Performance of Novel IOL Power Calculation Formulas Incorporating Total Keratometry in Patients with Keratoconus

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Background/Purpose

- Keratoconus (KCN) is a non-inflammatory ectatic corneal disorder characterized by progressive corneal thinning and protrusion

- Intraocular lens (IOL) power calculation in KCN is unreliable due to:
  - Keratometry repeatability and accuracy
  - Anterior/posterior corneal relationship
  - Effective lens position prediction error
  - Corneal apex and visual axis inconsistency

- Novel IOL power calculation formulas may improve prediction error

- Literature is lacking in large with comparative studies among formulas

- **Purpose:**
  - Compare the accuracy of available IOL power calculation formulas in patients with KCN
  - Evaluate formula performance by KCN severity

Methods

- Retrospective study of 98 eyes of 70 individuals with KCN who underwent uncomplicated cataract surgery with IOL implantation at the Bascom Palmer Eye Institute Miami FL, between 12/1/2014 – 6/1/2021
  - Exclusion criteria:
    - Hx of refractive or intraocular surgery
    - Keratometry values >60D (formula limitations)
    - Concomitant surgeries
- Grouped by KCN severity using steep keratometry: **mild (<48D), moderate (48-53D), and severe (53-60D)**

Formulas Evaluated	
Standard Formulas	**KCN-Specific Formulas**
SRK/T	Barrett True K v2.5
Holladay 1	Barrett TK True K v2.5
Barrett Universal II	Kane KCN
Barrett TK Universal II	Modified Holladay 1-EKR65

Demographics of Study Population

Parameter	N=70
Age (years), mean±SD	63.74±9.9
Sex, N (%)	
Male	32 (45.7%)
Female	38 (54.3%)
Race/Ethnicity, N (%)	
White	61 (87.1%)
Black or African/American	6 (8.6%)
Hispanic, any race	40 (57.1%)
Mean follow up time (months), mean±SD	2.1±1.7
Keratoconus Severity, n (%)	**N=98**
Mild (<48D)	53 (54.1%)
Moderate (48-53D)	30 (30.6%)
Severe (53-60D)	15 (15.3%)

Baseline Corneal Measurements

Measurements, mean ± SD	N=98
Axial length (mm)	25.22 ± 2.28
Flat Keratometry (D)	45.35 ± 3.45
Steep Keratometry (D)	48.36 ± 3.99
Mean K (D)	46.85 ± 3.53
Corneal thickness (mm)	509.15 ± 39.82
Lens thickness (mm)	4.32 ± 0.36
Pre-operative Best corrected visual acuity (BCVA)	0.12 (0.15)
Pre-operative spherical equivalent (D)	-5.61 ± 7.34

- BCVA improved from 0.43±0.42 to 0.12±0.15 after surgery($p<0.0001$)
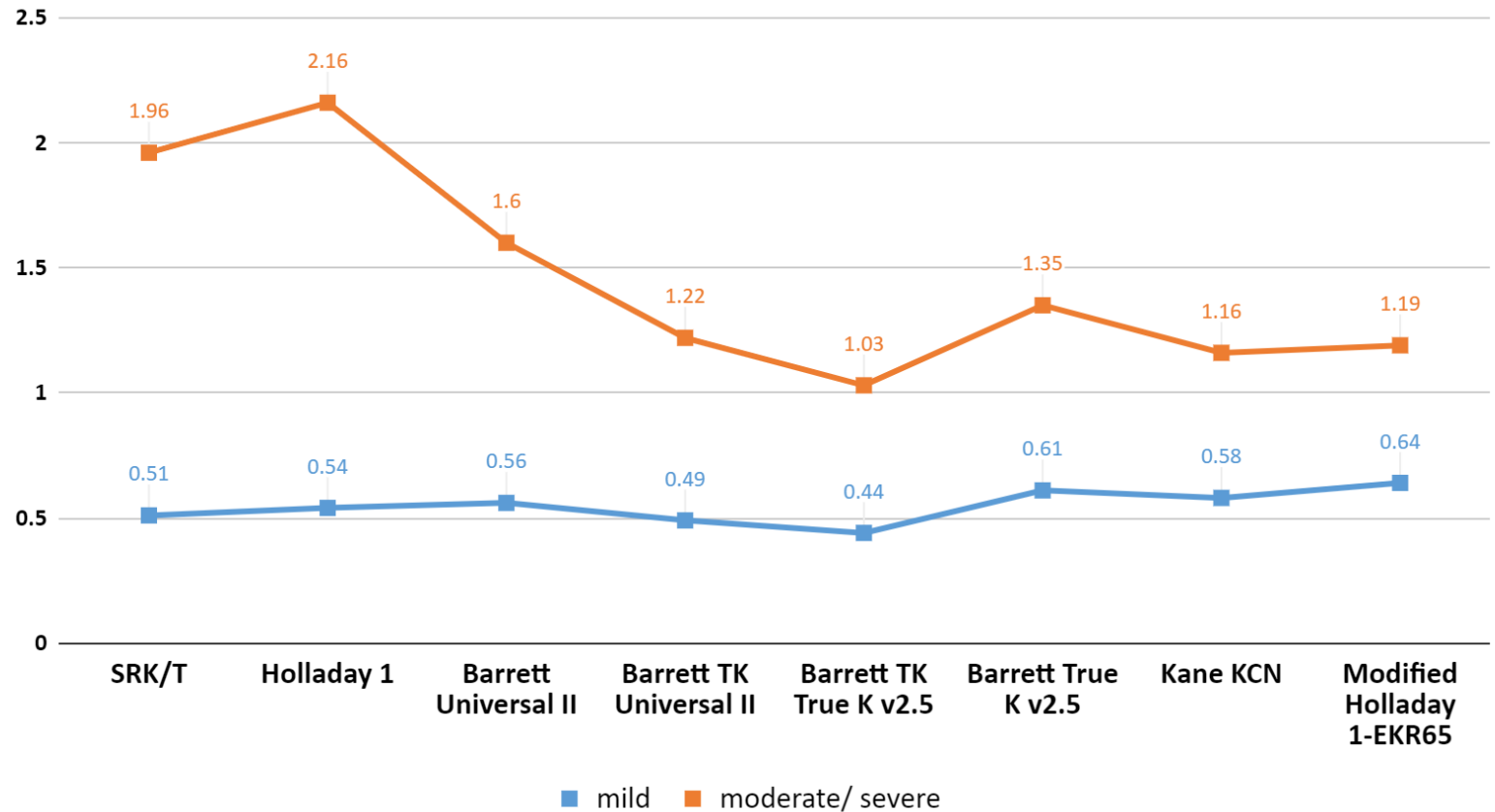- Spherical equivalent improved from -5.61±7.34 D to -0.63±1.76 D after surgery ($p<0.0001$)

Barrett(TK)True K had the Lowest MAE Across All KCN severities

KCN Severities	All Severities		Mild		Mod/Severe	
Formulas	MAE	ME	MAE	ME	MAE	ME
Barrett TK True K v2.5	0.67(0.81)	-0.08(1.06)	0.44(0.36)	-0.01(0.58)	1.03(1.15)	-0.19(1.57)
Barrett TK Universal II	0.76(0.83)	0.24(1.11)	0.49(0.41)	0.24(0.6)	1.22(1.16)	0.25(1.71)
Kane KCN	0.85(0.85)	-0.03(1.2)	0.58(0.57)	0(0.82)	1.16(1.01)	-0.07(1.55)
Modified Holladay 1 with EKR	0.88(0.71)	-0.29(1.11)	0.64(0.67)	-0.3(0.89)	1.19(0.67)	-0.27(1.39)
Barrett True K v2.5	0.95(0.93)	-0.01(1.33)	0.61(0.58)	-0.29(0.79)	1.35(1.1)	0.32(1.72)
Barrett Universal II	1.04(1.11)	0.41(1.47)	0.56(0.57)	0.03(0.8)	1.6(1.31)	0.84(1.9)
SRK/T	1.14(1.44)	0.23(1.82)	0.51(0.58)	-0.09(0.77)	1.96(1.78)	0.64(2.58)
Holladay 1	1.19(1.43)	0.64(1.75)	0.54(0.55)	0.17(0.75)	2.16(1.77)	1.34(2.47)

*MAE=Mean Absolute Error; ME= Mean Error

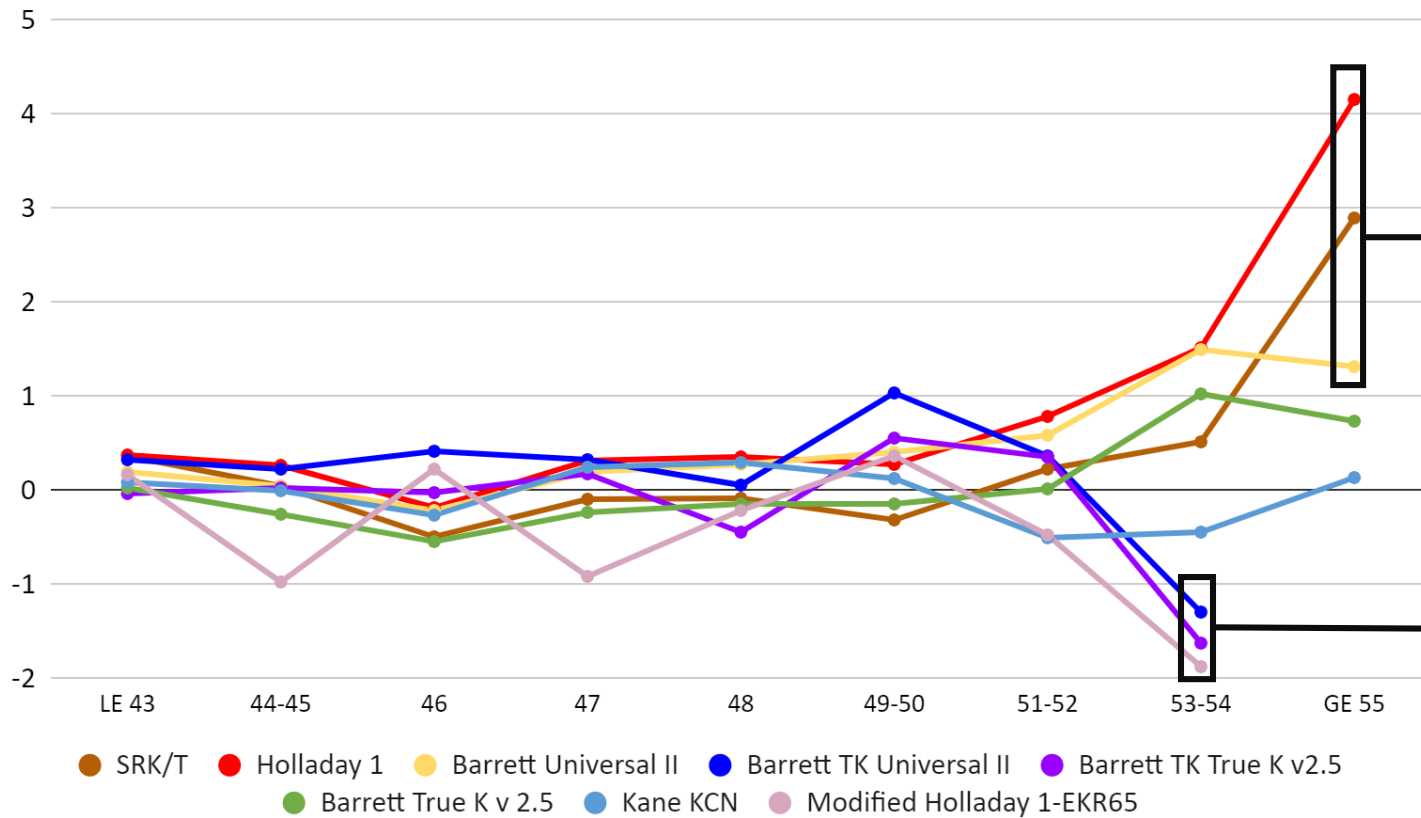# All Formulas had Higher MAE with Increased KCN Severity

- <u>Holladay 1, SRK/T, and Barrett Universal II</u> performed the worst in individuals with moderate/severe KCN

Mean Absolute Value of Errors by Severity Level

	SRK/T	Holladay 1	Barrett Universal II	Barrett TK Universal II	Barrett TK True K v2.5	Barrett True K v2.5	Kane KCN	Modified Holladay 1-EKR65
moderate/severe	1.96	2.16	1.6	1.22	1.03	1.35	1.16	1.19
mild	0.51	0.54	0.56	0.49	0.44	0.61	0.58	0.64

■ mild   ■ moderate/ severe

Mean Error Shows Refractive Surprise


Mean Error by Steep Keratometry

Holladay 1, SRK/T, and Barrett Universal II tend to produce <u>hyperopic surprise</u> in eyes with more advanced KCN

Barrett TK Universal II, Barrett TK True K v.2.5, and Modified Holladay 1-EKR65 tend to produce <u>myopic surprise</u> in eyes with more advanced KCN

All Formulas Performed Similarly in Patients with Mild KCN

Mild Severity
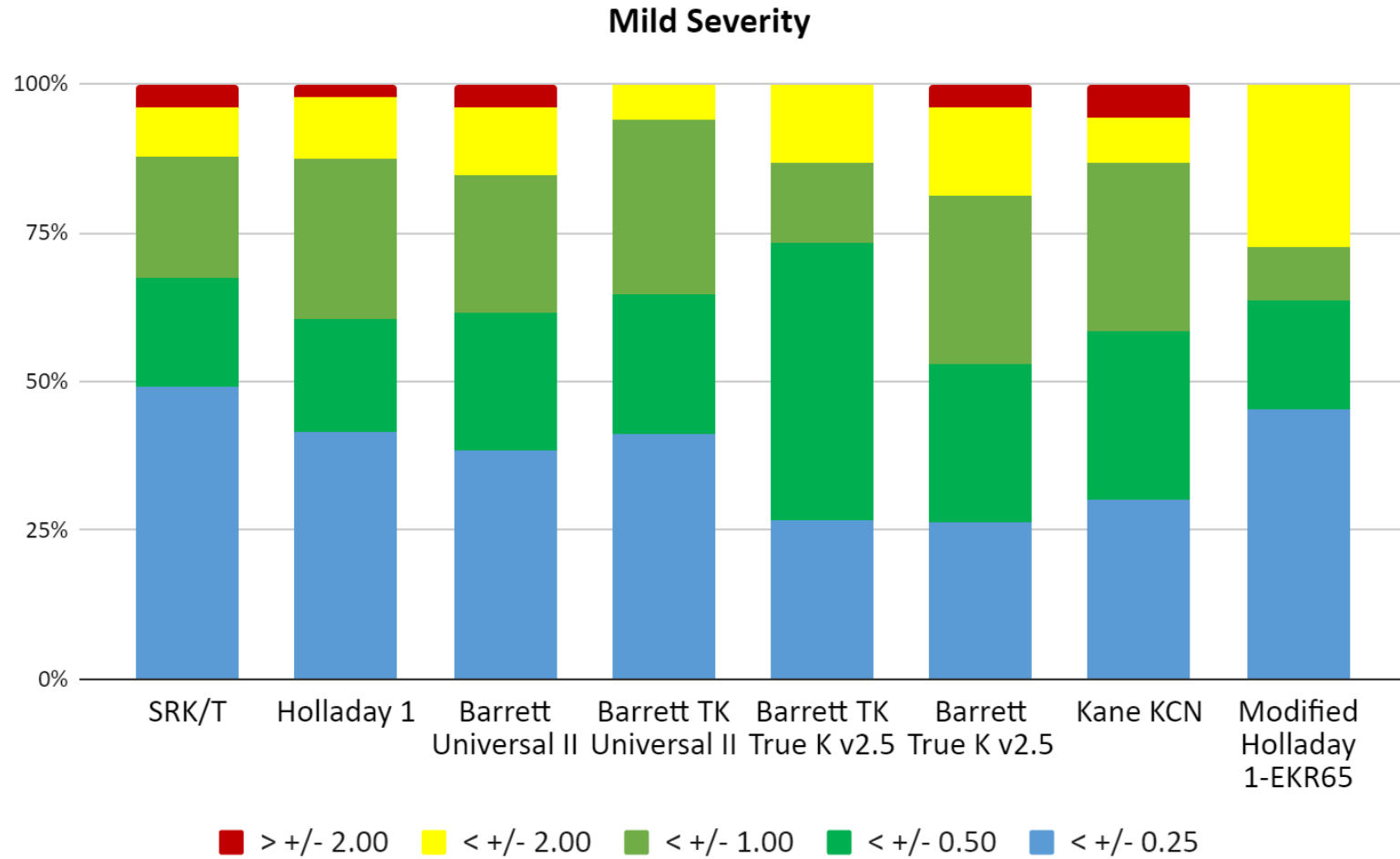
KCN Specific Formulas Performed Better than Standard Formulas in Individuals with Moderate/Severe KCN

Moderate and Severe Severity
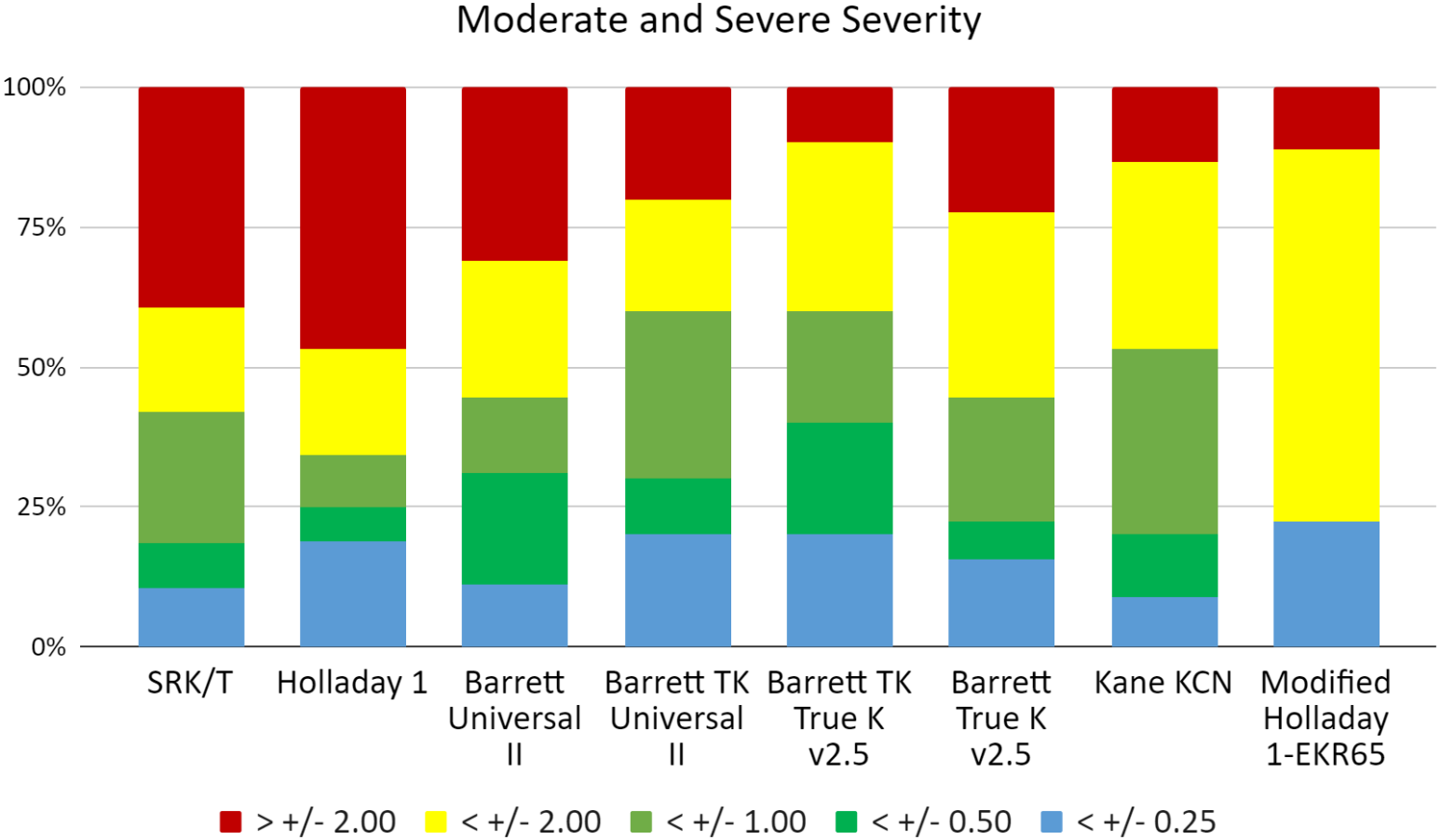
Barrett TK Universal II performed best among the standard formulas

Summary/Conclusions

1. All formulas behaved similarly in mild KCN
2. Formulas used in moderate/severe KCN had a **higher MAE** than in mild KCN across all formulas, particularly the SRK/T, Holladay 1, and Barrett Universal II
3. In moderate/severe KCN the SRK/T, Holladay 1, and Barrett Universal II resulted in a large (>2D) surprise in over 25% of eyes
4. Exercise caution when aiming myopic for severe KCN, as not all formulas may require it
5. **Barrett TK True K v2.5, Barrett TK Universal II, and Kane KCN** had the **lowest MAE** among all of the formulas in the all severities group

- Formulas using **total keratometry** may offer the most reliable outcomes in patients with KCN, regardless of severity.

- IOL power calculation in patients with KCN remains challenging. Total keratometry may improve refractive outcomes in these cases.

- Further research is required to evaluate the performance of IOL formulas in KCN, especially in patients with severe disease.

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