6% | 31.8% | 45.5% | 59.1% | 1.488 |
| EVO (K) | 1.12 | 1.156 | 0.783 | 1.161 | 4.07 | 27.3% | 45.5% | 45.5% | 54.5% | 1.594 |
| Barrett (TK) | 1.07 | 1.162 | 0.735 | 1.084 | 4.22 | 9.1% | 31.8% | 50.0% | 54.5% | 1.507 |
| K-6 (K) | 1.08 | 1.174 | 0.675 | 1.209 | 4.27 | 22.7% | 36.4% | 50.0% | 54.5% | 1.603 |
| Kane (K) | 1.18 | 1.211 | 0.803 | 1.178 | 4.18 | 27.3% | 45.5% | 45.5% | 54.5% | 1.650 |
| Barrett (K) | 1.23 | 1.260 | 0.919 | 1.184 | 4.32 | 22.7% | 45.5% | 45.5% | 50.0% | 1.687 |
| DGS (TK) | 1.27 | 1.296 | 0.967 | 1.076 | 4.10 | 13.6% | 22.7% | 45.5% | 50.0% | 1.647 |
| Holladay 1 (TK) | 1.23 | 1.301 | 0.888 | 1.199 | 3.97 | 18.2% | 31.8% | 45.5% | 50.0% | 1.701 |
| DGS (K) | 1.41 | 1.414 | 1.008 | 1.188 | 4.20 | 18.2% | 27.3% | 45.5% | 50.0% | 1.829 |
| Holladay 1 (K) | 1.40 | 1.428 | 0.927 | 1.321 | 4.05 | 13.6% | 40.9% | 45.5% | 50.0% | 1.902 |
| Haigis (TK) | 1.49 | 1.501 | 1.075 | 1.184 | 4.79 | 13.6% | 18.2% | 27.3% | 40.9% | 1.886 |
| Haigis (K) | 1.66 | 1.657 | 1.368 | 1.302 | 4.90 | 9.1% | 22.7% | 40.9% | 40.9% | 2.089 |
| Hoffer Q (TK) | 1.66 | 1.662 | 1.342 | 1.149 | 4.53 | 9.1% | 13.6% | 22.7% | 31.8% | 2.006 |
| Hoffer Q (K) | 1.82 | 1.820 | 1.421 | 1.256 | 4.63 | 0.0% | 13.6% | 22.7% | 40.9% | 2.195 |

- KCN formulas did very well
- Good ole SRK/T did well too!

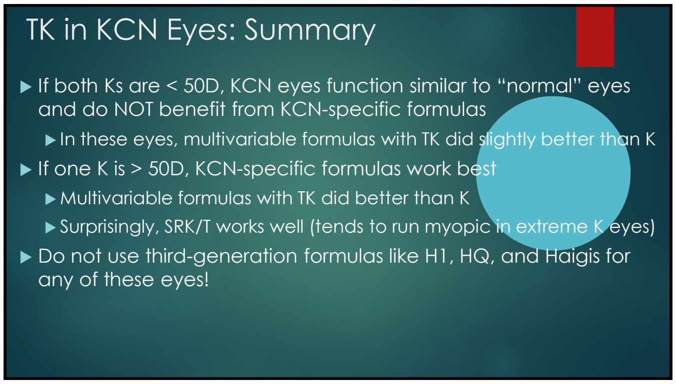


## TK in KCN Eyes – both K < 50D

TK KCN (K<50) (mean = 24.85 mm; from 21.37 to 29.05 mm) n = 65

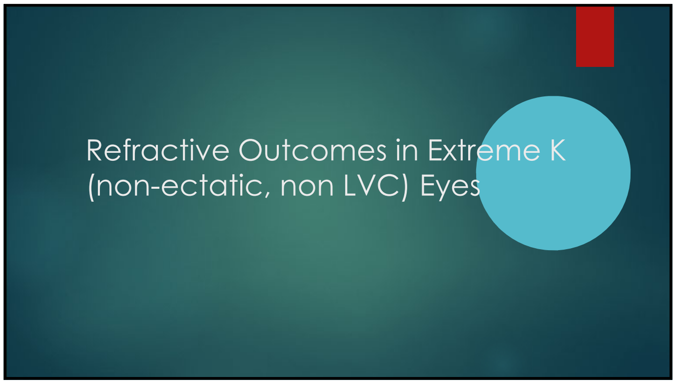
| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.25 D | % +/- 0.5 D | % +/- 0.75 D | % +/- 1.0 D | RMS |
|---|---|---|---|---|---|---|---|---|---|---|
| EVO (TK) | 0.37 | 0.802 | 0.458 | 1.161 | 4.67 | 35.4% | 50.8% | 63.1% | 70.8% | 1.209 |
| EVO (K) | 0.41 | 0.816 | 0.415 | 1.174 | 4.82 | 35.4% | 56.9% | 63.1% | 67.7% | 1.235 |
| Barrett KCN - measured (TK | 0.06 | 0.839 | 0.500 | 1.177 | 4.29 | 18.5% | 50.8% | 61.5% | 72.3% | 1.170 |
| Kane (TK) | 0.39 | 0.839 | 0.520 | 1.194 | 4.79 | 32.3% | 49.2% | 61.5% | 69.2% | 1.247 |
| Barrett (TK) | 0.48 | 0.846 | 0.514 | 1.183 | 4.83 | 30.8% | 49.2% | 63.1% | 69.2% | 1.268 |
| DGS (TK) | 0.42 | 0.852 | 0.581 | 1.172 | 4.79 | 26.2% | 46.2% | 60.0% | 67.7% | 1.238 |
| K-6 (TK) | 0.45 | 0.863 | 0.529 | 1.205 | 5.11 | 26.2% | 47.7% | 61.5% | 69.2% | 1.278 |
| Kane (K) | 0.45 | 0.863 | 0.417 | 1.207 | 4.93 | 30.8% | 55.4% | 58.5% | 66.2% | 1.280 |
| DGS (K) | 0.49 | 0.864 | 0.579 | 1.158 | 4.94 | 21.5% | 43.1% | 61.5% | 70.8% | 1.247 |
| Barrett (K) | 0.53 | 0.865 | 0.490 | 1.198 | 4.98 | 35.4% | 53.8% | 60.0% | 66.2% | 1.303 |
| K-6 (K) | 0.51 | 0.866 | 0.432 | 1.219 | 5.27 | 27.7% | 52.3% | 61.5% | 66.2% | 1.311 |
| Kane-KCN (TK) | 0.36 | 0.871 | 0.647 | 1.214 | 4.79 | 26.2% | 46.2% | 58.5% | 69.2% | 1.258 |
| Barrett KCN -predicted (K) | 0.19 | 0.872 | 0.578 | 1.233 | 4.52 | 26.2% | 46.2% | 58.5% | 66.2% | 1.238 |
| Kane-KCN (K) | 0.43 | 0.894 | 0.525 | 1.230 | 4.93 | 26.2% | 49.2% | 55.4% | 66.2% | 1.293 |
| Haigis (TK) | 0.49 | 0.904 | 0.592 | 1.236 | 5.31 | 21.5% | 46.2% | 56.9% | 72.3% | 1.322 |
| Haigis (K) | 0.55 | 0.919 | 0.723 | 1.223 | 5.48 | 21.5% | 41.5% | 52.3% | 72.3% | 1.333 |
| SRK/T (TK) | 0.36 | 0.944 | 0.590 | 1.263 | 4.67 | 21.5% | 41.5% | 56.9% | 60.0% | 1.304 |
| Holladay 1 (TK) | 0.57 | 0.946 | 0.567 | 1.237 | 5.14 | 26.2% | 43.1% | 55.4% | 60.0% | 1.352 |
| SRK/T (K) | 0.41 | 0.964 | 0.611 | 1.299 | 4.78 | 29.2% | 43.1% | 53.8% | 58.5% | 1.351 |
| Holladay 1 (K) | 0.62 | 0.967 | 0.606 | 1.259 | 5.28 | 29.2% | 44.6% | 56.9% | 61.5% | 1.394 |
| Hoffer Q (TK) | 0.64 | 0.970 | 0.668 | 1.224 | 5.37 | 18.5% | 36.9% | 55.4% | 66.2% | 1.371 |
| Hoffer Q (K) | 0.69 | 0.989 | 0.704 | 1.224 | 5.54 | 21.5% | 40.0% | 52.3% | 61.5% | 1.398 |

- KCN formulas don't do as well
- Multivariable formulas (EVO, Kane, Barrett, etc) with both TK and K values did well
- SRK/T does NOT do well

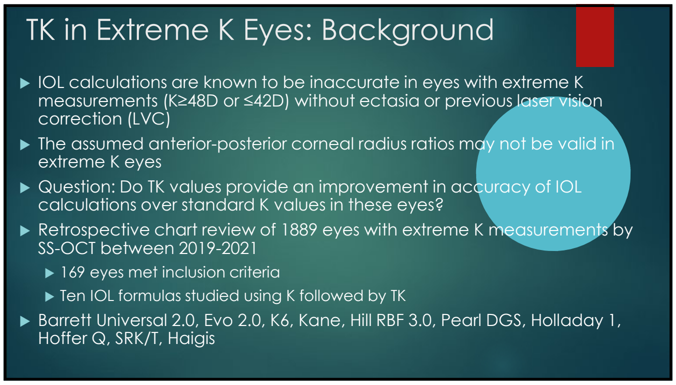


## TK in KCN Eyes: Summary

- If both Ks are < 50D, KCN eyes function similar to "normal" eyes and do NOT benefit from KCN-specific formulas
  - In these eyes, multivariable formulas with TK did slightly better than K
- If one K is > 50D, KCN-specific formulas work best
  - Multivariable formulas with TK did better than K
  - Surprisingly, SRK/T works well (tends to run myopic in extreme K eyes)
- Do not use third-generation formulas like H1, HQ, and Haigis for any of these eyes!

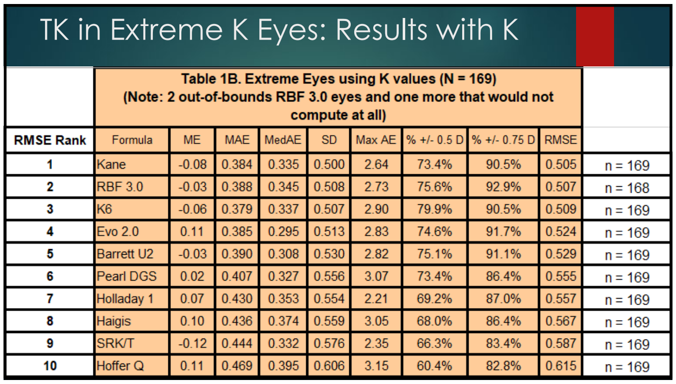


## Refractive Outcomes in Extreme K (non-ectatic, non LVC) Eyes



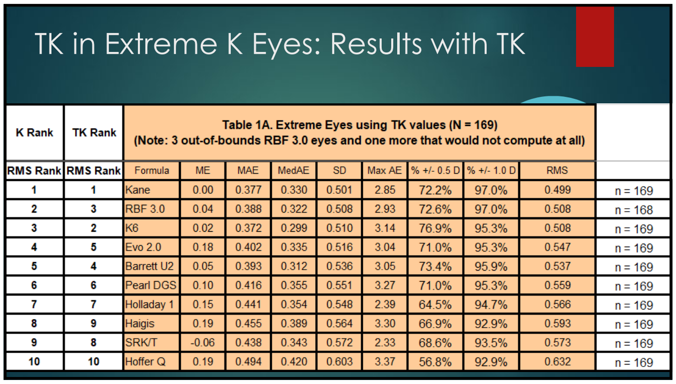
## TK in Extreme K Eyes: Background

- IOL calculations are known to be inaccurate in eyes with extreme K measurements (K≥48D or ≤42D) without ectasia or previous laser vision correction (LVC)
- The assumed anterior-posterior corneal radius ratios may not be valid in extreme K eyes
- Question: Do TK values provide an improvement in accuracy of IOL calculations over standard K values in these eyes?
- Retrospective chart review of 1889 eyes with extreme K measurements by SS-OCT between 2019-2021
  - 169 eyes met inclusion criteria
  - Ten IOL formulas studied using K followed by TK
- Barrett Universal 2.0, Evo 2.0, K6, Kane, Hill RBF 3.0, Pearl DGS, Holladay 1, Hoffer Q, SRK/T, Haigis



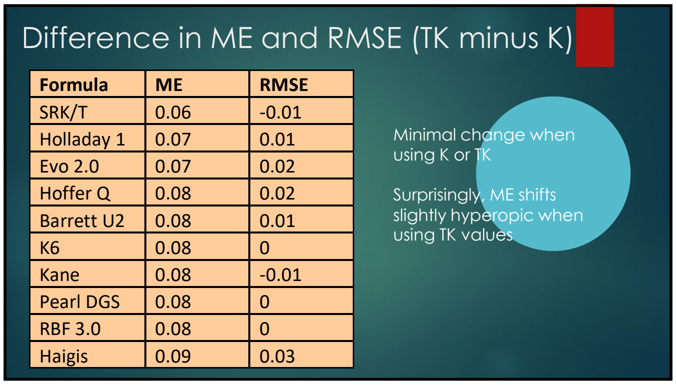
## TK in Extreme K Eyes: Results with K

| | Table 1B. Extreme Eyes using K values (N = 169) (Note: 2 out-of-bounds RBF 3.0 eyes and one more that would not compute at all) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **RMSE Rank** | Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 0.75 D | RMSE | |
| **1** | Kane | -0.08 | 0.384 | 0.335 | 0.500 | 2.64 | 73.4% | 90.5% | 0.505 | n = 169 |
| **2** | RBF 3.0 | -0.03 | 0.388 | 0.345 | 0.508 | 2.73 | 75.6% | 92.9% | 0.507 | n = 168 |
| **3** | K6 | -0.06 | 0.379 | 0.337 | 0.507 | 2.90 | 79.9% | 90.5% | 0.509 | n = 169 |
| **4** | Evo 2.0 | 0.11 | 0.385 | 0.295 | 0.513 | 2.83 | 74.6% | 91.7% | 0.524 | n = 169 |
| **5** | Barrett U2 | -0.03 | 0.390 | 0.308 | 0.530 | 2.82 | 75.1% | 91.1% | 0.529 | n = 169 |
| **6** | Pearl DGS | 0.02 | 0.407 | 0.327 | 0.556 | 3.07 | 73.4% | 86.4% | 0.555 | n = 169 |
| **7** | Holladay 1 | 0.07 | 0.430 | 0.353 | 0.554 | 2.21 | 69.2% | 87.0% | 0.557 | n = 169 |
| **8** | Haigis | 0.10 | 0.436 | 0.374 | 0.559 | 3.05 | 68.0% | 86.4% | 0.567 | n = 169 |
| **9** | SRK/T | -0.12 | 0.444 | 0.332 | 0.576 | 2.35 | 66.3% | 83.4% | 0.587 | n = 169 |
| **10** | Hoffer Q | 0.11 | 0.469 | 0.395 | 0.606 | 3.15 | 60.4% | 82.8% | 0.615 | n = 169 |



## TK in Extreme K Eyes: Results with TK

| **K Rank** | **TK Rank** | Table 1A. Extreme Eyes using TK values (N = 169) (Note: 3 out-of-bounds RBF 3.0 eyes and one more that would not compute at all) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RMS Rank** | **RMS Rank** | Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 1.0 D | RMS | |
| **1** | **1** | Kane | 0.00 | 0.377 | 0.330 | 0.501 | 2.85 | 72.2% | 97.0% | 0.499 | n = 169 |
| **2** | **3** | RBF 3.0 | 0.04 | 0.388 | 0.322 | 0.508 | 2.93 | 72.6% | 97.0% | 0.508 | n = 168 |
| **3** | **2** | K6 | 0.02 | 0.372 | 0.299 | 0.510 | 3.14 | 76.9% | 95.3% | 0.508 | n = 169 |
| **4** | **5** | Evo 2.0 | 0.18 | 0.402 | 0.335 | 0.516 | 3.04 | 71.0% | 95.3% | 0.547 | n = 169 |
| **5** | **4** | Barrett U2 | 0.05 | 0.393 | 0.312 | 0.536 | 3.05 | 73.4% | 95.9% | 0.537 | n = 169 |
| **6** | **6** | Pearl DGS | 0.10 | 0.416 | 0.355 | 0.551 | 3.27 | 71.0% | 95.3% | 0.559 | n = 169 |
| **7** | **7** | Holladay 1 | 0.15 | 0.441 | 0.354 | 0.548 | 2.39 | 64.5% | 94.7% | 0.566 | n = 169 |
| **8** | **9** | Haigis | 0.19 | 0.455 | 0.389 | 0.564 | 3.30 | 66.9% | 92.9% | 0.593 | n = 169 |
| **9** | **8** | SRK/T | -0.06 | 0.438 | 0.343 | 0.572 | 2.33 | 68.6% | 93.5% | 0.573 | n = 169 |
| **10** | **10** | Hoffer Q | 0.19 | 0.494 | 0.420 | 0.603 | 3.37 | 56.8% | 92.9% | 0.632 | n = 169 |

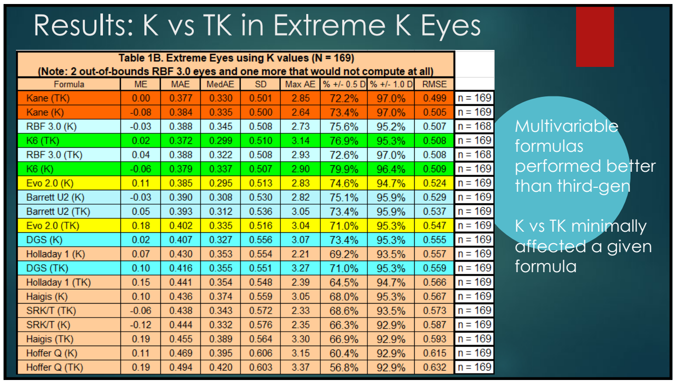


## Difference in ME and RMSE (TK minus K)

| Formula | ME | RMSE |
|---|---|---|
| SRK/T | 0.06 | -0.01 |
| Holladay 1 | 0.07 | 0.01 |
| Evo 2.0 | 0.07 | 0.02 |
| Hoffer Q | 0.08 | 0.02 |
| Barrett U2 | 0.08 | 0.01 |
| K6 | 0.08 | 0 |
| Kane | 0.08 | -0.01 |
| Pearl DGS | 0.08 | 0 |
| RBF 3.0 | 0.08 | 0 |
| Haigis | 0.09 | 0.03 |

Minimal change when using K or TK

Surprisingly, ME shifts slightly hyperopic when using TK values



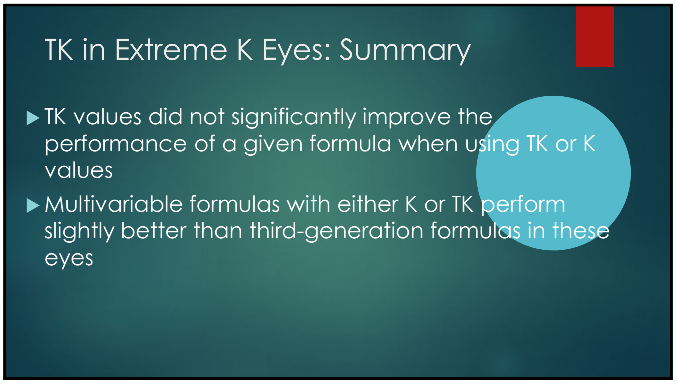
## Results: K vs TK in Extreme K Eyes

Table 1B. Extreme Eyes using K values (N = 169)
(Note: 2 out-of-bounds RBF 3.0 eyes and one more that would not compute at all)

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 1.0 D | RMSE | |
|---|---|---|---|---|---|---|---|---|---|
| Kane (TK) | 0.00 | 0.377 | 0.330 | 0.501 | 2.85 | 72.2% | 97.0% | 0.499 | n = 169 |
| Kane (K) | -0.08 | 0.384 | 0.335 | 0.500 | 2.64 | 73.4% | 97.0% | 0.505 | n = 169 |
| RBF 3.0 (K) | -0.03 | 0.388 | 0.345 | 0.508 | 2.73 | 75.6% | 95.2% | 0.507 | n = 168 |
| K6 (TK) | 0.02 | 0.372 | 0.299 | 0.510 | 3.14 | 76.9% | 95.3% | 0.508 | n = 169 |
| RBF 3.0 (TK) | 0.04 | 0.388 | 0.322 | 0.508 | 2.93 | 72.6% | 97.0% | 0.508 | n = 168 |
| K6 (K) | -0.06 | 0.379 | 0.337 | 0.507 | 2.90 | 79.9% | 96.4% | 0.509 | n = 169 |
| Evo 2.0 (K) | 0.11 | 0.385 | 0.295 | 0.513 | 2.83 | 74.6% | 94.7% | 0.524 | n = 169 |
| Barrett U2 (K) | -0.03 | 0.390 | 0.308 | 0.530 | 2.82 | 75.1% | 95.9% | 0.529 | n = 169 |
| Barrett U2 (TK) | 0.05 | 0.393 | 0.312 | 0.536 | 3.05 | 73.4% | 95.9% | 0.537 | n = 169 |
| Evo 2.0 (TK) | 0.18 | 0.402 | 0.335 | 0.516 | 3.04 | 71.0% | 95.3% | 0.547 | n = 169 |
| DGS (K) | 0.02 | 0.407 | 0.327 | 0.556 | 3.07 | 73.4% | 95.3% | 0.555 | n = 169 |
| Holladay 1 (K) | 0.07 | 0.430 | 0.353 | 0.554 | 2.21 | 69.2% | 93.5% | 0.557 | n = 169 |
| DGS (TK) | 0.10 | 0.416 | 0.355 | 0.551 | 3.27 | 71.0% | 95.3% | 0.559 | n = 169 |
| Holladay 1 (TK) | 0.15 | 0.441 | 0.354 | 0.548 | 2.39 | 64.5% | 94.7% | 0.566 | n = 169 |
| Haigis (K) | 0.10 | 0.436 | 0.374 | 0.559 | 3.05 | 68.0% | 95.3% | 0.567 | n = 169 |
| SRK/T (TK) | -0.06 | 0.438 | 0.343 | 0.572 | 2.33 | 68.6% | 93.5% | 0.573 | n = 169 |
| SRK/T (K) | -0.12 | 0.444 | 0.332 | 0.576 | 2.35 | 66.3% | 92.9% | 0.587 | n = 169 |
| Haigis (TK) | 0.19 | 0.455 | 0.389 | 0.564 | 3.30 | 66.9% | 92.9% | 0.593 | n = 169 |
| Hoffer Q (K) | 0.11 | 0.469 | 0.395 | 0.606 | 3.15 | 60.4% | 92.9% | 0.615 | n = 169 |
| Hoffer Q (TK) | 0.19 | 0.494 | 0.420 | 0.603 | 3.37 | 56.8% | 92.9% | 0.632 | n = 169 |

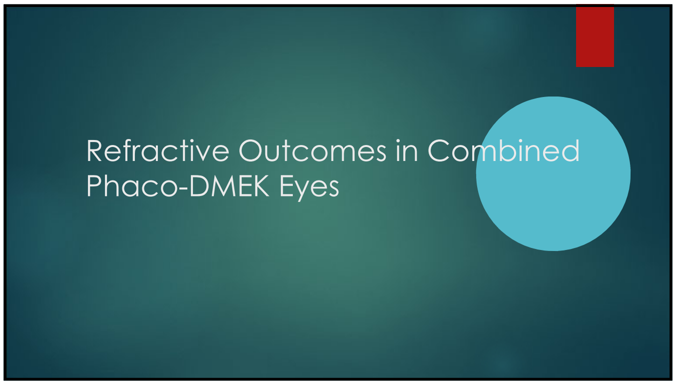
Multivariable formulas performed better than third-gen

K vs TK minimally affected a given formula

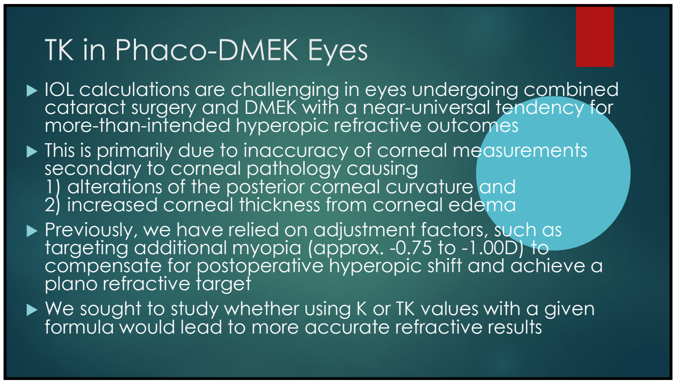


## TK in Extreme K Eyes: Summary

- TK values did not significantly improve the performance of a given formula when using TK or K values
- Multivariable formulas with either K or TK perform slightly better than third-generation formulas in these eyes

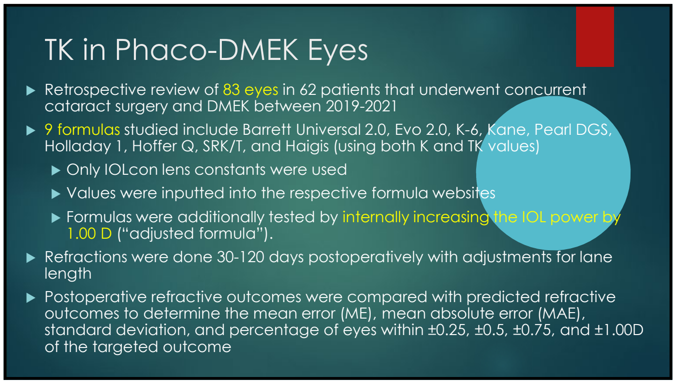


## Refractive Outcomes in Combined Phaco-DMEK Eyes



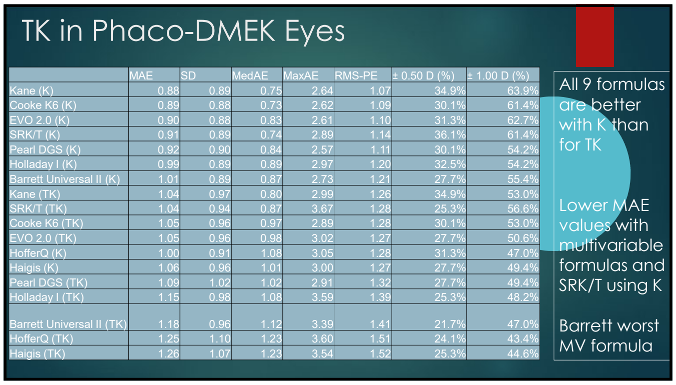
## TK in Phaco-DMEK Eyes

- IOL calculations are challenging in eyes undergoing combined cataract surgery and DMEK with a near-universal tendency for more-than-intended hyperopic refractive outcomes
- This is primarily due to inaccuracy of corneal measurements secondary to corneal pathology causing
  1) alterations of the posterior corneal curvature and
  2) increased corneal thickness from corneal edema
- Previously, we have relied on adjustment factors, such as targeting additional myopia (approx. -0.75 to -1.00D) to compensate for postoperative hyperopic shift and achieve a plano refractive target
- We sought to study whether using K or TK values with a given formula would lead to more accurate refractive results



## TK in Phaco-DMEK Eyes

- Retrospective review of 83 eyes in 62 patients that underwent concurrent cataract surgery and DMEK between 2019-2021
- 9 formulas studied include Barrett Universal 2.0, Evo 2.0, K-6, Kane, Pearl DGS, Holladay 1, Hoffer Q, SRK/T, and Haigis (using both K and TK values)
  - Only IOLcon lens constants were used
  - Values were inputted into the respective formula websites
  - Formulas were additionally tested by internally increasing the IOL power by 1.00 D ("adjusted formula").
- Refractions were done 30-120 days postoperatively with adjustments for lane length
- Postoperative refractive outcomes were compared with predicted refractive outcomes to determine the mean error (ME), mean absolute error (MAE), standard deviation, and percentage of eyes within ±0.25, ±0.5, ±0.75, and ±1.00D of the targeted outcome



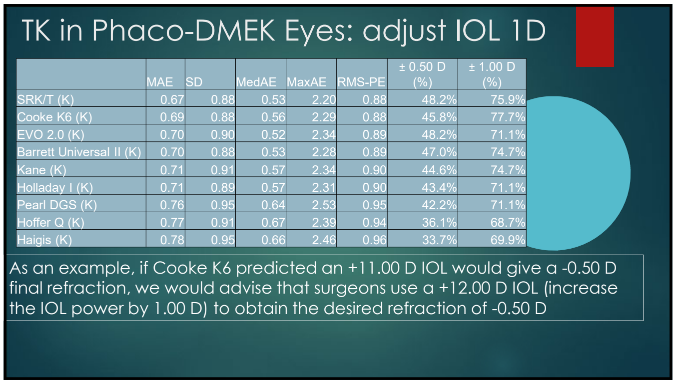
# TK in Phaco-DMEK Eyes

| | MAE | SD | MedAE | MaxAE | RMS-PE | ± 0.50 D (%) | ± 1.00 D (%) |
|---|---|---|---|---|---|---|---|
| Kane (K) | 0.88 | 0.89 | 0.75 | 2.64 | 1.07 | 34.9% | 63.9% |
| Cooke K6 (K) | 0.89 | 0.88 | 0.73 | 2.62 | 1.09 | 30.1% | 61.4% |
| EVO 2.0 (K) | 0.90 | 0.88 | 0.83 | 2.61 | 1.10 | 31.3% | 62.7% |
| SRK/T (K) | 0.91 | 0.89 | 0.74 | 2.89 | 1.14 | 36.1% | 61.4% |
| Pearl DGS (K) | 0.92 | 0.90 | 0.84 | 2.57 | 1.11 | 30.1% | 54.2% |
| Holladay I (K) | 0.99 | 0.89 | 0.89 | 2.97 | 1.20 | 32.5% | 54.2% |
| Barrett Universal II (K) | 1.01 | 0.89 | 0.87 | 2.73 | 1.21 | 27.7% | 55.4% |
| Kane (TK) | 1.04 | 0.97 | 0.80 | 2.99 | 1.26 | 34.9% | 53.0% |
| SRK/T (TK) | 1.04 | 0.94 | 0.87 | 3.67 | 1.28 | 25.3% | 56.6% |
| Cooke K6 (TK) | 1.05 | 0.96 | 0.97 | 2.89 | 1.28 | 30.1% | 53.0% |
| EVO 2.0 (TK) | 1.05 | 0.96 | 0.98 | 3.02 | 1.27 | 27.7% | 50.6% |
| HofferQ (K) | 1.00 | 0.91 | 1.08 | 3.05 | 1.28 | 31.3% | 47.0% |
| Haigis (K) | 1.06 | 0.96 | 1.01 | 3.00 | 1.27 | 27.7% | 49.4% |
| Pearl DGS (TK) | 1.09 | 1.02 | 1.02 | 2.91 | 1.32 | 27.7% | 49.4% |
| Holladay I (TK) | 1.15 | 0.98 | 1.08 | 3.59 | 1.39 | 25.3% | 48.2% |
| Barrett Universal II (TK) | 1.18 | 0.96 | 1.12 | 3.39 | 1.41 | 21.7% | 47.0% |
| HofferQ (TK) | 1.25 | 1.10 | 1.23 | 3.60 | 1.51 | 24.1% | 43.4% |
| Haigis (TK) | 1.26 | 1.07 | 1.23 | 3.54 | 1.52 | 25.3% | 44.6% |

All 9 formulas are better with K than for TK

Lower MAE values with multivariable formulas and SRK/T using K

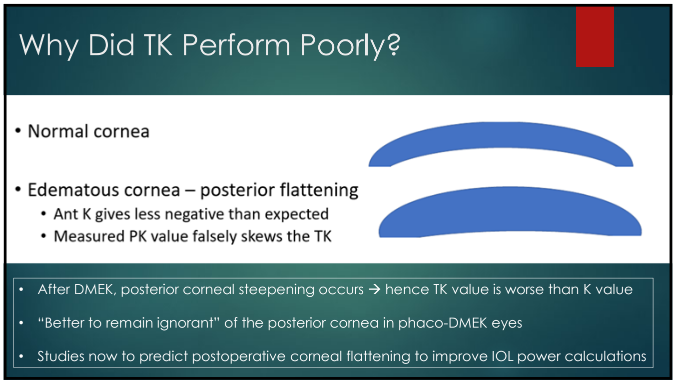
Barrett worst MV formula



# TK in Phaco-DMEK Eyes: adjust IOL 1D

| | MAE | SD | MedAE | MaxAE | RMS-PE | ± 0.50 D (%) | ± 1.00 D (%) |
|---|---|---|---|---|---|---|---|
| SRK/T (K) | 0.67 | 0.88 | 0.53 | 2.20 | 0.88 | 48.2% | 75.9% |
| Cooke K6 (K) | 0.69 | 0.88 | 0.56 | 2.29 | 0.88 | 45.8% | 77.7% |
| EVO 2.0 (K) | 0.70 | 0.90 | 0.52 | 2.34 | 0.89 | 48.2% | 71.1% |
| Barrett Universal II (K) | 0.70 | 0.88 | 0.53 | 2.28 | 0.89 | 47.0% | 74.7% |
| Kane (K) | 0.71 | 0.91 | 0.57 | 2.34 | 0.90 | 44.6% | 74.7% |
| Holladay I (K) | 0.71 | 0.89 | 0.57 | 2.31 | 0.90 | 43.4% | 71.1% |
| Pearl DGS (K) | 0.76 | 0.95 | 0.64 | 2.53 | 0.95 | 42.2% | 71.1% |
| Hoffer Q (K) | 0.77 | 0.91 | 0.67 | 2.39 | 0.94 | 36.1% | 68.7% |
| Haigis (K) | 0.78 | 0.95 | 0.66 | 2.46 | 0.96 | 33.7% | 69.9% |

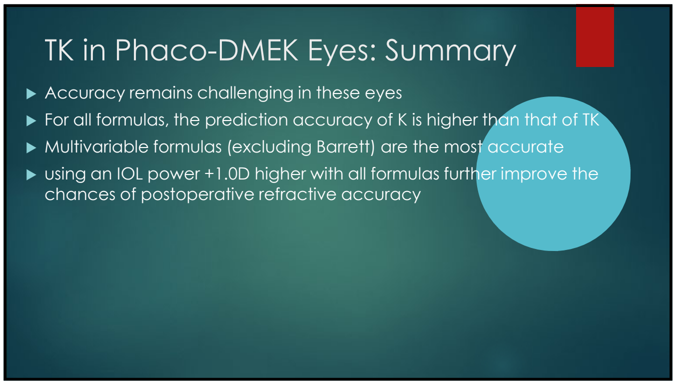
As an example, if Cooke K6 predicted an +11.00 D IOL would give a -0.50 D final refraction, we would advise that surgeons use a +12.00 D IOL (increase the IOL power by 1.00 D) to obtain the desired refraction of -0.50 D



# Why Did TK Perform Poorly?

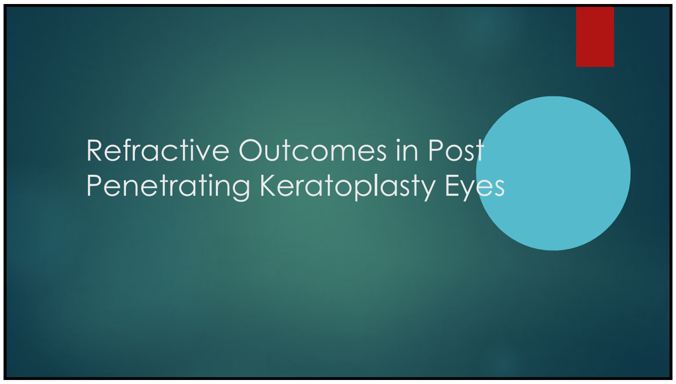
- Normal cornea
- Edematous cornea – posterior flattening
  - Ant K gives less negative than expected
  - Measured PK value falsely skews the TK

- After DMEK, posterior corneal steepening occurs → hence TK value is worse than K value
- "Better to remain ignorant" of the posterior cornea in phaco-DMEK eyes
- Studies now to predict postoperative corneal flattening to improve IOL power calculations

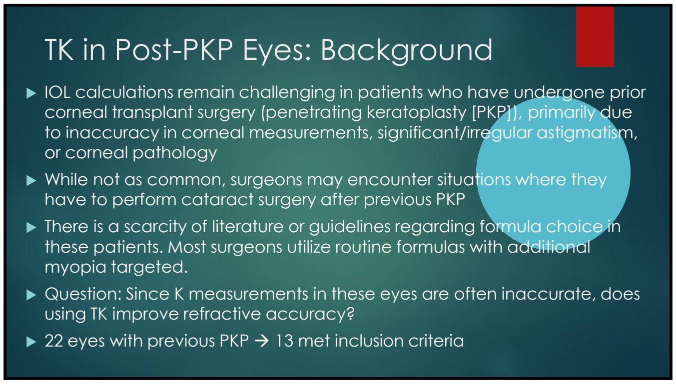


## TK in Phaco-DMEK Eyes: Summary

- Accuracy remains challenging in these eyes
- For all formulas, the prediction accuracy of K is higher than that of TK
- Multivariable formulas (excluding Barrett) are the most accurate
- using an IOL power +1.0D higher with all formulas further improve the chances of postoperative refractive accuracy

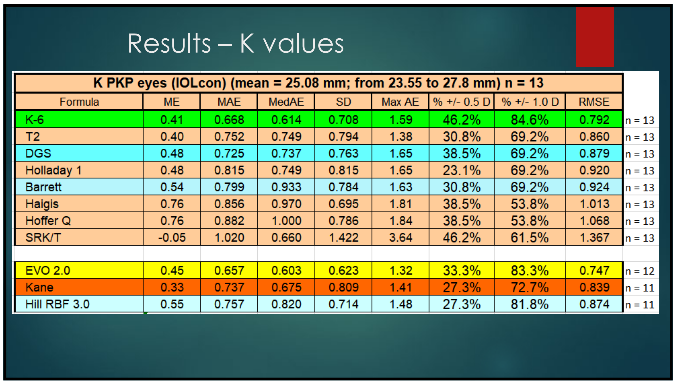


## Refractive Outcomes in Post Penetrating Keratoplasty Eyes



## TK in Post-PKP Eyes: Background

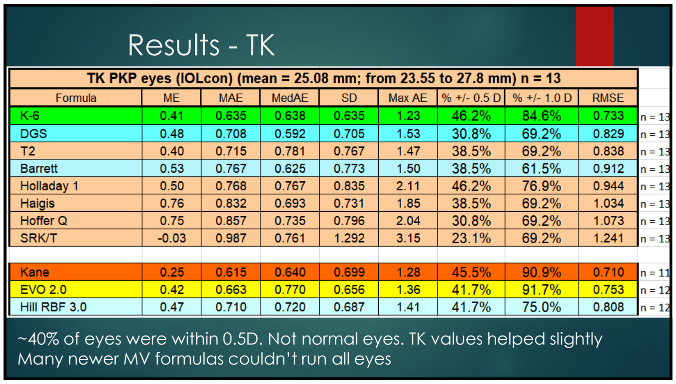
- IOL calculations remain challenging in patients who have undergone prior corneal transplant surgery (penetrating keratoplasty [PKP]), primarily due to inaccuracy in corneal measurements, significant/irregular astigmatism, or corneal pathology
- While not as common, surgeons may encounter situations where they have to perform cataract surgery after previous PKP
- There is a scarcity of literature or guidelines regarding formula choice in these patients. Most surgeons utilize routine formulas with additional myopia targeted.
- Question: Since K measurements in these eyes are often inaccurate, does using TK improve refractive accuracy?
- 22 eyes with previous PKP → 13 met inclusion criteria



## Results – K values

**K PKP eyes (IOLcon) (mean = 25.08 mm; from 23.55 to 27.8 mm) n = 13**

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 1.0 D | RMSE | |
|---|---|---|---|---|---|---|---|---|---|
| K-6 | 0.41 | 0.668 | 0.614 | 0.708 | 1.59 | 46.2% | 84.6% | 0.792 | n = 13 |
| T2 | 0.40 | 0.752 | 0.749 | 0.794 | 1.38 | 30.8% | 69.2% | 0.860 | n = 13 |
| DGS | 0.48 | 0.725 | 0.737 | 0.763 | 1.65 | 38.5% | 69.2% | 0.879 | n = 13 |
| Holladay 1 | 0.48 | 0.815 | 0.749 | 0.815 | 1.65 | 23.1% | 69.2% | 0.920 | n = 13 |
| Barrett | 0.54 | 0.799 | 0.933 | 0.784 | 1.63 | 30.8% | 69.2% | 0.924 | n = 13 |
| Haigis | 0.76 | 0.856 | 0.970 | 0.695 | 1.81 | 38.5% | 53.8% | 1.013 | n = 13 |
| Hoffer Q | 0.76 | 0.882 | 1.000 | 0.786 | 1.84 | 38.5% | 53.8% | 1.068 | n = 13 |
| SRK/T | -0.05 | 1.020 | 0.660 | 1.422 | 3.64 | 46.2% | 61.5% | 1.367 | n = 13 |
| | | | | | | | | | |
| EVO 2.0 | 0.45 | 0.657 | 0.603 | 0.623 | 1.32 | 33.3% | 83.3% | 0.747 | n = 12 |
| Kane | 0.33 | 0.737 | 0.675 | 0.809 | 1.41 | 27.3% | 72.7% | 0.839 | n = 11 |
| Hill RBF 3.0 | 0.55 | 0.757 | 0.820 | 0.714 | 1.48 | 27.3% | 81.8% | 0.874 | n = 11 |

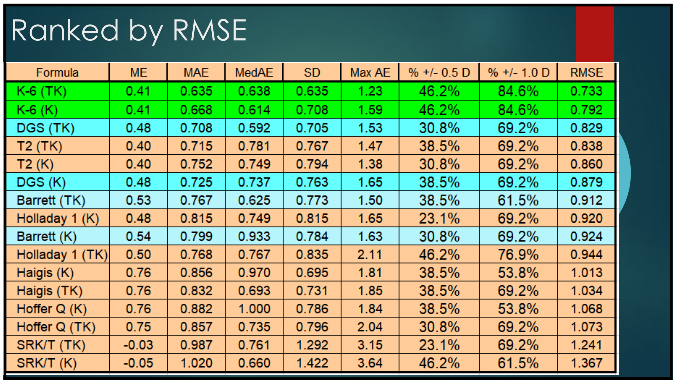


## Results - TK

**TK PKP eyes (IOLcon) (mean = 25.08 mm; from 23.55 to 27.8 mm) n = 13**

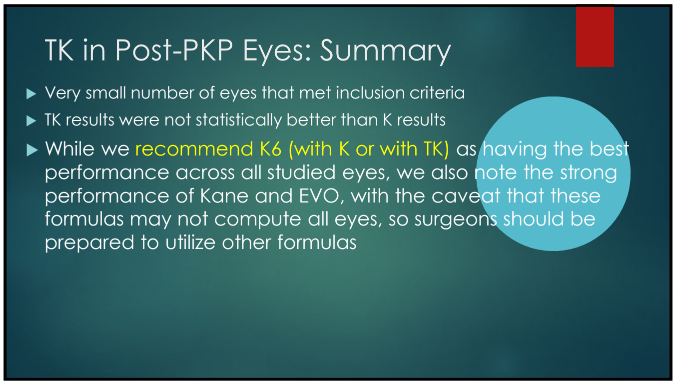
| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 1.0 D | RMSE | |
|---|---|---|---|---|---|---|---|---|---|
| K-6 | 0.41 | 0.635 | 0.638 | 0.635 | 1.23 | 46.2% | 84.6% | 0.733 | n = 13 |
| DGS | 0.48 | 0.708 | 0.592 | 0.705 | 1.53 | 30.8% | 69.2% | 0.829 | n = 13 |
| T2 | 0.40 | 0.715 | 0.781 | 0.767 | 1.47 | 38.5% | 69.2% | 0.838 | n = 13 |
| Barrett | 0.53 | 0.767 | 0.625 | 0.773 | 1.50 | 38.5% | 61.5% | 0.912 | n = 13 |
| Holladay 1 | 0.50 | 0.768 | 0.767 | 0.835 | 2.11 | 46.2% | 76.9% | 0.944 | n = 13 |
| Haigis | 0.76 | 0.832 | 0.693 | 0.731 | 1.85 | 38.5% | 69.2% | 1.034 | n = 13 |
| Hoffer Q | 0.75 | 0.857 | 0.735 | 0.796 | 2.04 | 30.8% | 69.2% | 1.073 | n = 13 |
| SRK/T | -0.03 | 0.987 | 0.761 | 1.292 | 3.15 | 23.1% | 69.2% | 1.241 | n = 13 |
| | | | | | | | | | |
| Kane | 0.25 | 0.615 | 0.640 | 0.699 | 1.28 | 45.5% | 90.9% | 0.710 | n = 11 |
| EVO 2.0 | 0.42 | 0.663 | 0.770 | 0.656 | 1.36 | 41.7% | 91.7% | 0.753 | n = 12 |
| Hill RBF 3.0 | 0.47 | 0.710 | 0.720 | 0.687 | 1.41 | 41.7% | 75.0% | 0.808 | n = 12 |

~40% of eyes were within 0.5D. Not normal eyes. TK values helped slightly
Many newer MV formulas couldn't run all eyes



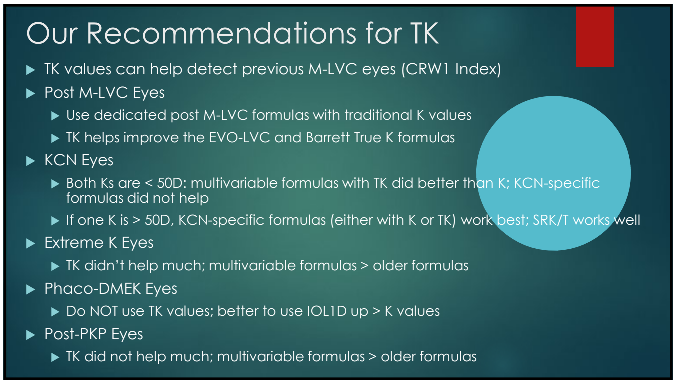
## Ranked by RMSE

| Formula | ME | MAE | MedAE | SD | Max AE | % +/- 0.5 D | % +/- 1.0 D | RMSE |
|---|---|---|---|---|---|---|---|---|
| K-6 (TK) | 0.41 | 0.635 | 0.638 | 0.635 | 1.23 | 46.2% | 84.6% | 0.733 |
| K-6 (K) | 0.41 | 0.668 | 0.614 | 0.708 | 1.59 | 46.2% | 84.6% | 0.792 |
| DGS (TK) | 0.48 | 0.708 | 0.592 | 0.705 | 1.53 | 30.8% | 69.2% | 0.829 |
| T2 (TK) | 0.40 | 0.715 | 0.781 | 0.767 | 1.47 | 38.5% | 69.2% | 0.838 |
| T2 (K) | 0.40 | 0.752 | 0.749 | 0.794 | 1.38 | 30.8% | 69.2% | 0.860 |
| DGS (K) | 0.48 | 0.725 | 0.737 | 0.763 | 1.65 | 38.5% | 69.2% | 0.879 |
| Barrett (TK) | 0.53 | 0.767 | 0.625 | 0.773 | 1.50 | 38.5% | 61.5% | 0.912 |
| Holladay 1 (K) | 0.48 | 0.815 | 0.749 | 0.815 | 1.65 | 23.1% | 69.2% | 0.920 |
| Barrett (K) | 0.54 | 0.799 | 0.933 | 0.784 | 1.63 | 30.8% | 69.2% | 0.924 |
| Holladay 1 (TK) | 0.50 | 0.768 | 0.767 | 0.835 | 2.11 | 46.2% | 76.9% | 0.944 |
| Haigis (K) | 0.76 | 0.856 | 0.970 | 0.695 | 1.81 | 38.5% | 53.8% | 1.013 |
| Haigis (TK) | 0.76 | 0.832 | 0.693 | 0.731 | 1.85 | 38.5% | 69.2% | 1.034 |
| Hoffer Q (K) | 0.76 | 0.882 | 1.000 | 0.786 | 1.84 | 38.5% | 53.8% | 1.068 |
| Hoffer Q (TK) | 0.75 | 0.857 | 0.735 | 0.796 | 2.04 | 30.8% | 69.2% | 1.073 |
| SRK/T (TK) | -0.03 | 0.987 | 0.761 | 1.292 | 3.15 | 23.1% | 69.2% | 1.241 |
| SRK/T (K) | -0.05 | 1.020 | 0.660 | 1.422 | 3.64 | 46.2% | 61.5% | 1.367 |



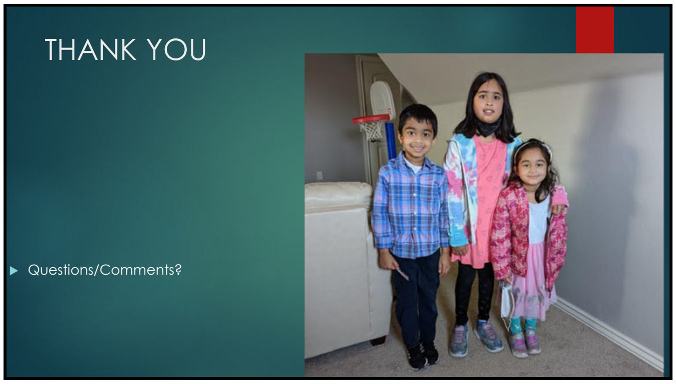
## TK in Post-PKP Eyes: Summary

- Very small number of eyes that met inclusion criteria
- TK results were not statistically better than K results
- While we recommend K6 (with K or with TK) as having the best performance across all studied eyes, we also note the strong performance of Kane and EVO, with the caveat that these formulas may not compute all eyes, so surgeons should be prepared to utilize other formulas



## Our Recommendations for TK

- TK values can help detect previous M-LVC eyes (CRW1 Index)
- Post M-LVC Eyes
  - Use dedicated post M-LVC formulas with traditional K values
  - TK helps improve the EVO-LVC and Barrett True K formulas
- KCN Eyes
  - Both Ks are < 50D: multivariable formulas with TK did better than K; KCN-specific formulas did not help
  - If one K is > 50D, KCN-specific formulas (either with K or TK) work best; SRK/T works well
- Extreme K Eyes
  - TK didn't help much; multivariable formulas > older formulas
- Phaco-DMEK Eyes
  - Do NOT use TK values; better to use IOL1D up > K values
- Post-PKP Eyes
  - TK did not help much; multivariable formulas > older formulas



## THANK YOU

- Questions/Comments?