Accuracy of the Kane Formula for Intraocular Lens Power Calculation in Comparison with Existing Formulas: A Retrospective Review

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Purpose: To evaluate the accuracy of the Kane formula for intraocular lens (IOL) power calculation in comparison with existing formulas by incorporating optional variables into calculation.

Materials and Methods: This retrospective review consisted of 78 eyes of patients who had undergone uneventful phacoemulsification with intraocular implantation at Severance Hospital in Seoul, Korea between February 2020 and January 2021. The Kane formula was compared with six of the existing IOL formulas (SRK/T, Hoffer-Q, Haigis, Holladay1, Holladay2, Barrett Universal II) based on the mean absolute error (MAE), median absolute error (MedAE), and the percentages of eyes within prediction errors of ±0.25D, ±0.50D, and ±1.00D.

Results: The Barrett Universal II formula demonstrated the lowest MAEs (0.26±0.17D), MedAEs (0.28D), and percentage of eyes within prediction errors of ±0.25D, ± 0.50D, and ±1.00D, although there was no statistically significant difference between Barrett Universal II-SRK/T (*p*=0.06), and Barrett Universal II-Kane formula (*p*<0.51). Following the Barrett Universal II formula, the Kane formula demonstrated the second most accurate formula with MAEs (0.30±0.19D) and MedAEs (0.28D). However, no statistical difference was shown between Kane-Barrett Universal II (*p*=0.51) and Kane-SRK/T (*p*=0.14).

Conclusion: Although slightly better refractory outcome was noted in the Barrett Universal II formula, the performance of the Kane formula in refractive prediction was comparable in IOL power calculation, marking its superiority over many conventional IOL formulas, such as HofferQ, Haigis, Holladay1, and Holladay2.

Key Words: Kane, IOL power calculation, Barrett Universal II, refractive outcomes

INTRODUCTION

With ongoing advances in medical science, expectations toward refractory outcomes after cataract surgery are growing. Surgical techniques, accurate biometry, and newer intraocular lens formulas have enabled the control of refractive outcomes with ever-increasing accuracy.[1] In 2018, one large multicenter retrospective study of total 18501 cases reported up to 81% and 98% of eyes within ±0.50D and ±1.00D of predicted refraction, respectively.[2]

For many years, only a few intraocular lens (IOL) formulas have been used to estimate the IOL for patients undergoing cataract surgery: SRK/T, HofferQ, Haigis, and Holladay1.[3,4] In recent years, numerous modern formulas have been introduced in an attempt to improve the accuracy of their refractive outcome predictions. Newer generation formulas included Holladay2, Barrett Universal II, Hill-RBF, Olsen, and Kane.[5] Predominantly, these differ from the older generation formulas in the number of relevant variables assessed in the formulas: the number of metric assessed: 2 or 3 in older generation (SRK/T, HofferQ, Haigis, Holladay1) vs. 5 to 7 in newer generation (Olsen, Barrett Universal II, Hill-RBF 2.0, Holladay2, Kane).[6] Furthermore, some of the modern formulas, such as Hill-RBF and Kane, have incorporated the technology of adaptive learning from a large dataset to predict refractive outcomes.[3,7]

With the advent of several new IOL formulas, many studies have attempted to evaluate which of the formulas for IOL power calculation is the best predictor of the actual postoperative refractive results. In 2018, Melles, et al.[2] reported that Barrett Universal II and Olsen formula yielded the most accurate outcomes. However, their study did not include modern formulas such as Hill-RBF, EVO, and Kane for the analysis, and the newer update published in 2019 reported that Kane, Barrett Universal II, and Olsen formulas showed comparable results.[8] Many additional studies have demonstrated Kane formula's potency in IOL power predictability, and some of the studies even reported more favorable results by Kane compared to Barrett Universal II formula, which was known to be the most accurate among modern formulas for years.[3,5,9] However, many of the published studies about Kane formula analyzed data from multiple IOLMaster models for assessment, and often omitted lens thickness (LT) and central corneal thickness (CCT) as optional metrics for IOL power calculation due to the lack of availability of the newest version of IOLMaster device.[5,6]

The purpose of this study was to evaluate the accuracy of the Kane formula for IOL power calculation in comparison with other existing formulas using a single version of biometry device (IOLMaster 700) while incorporating LT and CCT variables into calculation.

MATERIALS AND METHODS

Participants
This retrospective, observational study consisted of 78 eyes of 63 patients who had already undergone uneventful phacoemulsification with IOL implantation by a single surgeon at Severance Hospital in Seoul, Korea between February 2020 and January 2021. Inclusion criteria were as follows: availability of preoperative ocular biometry measurements from IOLMaster 700, auto-refraction performed at 1 month after cataract surgery, absence of complications during or after cataract

surgery, and Tecnis ZCB00 (Abbott Medical Optics, Santa Ana, CA, USA) IOL implantation during surgery. Exclusion criteria were corneal astigmatism more than 2.0 diopters, previous ocular surgery, ocular trauma, active ocular infection or inflammation, or ocular diseases and opacities that may impair postoperative refractive outcomes.

This study was approved by the Institutional Review Board of the Yonsei University College of Medicine (4-2021-0204), and was conducted in accordance with the tenets of the Declaration of Helsinki. Informed consent was waived due to the retrospective nature of the study.

Preoperative and postoperative assessments
Each patient underwent routine preoperative examination performed within 3 months prior to cataract surgery with IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany) and high-resolution Scheimpflug corneal tomography (Pentacam HR, Oculus, Wetzlar, Germany). Optical biometer parameters, including axial length (AL), anterior chamber depth (ACD), white-to-white distance (WTW), CCT, LT, flat keratometry (K1), steep keratometry (K2), and mean keratometry (Km) were measured with IOLMaster 700. Furthermore, preoperative examination included assessments of best-corrected visual acuity (BCVA), intraocular pressure (IOP) (CANON, TX-20, Tokyo, Japan), manifest refraction, auto-refraction (Topcon, KR-1, Tokyo, Japan), slit-lamp examination, fundoscopy, retinal examination using Heidelberg spectralis optical coherence tomography (software V.5.4.7.0; Heidelberg Engineering, Heidelberg, Germany), and specular microscopy OA-2000 (Tomey, EM4000, GmbH, Nagoya, Japan).

All of the included patients had a documented follow-up visit at 1 day, 1 week, and 1 month postoperatively during which auto-refraction, manifest refraction, slit-lamp examination, IOP measurements, and keratometry measurements were performed. Postoperative refractive errors measured 1 month after the surgery using automatic refracto-keratometry were compared with the predicted postoperative refraction calculated by the IOLMaster for analysis.

IOL calculation
The power of the implanted IOL was determined by SRK/T, HofferQ, Haigis, Holladay1, Holladay2, Barrett Universal II formulas using User Group for Laser Interference Biometry constants. Calculations for Kane formula were performed using their online calculators (available at: https://www.iolformula.com/). Optional values, including LT and CCT, were included for all cases. A single experienced surgeon selected the IOL power for each patient according to surgical preferences, and the predicted postoperative spherical equivalent (SE) refractions for all formulas were documented.

Surgical technique
All patients underwent scheduled cataract surgery per-

formed by a single surgeon (K.S.). Topical anesthesia with proparacaine hydrochloride (Alcaine, Alcon, Fort Worth, TX, USA) was administered for local anesthesia prior to the operation. Using a 2.8-mm microkeratome, a clear corneal incision was made at the temporal cornea, and the anterior chamber was stabilized with the ophthalmic visco-surgical device. The crystalline lens was removed through conventional phacoemulsification using a Centurion Vision System (Alcon). After phacoemulsification, one-piece aspheric foldable IOL, Tecnis ZCB00, was implanted into the capsular bag using an injector. The remaining ophthalmic viscoelastic device was aspirated from the anterior chamber, and the incision sites were hydrated using BSS to prevent leakage.

Statistical analyses

The refractive outcomes were evaluated based on the absolute prediction errors (APEs) and proportion of eyes within ±0.25D, ±0.50D, and ±1.00D of the predicted postoperative SE. The mean prediction error (ME) was calculated as the mean value of the actual postoperative refraction minus the refractive result predicted by each formula. APE was defined as the absolute difference between the actual postoperative SE and the predicted postoperative SE, and the mean absolute errors (MAEs) and the median absolute errors (MedAEs) were the mean and median values of APE, respectively.[10]

The percentages of eyes within ±0.25D, ±0.50D, and ±1.00D of the predicted postoperative SE in different IOL formulas were compared using Cochran Q test, and McNemar chi-squared t test was applied for significant results. For the assessment of MAEs and MedAEs from each formula, Friedman test was used. In the event of a significant result, post hoc analysis was performed using the Wilcoxon signed-rank test with Bonferroni correction. A p value less than 0.05 was considered statistically significant. Data analysis was done using SPSS Statistics software (version 25; IBM Corp., Armonk, NY, USA) and Microsoft Excel 2016 (Microsoft Corp, Redmond, WA, USA).

RESULTS

Patient characteristics and preoperative measurements

Baseline patient characteristics and preoperative measurements are shown in Table 1. A total of 78 eyes (45 right, 33 left) of 63 patients (21 male, 42 female) were included. The patients' mean age was 70.01±8.91 years. The mean AL was 23.66±1.18 mm and the mean ACD was 3.16±0.44 mm. The mean LT was 4.54±0.44 mm, and the mean CCT was 533.99 ± 34.56 μm. The mean K1, K2, and Km were 43.99±1.21D, 44.77±1.24D, and 44.36±1.23D, respectively. The mean preoperative and postoperative BCVAs (LogMAR) were 0.45±0.30 and 0.01±0.04, respectively. The mean IOL power selected by the surgeon was

22.17±3.11D.

Refractive outcomes

Tables 2 and 3 shows refractive errors calculated by seven IOL formulas (SRK/T, HofferQ, Haigis, Holladay1, Holladay2, Barrett Universal II, and Kane). The MAEs ranged from 0.264 to 0.375D, and the MedAEs ranged from 0.225D to 0.330D. There was a statistically significant difference between groups (p<0.05). The most accurate formula was the Barrett Universal II formula, which showed the lowest MAEs (0.264D) and MedAEs (0.225D). The difference was statistically significant when compared with HofferQ, Haigis, Holladay1, and Holladay2 (all p<0.05), but not in comparison to SRK/T and Kane formulas (p=0.063 and p=0.506, respectively). Following Barrett Universal II formula, the second most accurate formula was the Kane formula with MAEs (0.279D) and MedAEs (0.280D). The difference was statistically significant compared to HofferQ, Haigis, Holladay1, and Holladay2 (all p<0.05), but not in comparison to SRK/T and Barrett Universal II formulas (p=0.142 and p=0.506, respectively).

The percentage of eyes which had a prediction error within ±0.25D, ±0.50D, and ±1.00D for each formula are shown in Fig. 1 and Tables 4 and 5. There was a statistically significant difference between the seven IOL formulas. The highest percentage of eyes within ±0.25D, ±0.50D of prediction errors was seen using the Barrett Universal II formula, followed by the Kane formula as the second highest. The proportion of eyes within ±1.00D of prediction errors were comparable between groups: Barrett Universal II, Kane, Haigis, and Hoffer2 yielded the highest values of 98.7%. Furthermore, our analysis showed

Table 1. Patient Demographics and Ocular Biometry

Parameter	Value
Patients/Eyes	63/78
Right/Left	45/33
Male/Female	21/42
Age (yr)	70.01±8.91
Preop BCVA (LogMAR)	0.45±0.30
Postop BCVA (LogMAR)	0.01±0.04
AL (mm)	23.66±1.18
ACD (mm)	3.16±0.44
LT (mm)	4.54±0.44
WTW (mm)	11.70±0.38
CCT (μm)	533.99±34.56
Flat keratometry (K1) (D)	43.99±1.21
Steep keratometry (K2) (D)	44.77±1.24
Mean keratometry (Km) (D)	44.36±1.23
IOL power (D)	22.17±3.11
Postop Refraction (SE)	-0.69±0.86

BCVA, best-corrected visual acuity; AL, axial length; ACD, anterior chamber depth; LT, lens thickness; WTW, white-to-white distance; CCT, central corneal thickness; IOL, intraocular lens; SE, spherical equivalent.
Results are expressed as means±standard deviation.

Table 2. MAEs and MedAEs for All IOL Formulas

IOL formula	ME	SD*	MAEs	MedAEs	Minimum	Maximum	SD
SRK/T	-0.10	0.38	0.37	0.31	0.00	1.01	0.23
Haigis	-0.01	0.39	0.33	0.33	0.01	0.94	0.23
HofferQ	-0.04	0.43	0.30	0.31	0.01	0.91	0.20
Holladay1	-0.66	0.40	0.33	0.33	0.00	1.01	0.23
Holladay2	-0.66	0.40	0.33	0.33	0.00	1.01	0.23
Barrett Universal II	0.04	0.31	0.26	0.23	0.01	0.95	0.17
Kane	-0.09	0.32	0.28	0.28	0.01	0.76	0.19
Kane (without LT, CCT)	-0.12	0.38	0.32	0.29	0.00	0.87	0.24

IOL: intraocular lens; ME, mean prediction error; SD*, standard deviation of ME; MAEs, mean absolute errors; MedAEs, median absolute errors; SD, standard deviation of MedAE; LT, lens thickness; CCT, central corneal thickness.

Table 3. Comparison between IOL Formulas

Comparison between formulas		*p* value	Comparison between formulas		*p* value
SRK/T	Haigis	0.28	Holladay2	SRK/T	0.12
	HofferQ	<0.05*		Haigis	0.84
	Holladay1	0.12		HofferQ	<0.05*
	Holladay2	0.12		Holladay1	1.00
	Barrett Universal II	0.06		Barrett Universal II	<0.05*
	Kane	0.14		Kane	<0.05*
Haigis	SRK/T	0.28	Barrett Universal II	SRK/T	0.06
	HofferQ	0.10		Haigis	<0.05*
	Holladay1	0.84		HofferQ	<0.05*
	Holladay2	0.84		Holladay1	<0.05*
	Barrett Universal II	<0.05*		Holladay2	<0.05*
	Kane	<0.05*		Kane	0.51
HofferQ	SRK/T	<0.05*	Kane	SRK/T	0.14
	Haigis	0.10		HofferQ	<0.05*
	Holladay1	<0.05*		Haigis	<0.05*
	Holladay2	<0.05*		Holladay1	<0.05*
	Barrett Universal II	<0.05*		Holladay2	<0.05*
	Kane	<0.05*		Barrett Universal II	0.51
Holladay1	SRK/T	0.12			
	Haigis	0.84			
	HofferQ	<0.05*			
	Holladay2	1.00			
	Barrett Universal II	<0.05*			
	Kane	<0.05*			

IOL, intraocular lens.
Friedman test and Wilcoxon signed-rank test with Bonferroni correction for post hoc analysis, *p*<0.05.
*statistically significant.

that the Kane formula showed more accurate predictions when incorporating optional variables, LT and CCT, provided by IOLMaster 700, as shown in Tables 2–5.

DISCUSSION

Cataract extraction is the most frequently performed surgical intervention worldwide, and its demand is continuously rising due to an increase in elderly population.[9,11-13] With the grow-

ing popularity, patients' refractive expectations after the cataract surgery continue to increase, and achieving the desired refractive outcome has become a key principle in recent years.[7] Identifying an IOL formula that best predicts the postoperative refractive outcome is one of the most important factors leading to a successful cataract surgery. Recently, newer generation of IOL formulas, which integrate artificial intelligence and larger number of preoperative eye parameters for prediction, have been introduced.

The Kane formula is a novel IOL power calculation formula
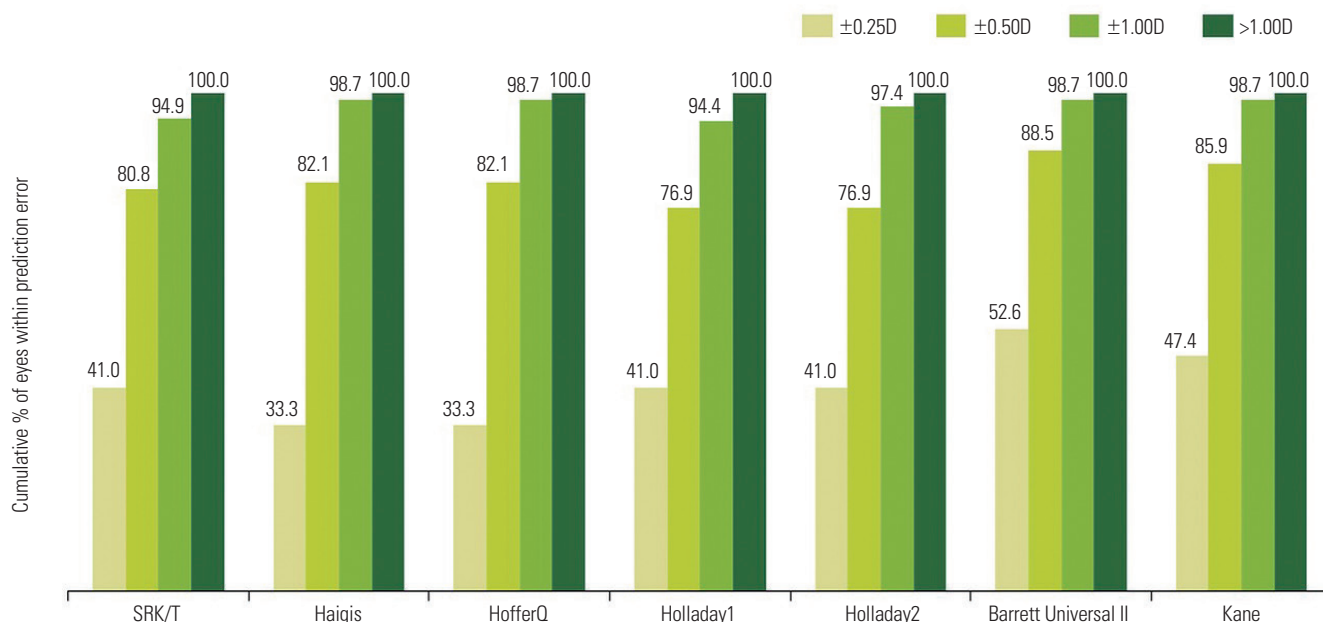
Fig. 1. Stacked histogram comparing the percentages of eyes within ±0.25D, ±0.50D, and ±1.00D of the predicted postoperative spherical equivalent refraction across all formulas.

that uses theoretical optics which also incorporates both regression and artificial intelligence components.[3,5,9] The Kane formula requires the AL, ACD, K values, and gender to make its estimations, and LT and CCT are optional values which are known to improve the accuracy of the formula.[3,5] Since the advent of the Kane formula in September 2017, multiple publications have demonstrated its outstanding performance in IOL power calculation, yielding the lowest MAEs and MedAEs, and the highest percentage of eyes within ±0.25D, ±0.50D, and ±1.00D of prediction errors compared to other well-known existing formulas.[3,5,14] As conventional biometry devices do not provide measurements for LT and CCT, many of the studies relied on IOL calculations without optional values for the IOL formulas. Therefore, there is a paucity of data evaluating the Kane formula when all of the optional values of LT and CCT are taken into consideration. Hence, we aimed to evaluate the accuracy of the Kane formula for IOL power calculation in comparison with existing formulas using the newest version of biometry device, IOLMaster 700, while incorporating LT and CCT variables into IOL power calculation. The analysis of this study showed that the Barrett Universal II was the most accurate formula, having a lower MAE and MedAE and a higher percentage of eyes with prediction errors within ±0.25D, ±0.50D, and ±1.00D. However, the Kane formula was the second most accurate formula, exhibiting comparable performance with the Barrett Universal II formula; no statistically significant difference was noted between the two groups.

Our study followed the process of assessing IOL power prediction accuracy based on the MAE and MedAE as suggested by Kane, et al.,[6] as well as the methodologies for IOL power studies recommended by Hoffer, et al.[15] In order to minimize the potential bias from diverse operating styles or techniques, we used a single IOL model, and all surgeries were performed by a single surgeon.[16]

Previous literatures have demonstrated higher prediction accuracy for IOL calculation in patients undergoing conventional cataract surgery using the Kane formula. In a retrospective study including 846 eyes, Connell, et al.[3] reported that the Kane formula had the lowest MAE (0.329) and the highest percentage of eyes within ±0.25D, ±0.50D, and ±1.00D of prediction errors (52.4%, 77.9%, and 96.6%, respectively) compared to other IOL power formulas (Hill-RBF V.2.0, Holladay2, Olsen, Barrett Universal II, Haigis, Holladay1, HofferQ, and SRK/T). Melles, et al.[8] analyzed a retrospective data of 18501 patients who underwent cataract surgery with either SN60WF and SA60AT implants and reported that the Kane formula was the most accurate, with 83% of the eyes predicted within 0.50D of the actual postoperative refractive result when compared with Olsen, Barrett Universal II, Evo, Hill-RBF, Holladay1, Holladay2, Haigis, SRK/T, and HofferQ. Reitblat, et al.[9] compared the Kane formula with Barrett Universal II, Haigis, HofferQ, Holladay1, and SRK/T formulas in the elderly population, and showed that the Kane formula was found to be of equal precision to the Barrett Universal II and superior to the HofferQ, Holladay1, and SRK/T formulas. Savini, et al.[14] analyzed the results of IOL power calculation using measurements by a swept-source optical coherence tomography (SS-OCT) optical biometer. Overall, better refractive outcome was observed in all IOL formulas analyzed using SS-OCT optical biometer, Tomey OA-2000 (Tomey Corporation, Nagoya, Japan), and the Barrett Universal II, EVO, Holladay2, Kane, RBF, and SRK/T2 achieved the highest percentages of eyes (90%) with a predic-

Table 4. Percentage of Eyes within ±0.25D, ±0.50D, and ±1.00D of the Predicted Postoperative Spherical Equivalent Refraction between All Intraocular Formulas

IOL formula	Postoperative spherical equivalent refraction (D)		
	±0.25D	±0.50D	±1.00D
SRK/T	41.0	80.8	94.9
Haigis	33.3	82.1	98.7
HofferQ	33.3	82.1	98.7
Holladay1	41.0	76.9	94.4
Holladay2	41.0	76.9	97.4
Barrett Universal II	52.6	88.5	98.7
Kane	47.4	85.9	98.7
Kane (without LT, CCT)	43.6	79.5	98.7

IOL, intraocular lens; LT, lens thickness; CCT, central corneal thickness.

Table 5. Comparison between IOL Formulas Regarding Percentage of Eyes within ±0.25D and ±0.50D of Predicted Postoperative Spherical Equivalent Refraction

Comparison between formulas		*p* value		Comparison between formulas		*p* value	
		±0.25D	±0.50D			±0.25D	±0.50D
SRK/T	Haigis	0.19	>0.99	Holladay2	SRK/T	>0.99	0.58
	HofferQ	0.26	0.26		Haigis	0.21	0.29
	Holladay1	>0.99	0.58		HofferQ	0.23	0.45
	Holladay2	>0.99	0.58		Holladay1	>0.99	>0.99
	Barrett Universal II	0.12	0.15		Barrett Universal II	0.09	<0.05*
	Kane	0.56	0.34		Kane	0.41	0.12
Haigis	SRK/T	0.19	>0.99	Barrett Universal II	SRK/T	0.12	0.15
	HofferQ	>0.99	0.07		Haigis	<0.05*	0.13
	Holladay1	0.21	0.29		HofferQ	0.01	<0.05*
	Holladay2	0.21	0.29		Holladay1	0.09	<0.05*
	Barrett Universal II	<0.05*	0.13		Holladay2	0.09	<0.05*
	Kane	0.05	0.32		Kane	0.52	0.73
HofferQ	SRK/T	0.26	0.26	Kane	SRK/T	0.56	0.34
	Haigis	>0.99	0.07		HofferQ	0.05	0.32
	Holladay1	0.23	0.45		Haigis	0.05	<0.05*
	Holladay2	0.23	0.45		Holladay1	0.41	0.12
	Barrett Universal II	<0.05*	<0.05*		Holladay2	0.41	0.12
	Kane	0.05	<0.05*		Barrett Universal II	0.52	0.73
Holladay1	SRK/T	>0.99	0.58				
	Haigis	0.21	0.29				
	HofferQ	0.23	0.45				
	Holladay2	>0.99	>0.99				
	Barrett Universal II	0.09	<0.05*				
	Kane	0.41	0.12				

IOL: intraocular lens.
Cochran Q test, paired McNemar's chi-square test for post hoc analysis, $p < 0.05$ within ±0.25D, ±0.50D; $p > 0.99$ within ±1.00D.
*statistically significant.

tion error of ±0.50D.

Although our study incorporated the optional metrics (LT and CCT) into IOL power calculation, our preliminary results were in concordance with the previous publications comparing existing formulas with the Kane formula, highlighting its superiority over other conventional formulas in IOL power calculation. Although no statistically significant difference was shown in our study, a trend toward better refractive outcome using Barrett Universal II formula was demonstrated, and the Kane formula was presented as the second most accurate method. This was not surprising since both Barrett Universal II and Kane formulas are designed to yield better results with optional values that are provided by the new SS-OCT type biometry, IOL Master 700 (Carl Zeiss Meditec, Jena,

Germany). The Barrett Universal II formula uses a theoretical model of the eye in which ACD is related to the AL and corneal curvature (K). The effective lens position is calculated based on a combination of ACD and a lens factor (LF). Furthermore, LF is dependent on five variables, including AL, ACD, K, LT, corneal diameter, and WTW. Among them, LT, WTW, and CCT are optional values which were not often available in previously used models of anterior biometry devices. Therefore, the additional values measured from the new biometry device not only improved the prediction accuracy of the Kane formula, but also the Barrett Universal II formula.[17] Among multiple existing IOL formulas, the Barrett Universal II yielded the lowest MAEs and MedAEs. The Kane formula yielded the second lowest MAEs and MedAEs. The superiority of Kane and Barrett Universal II over other formulas was statistically significant (all $p<0.05$, except for SRK/T). Furthermore, the Barrett Universal II demonstrated the highest percentage of eyes with prediction errors within ±0.25D, ±0.50D, and ±1.00D (52.6%, 88.5%, and 98.7%, respectively), followed by the Kane formula (47.4%, 85.9%, and 98.7%, respectively). However, no statistical difference was found between most of the formulas.

This study had some limitations. First, the inclusion of bilateral eyes from some of the patients enrolled in the study may lead to bias. As ocular measurements between fellow eyes tend to have similar values, Hoffer, et al.[15] recommended that each study should include only a single eye from each patient to reduce confounding factors. However, both eyes from 15 patients were included for analysis in the current study. Second, our study had a relatively small number of eyes included for the analysis compared to the previous studies using multi-center, large databases. However, with the nature of multi-center studies, previous studies might have been affected by a potential bias resulting from inconsistent surgical techniques, biometry devices, follow-up dates, refractory outcome assessments, and etc. We have minimized such bias by using data from a single IOL model, a single biometry device, and surgeries performed by a single surgeon with consistent assessments before and after the surgery. Third, most of our patients were shown to have a relatively normal range of biometric parameters; therefore, the results of this study cannot be applied to patients with extreme parameters.

In conclusion, using a single SS-OCT type biometry, IOLM700, we were able to compare the Kane formula with other existing formulas by incorporating all of the optional metrics for IOL power calculation. Our preliminary analysis suggests that the Barrett Universal II formula most accurately predicts the postoperative refraction in cataract surgery. Furthermore, we found the Kane formula to be the second most accurate formula that showed a comparable performance with the Barrett Universal II formula in IOL calculation, marking its superiority over many of the conventional IOL formulas, such as the HofferQ, Haigis, Holladay1, and Holladay2.

AUTHOR CONTRIBUTIONS

Conceptualization: Ikhyun Jun and Eung Kweon Kim. Data curation: Soyoung Ryu. Formal analysis: Ikhyun Jun and Kyung Yul Seo. Funding acquisition: Ikhyun Jun. Investigation: Ikhyun Jun and Tae-im Kim. Methodology: Ikhyun Jun, Kyung Yul Seo, and Eung Kweon Kim. Project administration: Ikhyun Jun and Kyung Yul Seo. Resources: Ikhyun Jun and Kyung Yul Seo. Software: Ikhyun Jun. Supervision: Ikhyun Jun, Kyung Yul Seo, Tae-im Kim, and Eung Kweon Kim. Validation: Ikhyun Jun, Tae-im Kim, and Eung Kweon Kim. Visualization: Ikhyun Jun and Kyung Yul Seo. Writing—original draft: Soyoung Ryu. Writing—review & editing: Soyoung Ryu, Ikhyun Jun, Tae-im Kim, Eung Kweon Kim, and Kyung Yul Seo. Approval of final manuscript: all authors.

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REFERENCES

1. Fontes BM, Fontes BM, Castro E. Intraocular lens power calculation by measuring axial length with partial optical coherence and ultrasonic biometry. Arq Bras Oftalmol 2011;74:166-70.
2. Melles RB, Holladay JT, Chang WJ. Accuracy of intraocular lens calculation formulas. Ophthalmology 2018;125:169-78.
3. Connell BJ, Kane JX. Comparison of the Kane formula with existing formulas for intraocular lens power selection. BMJ Open Ophthalmol 2019;4:e000251.
4. Retzlaff JA, Sanders DR, Kraff MC. Development of the SRK/T intraocular lens implant power calculation formula. J Cataract Refract Surg 1990;16:333-40.
5. Darcy K, Gunn D, Tavassoli S, Sparrow J, Kane JX. Assessment of the accuracy of new and updated intraocular lens power calculation formulas in 10 930 eyes from the UK National Health Service. J Cataract Refract Surg 2020;46:2-7.
6. Kane JX, Van Heerden A, Atik A, Petsoglou C. Intraocular lens power formula accuracy: comparison of 7 formulas. J Cataract Refract Surg 2016;42:1490-500.
7. Hipólito-Fernandes D, Elisa Luís M, Gil P, Maduro V, Feijão J, Yeo TK, et al. VRF-G, a new intraocular lens power calculation formula: a 13-formulas comparison study. Clin Ophthalmol 2020;14:4395-402.
8. Melles RB, Kane JX, Olsen T, Chang WJ. Update on intraocular lens calculation formulas. Ophthalmology 2019;126:1334-5.
9. Reitblat O, Gali HE, Chou L, Bahar I, Weinreb RN, Afshari NA, et al. Intraocular lens power calculation in the elderly population using the Kane formula in comparison with existing methods. J Cataract Refract Surg 2020;46:1501-7.

10. Aristodemou P, Cartwright NK, Sparrow JM, Johnston R. Intraocular lens calculations. Ophthalmology 2011;118:1221.

11. Foreman KJ, Marquez N, Dolgert A, Fukutaki K, Fullman N, McGaughey M, et al. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016-40 for 195 countries and territories. Lancet 2018;392:2052-90.

12. Fukuoka H, Afshari NA. The impact of age-related cataract on measures of frailty in an aging global population. Curr Opin Ophthalmol 2017;28:93-7.

13. Lutz W, Sanderson W, Scherbov S. The coming acceleration of global population ageing. Nature 2008;451:716-9.

14. Savini G, Hoffer KJ, Balducci N, Barboni P, Schiano-Lomoriello D. Comparison of formula accuracy for intraocular lens power calculation based on measurements by a swept-source optical coherence tomography optical biometer. J Cataract Refract Surg 2020; 46:27-33.

15. Hoffer KJ, Savini G. Update on intraocular lens power calculation study protocols: the better way to design and report clinical trials. Ophthalmology. 2020 Jul 9. [Epub]. Available at: https://doi.org/10.1016/j.ophtha.2020.07.005.

16. Rocha-de-Lossada C, Colmenero-Reina E, Flikier D, Castro-Alonso FJ, Rodriguez-Raton A, García-Madrona JL, et al. Intraocular lens power calculation formula accuracy: comparison of 12 formulas for a trifocal hydrophilic intraocular lens. Eur J Ophthalmol 2020 Dec 18. [Epub]. Available at: https://doi.org/10.1177/1120672120980690.

17. Biswas P, Batra S. Commentary: Barrett's universal II formula: time to change the old trends? Indian J Ophthalmol 2020;68:64-5.