

SUPPLEMENTARY MATERIAL

Title: Capsular Tension Ring Implantation Improves Intraocular Lens Power Prediction Accuracy in Cataract with Retinitis Pigmentosa

Short title: CTR Improves IOL Accuracy in RP

Authors

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Supplementary Table 1

Comparison of root-mean-square absolute error (RMSAE) values among 12 IOL calculation formulas in the entire study cohort (N = 53). Statistical significance was determined using the paired Wilcoxon signed-rank test with Benjamini-Hochberg correction for multiple comparisons. BUII = Barrett Universal II; EVO = Emmetropia Verifying Optical.

Formula	RMSAE	BUII	Cooke K6	EVO 2.0	Haigis	Hoffer Q	Hoffer QST	Holladay	Kane	Karmona	LADAS	PEARL-DGS	SRK_T
BUII	0.56	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cooke K6	0.60	0.81	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EVO 2.0	0.60	0.91	0.97	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haigis	0.59	0.97	0.97	0.97	-	NA	NA	NA	NA	NA	NA	NA	NA
Hoffer Q	0.67	0.47	0.91	0.81	0.81	-	NA	NA	NA	NA	NA	NA	NA
Hoffer QST	0.65	1.00	0.97	0.97	0.97	0.47	-	NA	NA	NA	NA	NA	NA
Holladay	0.70	0.37	0.81	0.60	0.39	0.49	0.35	-	NA	NA	NA	NA	NA
Kane	0.59	0.81	0.97	0.94	0.97	0.81	0.97	0.47	-	NA	NA	NA	NA
Karmona	0.62	0.93	0.97	0.97	0.97	0.93	0.97	0.60	0.97	-	NA	NA	NA
LADAS	0.85	0.37	0.84	0.37	0.47	0.91	0.44	0.97	0.38	0.40	-	NA	NA
PEARL-DGS	0.70	0.39	0.35	0.39	0.81	0.97	0.83	0.97	0.44	0.52	0.97	-	NA
SRK_T	0.76	0.24	0.52	0.35	0.39	0.60	0.37	0.97	0.23	0.37	0.60	0.97	-

Supplementary Table 2

Comparison of root-mean-square absolute error (RMSAE) values among 12 IOL calculation formulas in the CTR group (N = 23). Statistical significance was determined using the paired Wilcoxon signed-rank test with Benjamini-Hochberg correction for multiple comparisons. BUII = Barrett Universal II; EVO = Emmetropia Verifying Optical.

Formula	RMSAE	BUII	Cooke K6	EVO 2.0	Haigis	Hoffer Q	Hoffer QST	Holladay	Kane	Karmona	LADAS	PEARL-DGS	SRK_T
BUII	0.46	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cooke K6	0.43	0.728	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EVO 2.0	0.43	0.645	0.737	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haigis	0.46	0.8	0.421	0.657	-	NA	NA	NA	NA	NA	NA	NA	NA
Hoffer Q	0.56	0.052	0.089	0.052	0.335	-	NA	NA	NA	NA	NA	NA	NA
Hoffer QST	0.49	0.291	0.335	0.339	0.681	0.28	-	NA	NA	NA	NA	NA	NA
Holladay	0.65	0.03	0.052	0.03	0.052	0.089	0.03	-	NA	NA	NA	NA	NA
Kane	0.41	0.421	0.8	0.481	0.681	0.064	0.241	0.03	-	NA	NA	NA	NA
Karmona	0.44	0.703	0.942	0.833	0.557	0.103	0.335	0.052	0.833	-	NA	NA	NA
LADAS	0.51	0.53	0.362	0.11	0.791	0.12	0.907	0.052	0.099	0.293	-	NA	NA
PEARL-DGS	0.49	0.975	0.545	0.833	0.681	0.481	0.8	0.119	0.681	0.681	0.8	-	NA
SRK_T	0.55	0.103	0.136	0.052	0.703	0.859	0.737	0.052	0.044	0.141	0.362	0.557	-

Supplementary Table 3

Comparison of root-mean-square absolute error (RMSAE) values among 12 IOL calculation formulas in the non-CTR group (N = 30). Statistical significance was determined using the paired Wilcoxon signed-rank test with Benjamini-Hochberg correction for multiple comparisons. BUII = Barrett Universal II; EVO = Emmetropia Verifying Optical.

Formula	RMSAE	BUII	Cooke K6	EVO 2.0	Haigis	Hoffer Q	Hoffer QST	Holladay	Kane	Karmona	LADAS	PEARL-DGS	SRK_T
BUII	0.63	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cooke K6	0.70	0.55	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EVO 2.0	0.71	0.56	0.67	-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Haigis	0.68	0.95	0.67	0.73	-	NA	NA	NA	NA	NA	NA	NA	NA
Hoffer Q	0.74	0.98	0.78	0.91	0.95	-	NA	NA	NA	NA	NA	NA	NA
Hoffer QST	0.75	0.70	0.57	0.67	0.88	0.78	-	NA	NA	NA	NA	NA	NA
Holladay	0.74	0.98	0.67	0.78	0.98	0.95	0.98	-	NA	NA	NA	NA	NA
Kane	0.69	0.55	0.86	0.98	0.70	0.91	0.61	0.83	-	NA	NA	NA	NA
Karmona	0.74	0.56	1.00	0.91	0.67	0.84	0.67	0.95	0.95	-	NA	NA	NA
LADAS	1.04	0.55	0.91	0.73	0.56	0.55	0.55	0.56	0.91	0.73	-	NA	NA
PEARL-DGS	0.83	0.55	0.55	0.55	0.56	0.67	0.67	0.67	0.57	0.67	0.78	-	NA
SRK_T	0.89	0.55	0.98	0.67	0.55	0.56	0.55	0.55	0.56	0.67	0.91	0.91	-

Supplementary Table 4

Detailed Sensitivity Analysis of Refractive Prediction Outcomes in the CTR and Non-CTR Groups (One Eye per Patient, n=38)

Formula	CTR (<i>n</i> = 15)			Non-CTR (<i>n</i> = 23)			<i>P</i> value *
	MAE	MedAE	RMSAE	MAE	MedAE	RMSAE	
BUII	0.31 ± 0.24	0.21	0.39	0.43 ± 0.25	0.43	0.49	0.129
Cooke K6	0.29 ± 0.28	0.33	0.40	0.50 ± 0.29	0.45	0.57	0.032
EVO 2.0	0.27 ± 0.21	0.21	0.34	0.51 ± 0.30	0.52	0.59	0.011
Haigis	0.37 ± 0.21	0.32	0.42	0.48 ± 0.37	0.34	0.60	0.600
Hoffer Q	0.41 ± 0.26	0.37	0.48	0.51 ± 0.50	0.36	0.70	0.956
Hoffer QST	0.33 ± 0.20	0.32	0.40	0.50 ± 0.54	0.35	0.73	0.679
Holladay	0.45 ± 0.21	0.51	0.50	0.48 ± 0.47	0.28	0.67	0.431
Kane	0.27 ± 0.21	0.22	0.33	0.51 ± 0.28	0.59	0.58	0.012
Karmona	0.30 ± 0.25	0.185	0.39	0.52 ± 0.36	0.52	0.64	0.070
LADAS	0.35 ± 0.27	0.27	0.43	0.72 ± 0.76	0.53	1.04	0.055
PEARL-DGS	0.42 ± 0.32	0.37	0.52	0.60 ± 0.40	0.61	0.75	0.183
SRK_T	0.34 ± 0.26	0.28	0.42	0.63 ± 0.53	0.53	0.82	0.048

BUII = Barrett Universal II; D = diopters; EVO = Emmetropia Verifying Optical; IOL = intraocular lens; MAE = mean absolute error; MedAE = median absolute error; RMSAE = root-mean-square absolute error; SD = standard deviation; CTR = capsular tension ring. * Comparison of MAE between the CTR and non-CTR groups, determined by the Mann-Whitney U test.

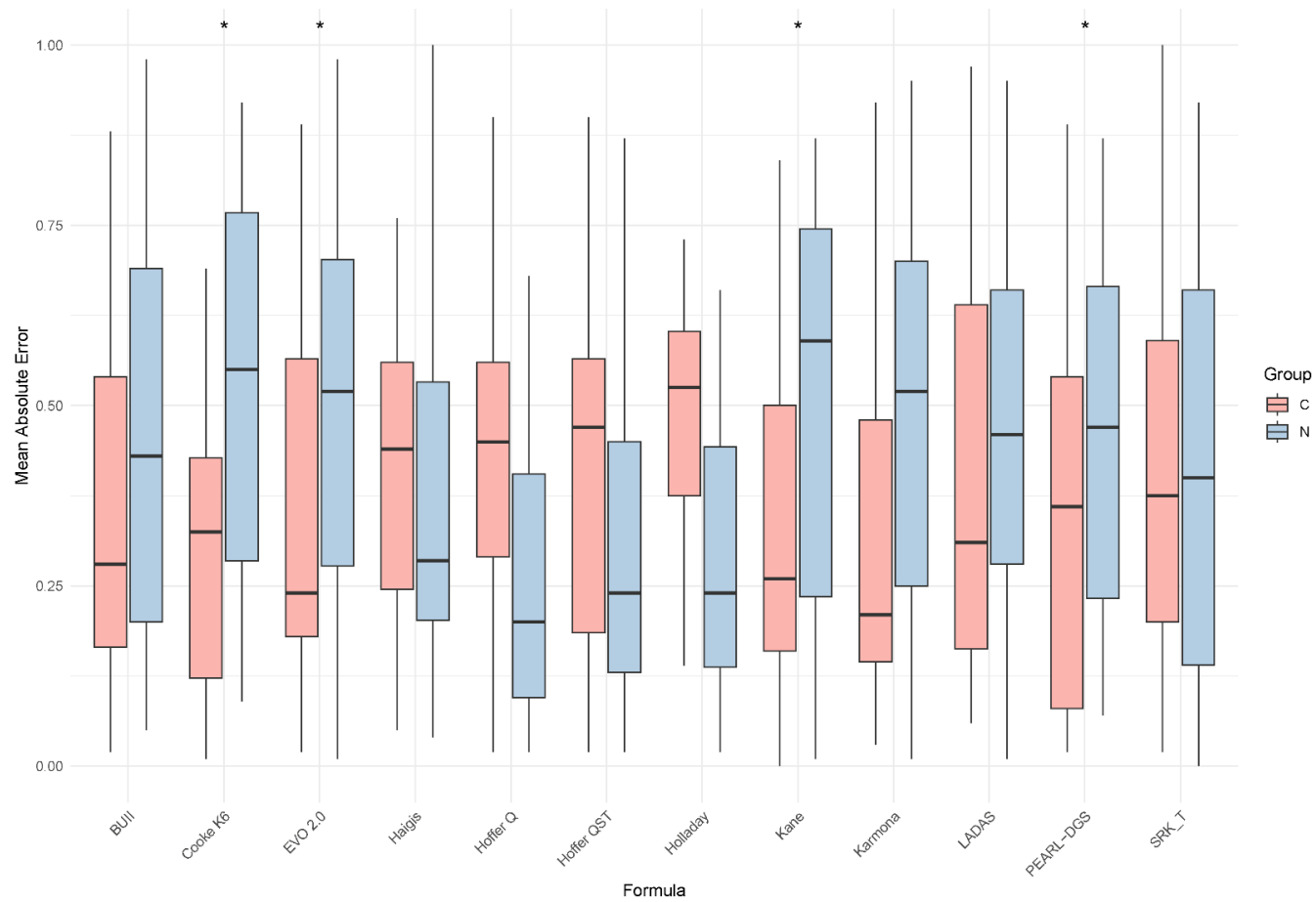
Supplementary Table 5

Predictive Outcomes for the 12 Formulas Across LT Subgroups.

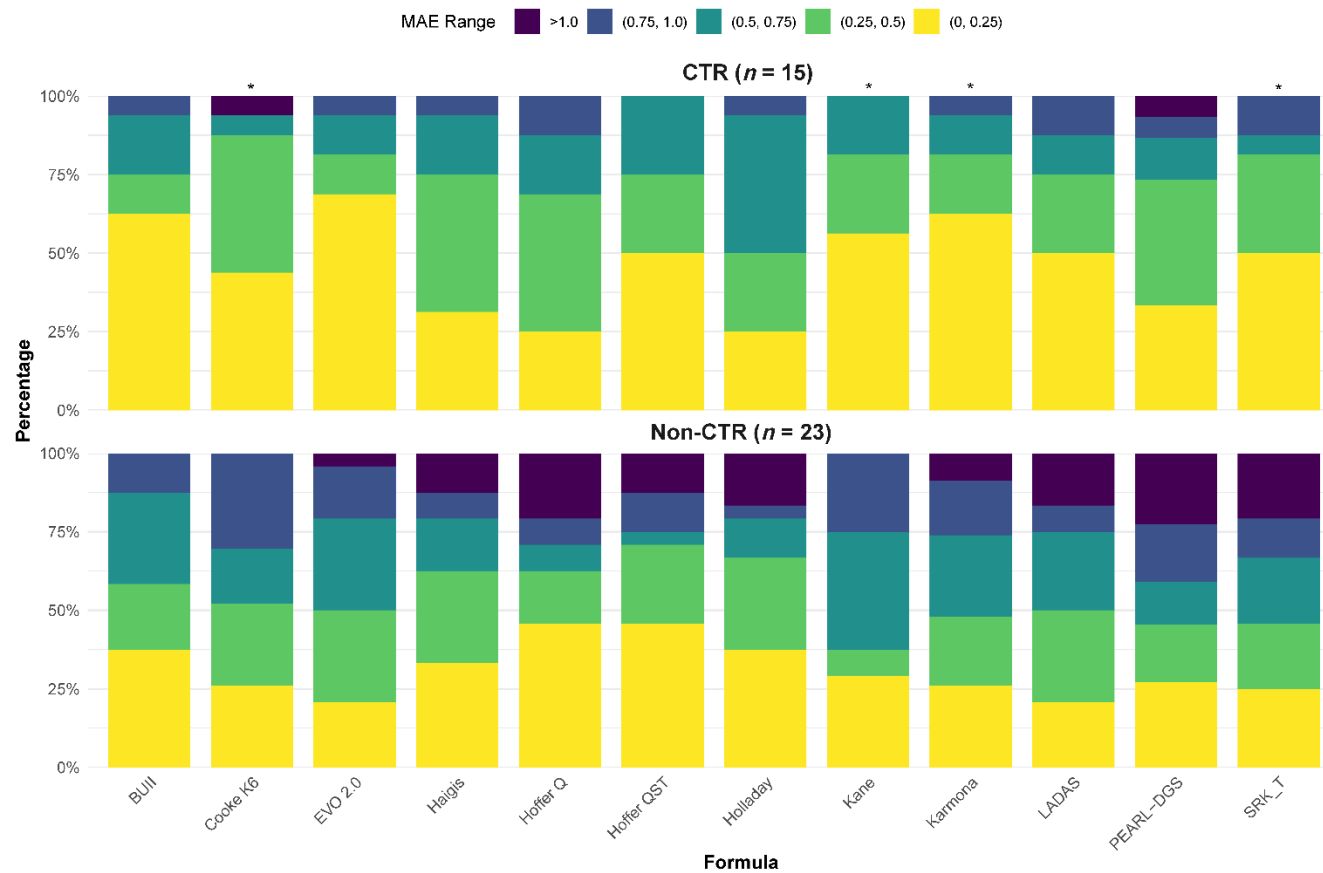
Formula	≤ 4.62 ($n = 14$)			4.62-4.86 ($n = 13$)			4.86-5.1 ($n = 13$)			> 5.1 ($n = 13$)		
	ME $\pm$ SD	MAE	RMSAE	ME $\pm$ SD	MAE	RMSAE	ME $\pm$ SD	MAE	RMSAE	ME $\pm$ SD	MAE	RMSAE
BUII	-0.11 $\pm$	0.41 $\pm$	0.47	-0.11 $\pm$	0.29 $\pm$	0.36	-0.06 $\pm$	0.50 $\pm$	0.58	0.24 $\pm$	0.59 $\pm$	0.77
	0.47	0.24		0.36	0.22		0.60	0.31		0.76	0.51	
Cooke K6	0.15 $\pm$	0.40 $\pm$	0.49	-0.01 $\pm$	0.32 $\pm$	0.39	0.19 $\pm$	0.51 $\pm$	0.59	0.53 $\pm$	0.63 $\pm$	0.85
	0.48	0.35		0.41	0.24		0.58	0.31		0.69	0.59	
EVO 2.0	0.06 $\pm$	0.41 $\pm$	0.49	-0.10 $\pm$	0.31 $\pm$	0.38	0.07 $\pm$	0.48 $\pm$	0.55	0.49 $\pm$	0.68 $\pm$	0.87
	0.51	0.27		0.39	0.23		0.57	0.29		0.75	0.57	
Haigis	-0.29 $\pm$	0.46 $\pm$	0.51	-0.03 $\pm$	0.32 $\pm$	0.42	-0.09 $\pm$	0.35 $\pm$	0.40	0.39 $\pm$	0.69 $\pm$	0.87
	0.44	0.24		0.44	0.29		0.41	0.20		0.80	0.54	
Hoffer QST	-0.33 $\pm$	0.54 $\pm$	0.61	-0.18 $\pm$	0.30 $\pm$	0.40	-0.28 $\pm$	0.37 $\pm$	0.50	0.31 $\pm$	0.71 $\pm$	0.97
	0.53	0.30		0.38	0.28		0.44	0.36		0.95	0.68	
Hoffer Q	-0.31 $\pm$	0.57 $\pm$	0.65	-0.26 $\pm$	0.33 $\pm$	0.47	-0.29 $\pm$	0.44 $\pm$	0.59	0.11 $\pm$	0.68 $\pm$	0.87
	0.59	0.32		0.41	0.35		0.54	0.42		0.90	0.57	
Holladay	-0.33 $\pm$	0.55 $\pm$	0.65	-0.43 $\pm$	0.45 $\pm$	0.56	-0.32 $\pm$	0.61 $\pm$	0.74	0.14 $\pm$	0.66 $\pm$	0.86
	0.58	0.36		0.38	0.35		0.20	0.43		0.89	0.57	
Kane	-0.03 $\pm$	0.46 $\pm$	0.54	-0.12 $\pm$	0.36 $\pm$	0.43	-0.01 $\pm$	0.45 $\pm$	0.55	0.40 $\pm$	0.61 $\pm$	0.78
	0.56	0.30		0.43	0.25		0.58	0.34		0.69	0.50	
Karmona	0.22 $\pm$	0.45 $\pm$	0.58	0.00 $\pm$	0.29 $\pm$	0.38	0.12 $\pm$	0.45 $\pm$	0.55	0.48 $\pm$	0.69 $\pm$	0.87
	0.56	0.38		0.39	0.25		0.56	0.33		0.75	0.55	
LADAS	-0.32 $\pm$	0.70 $\pm$	1.09	-0.16 $\pm$	0.36 $\pm$	0.44	-0.08 $\pm$	0.44 $\pm$	0.54	0.44 $\pm$	0.91 $\pm$	1.10
	1.08	0.87		0.43	0.26		0.56	0.33		1.05	0.63	

PEARL-	0.25 ±	0.40 ±		0.13 ±	0.36 ±		0.29 ±	0.50 ±		0.82 ±	0.92 ±	
DGS	0.48	0.35	0.52	0.43	0.25	0.43	0.54	0.33	0.59	0.80	0.65	1.11
SRK_T	-0.05 ±	0.54 ±		-0.16 ±	0.37 ±		-0.15 ±	0.62 ±		0.53 ±	0.85 ±	
	0.70	0.42	0.68	0.45	0.29	0.46	0.72	0.36	0.71	1.00	0.72	1.09

LT = lens thickness; BU11 = Barrett Universal II; D = diopters; EVO = Emmetropia Verifying Optical; ME = mean prediction error; MAE = mean absolute error; RMSAE = root-mean-square absolute error; SD = standard deviation.



Supplementary Figure 1 Mean absolute error (in diopters) of each formula, distributed by CTR and non-CTR groups, listed by alphabetic order. $*P < 0.05$, Mann-Whitney U test. BUll = Barrett Universal II; EVO, Emmetropia Verifying Optical; C = CTR group; N = non-CTR group.



Supplementary Figure 2 Sensitivity Analysis of the Percentage of Eyes Within Prediction Error Ranges for 12 IOL Calculation Formulas in CTR and Non-CTR Groups (One Eye per Patient, n = 38). BU II = Barrett Universal II; EVO = Emmetropia Verifying Optical. * $P < 0.05$, Fisher's exact test on the PE of ± 0.50 D between the two groups.

Appendix Summary of IOL Models and Constants Used

IOL Manufacturer	IOL Model	IOL Material / Design	Number of Eyes (n)	Percentage of Total Sample (%)	Optimized Constants*			
					SRK/T (A)	Haigis (a_0 / a_1 / a_2)	Hoffer Q (pACD)	Holladay (SF)
Alcon	AcrySof IQ SN60WF	Hydrophobic, Aspheric	40	75.47%	118.97	-0.025 / 0.31 / 0.173	5.57	1.8
Alcon	AcrySof SN6AT (3-6)	Hydrophobic, Aspheric	11	20.75%	119.04	1.50 / 0.40 / 0.10	5.63	1.84
HumanOptics	Aspira-aA	Hydrophilic, Aspheric	2	3.77%	118.78	-1.6294 / 0.2346 / 0.2458	5.401	1.658
Total	-	-	53	100%	-	-	-	-

* Obtained from the IOLCon website (<https://iolcon.org/>)