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Original Research Article

COMPARATIVE ANALYSIS OF THE ACCURACY OF INTRAOCULAR LENS POWER CALCULATION FORMULAS IN COMBINED PHACOVITRECTOMY

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Abstract: *The retrospective study was conducted in Bakhtawar Amin & Nishtar Medical Hospital from January 2022 to January 2023 to evaluate the accuracy of three new-generation formulas, using measurements from IOL-Master 700, in patients with vitreomacular interface disorders undergoing combined phacovitrectomy. A total of 110 patients (110 eyes) were included; Group I had 110 eyes, and Group II had 100 eyes. Group I had patients with normal phacoemulsification, and Group II had normally combined phacovitrectomy. For both groups, predictions from 8 IOL power calculation formulas were recorded. Results showed insignificant differences between Group I (P=.934) and Group II (P=.971). Regarding the mean prediction error of formulas In Group I, the Kane formula had the best outcome.in Group II, the Kane formula has the lowest MAE. The Kane formula had the lowest MAE in Group III, though the difference was not statistically significant. It is concluded that the Kane formula consistently had the best rank, independent of the Group.*

Keywords: Intraocular Lens Power, Phacovitrectomy, Formula Accuracy

Introduction

Recently, phacovitrectomy, which is the combination of intraocular lens implant (IOL), phacoemulsification, and pars planavitrectomy (PPV), has become increasingly popular for the management of vitreoretinal disorders(Sizmaz et al., 2019). Combined phacovitrectomy has many advantages improved retinal vision, safe vitreous shaving, fast visual acuity recovery, and low cost(Antaki et al., 2020). Due to increased patient expectations, achieving target refractive results has become increasingly important. Currently, IOL power calculations are done without adjustments due to added vitrectomy. It may explain lower refractive outcomes in some patients(Hamoudi et al., 2018; Hötte et al., 2018).

Some IOL power calculation formulas recently use various pre-operative parameters and new methodologies for calculating post-operative refractive error. PEARL-DGS formula uses output linearization and machine learning modeling for predicting ELP. Emmetropia Verifying Optical (EVO) formula B is developed from the theory of emmetropization, and Kane formula A is developed from theoretical optics and includes both artificial intelligence and regression components for refining predictions. Different studies have been conducted to compare formula performance for phacoemulsification(Cheng et al., 2020; Darcy et al., 2020). However, data are scarce regarding phacovitrectomy. Moreover, there is a lack of studies using the swept-source optical coherence tomography (OCT) based biometer (IOL-Master 700) using EVO 2.0 formulas and PEARL-DGS formulas. Thus, this study aims to evaluate the accuracy of three new-generation formulas, using measurements from IOL-Master 700, in patients with vitreomacular interface disorders undergoing combined phacovitrectomy.

Methodology

The retrospective study was conducted in Bakhtawa Amin & Nishtar Medical Hospital from January 2022 to January 2023. The study included patients who underwent phacoemulsification alone or phacovitrectomy. Patients with corneal disease, ocular trauma, secondary epi retinal membrane, previous refractive or intraocular surgery, keratometric astigmatism>4D, or post-operative complications were excluded. Informed consent of the participants was taken. The ethical board of the hospital approved the study.

Participants were divided into two groups. Group I had patients with normal phacoemulsification, and Group II had normally combined phacovitrectomy.

Symptomatic patients (metamorphopsia or decreased visual acuity) were candidates for Phacovitrectomy. Two experienced surgeons performed surgeries in both groups. Only one eye of each patient was evaluated. Eyes with an axial length of 21 mm to 27 mm were included. The complete pre-operative ophthalmological evaluation was done in all patients IOL-Mater 700 (Carl Zeiss Meditec AG, Germany) was used for performing optical biometry in all patients. The following data were obtained for each participant: axial length (AL), lens thickness (LT), horizontal corneal diameter, keratometry (K), central corneal thickness (CT), and anterior chamber depth (ACD). Patients were re-evaluated after 8 weeks for assessment of post-operative manifest refraction.

For both groups, predictions from 8 IOL power calculation formulas were recorded. IOLzero©D calculated Hofer Q, Haigis, Holladay 1, and SRK/T. PEARL, EVO 2.0, Kane, and Barrett Universal II (Barrett UII) were calculated using their respective websites. The mean prediction error(ME) of zero was achieved by optimizing the formula constant for each Group (Hoffer et al., 2015).

The primary outcome was a refractive predictive error. Negative refractive error implied a myopic outcome, and positive refractive error implied a hyperopic result. Study outcomes were ME and each formula's mean absolute error (MAE). The percentage of eyes in ±1.00D, ±0.50D, and ±0.25D was also calculated. Optimized constants of Group I were applied to Group II, and new refractive prediction errors of all formulas (Group III) were calculated. Cooke et al. used guidelines for ranking formulas (Cooke and Cooke, 2016).

Data were analyzed using SPSS version 23.0. Biometric and demographic data were represented as mean and frequencies. Comparison between groups was made by chi-square test, Mann–Whitney-U test, and sample t-test. ANOVA was used for comparing intra-group formula prediction errors. Friedman test was used for comparing absolute errors. The percentage of eyes in ±1.00D, ±0.50D, and ±0.25D was compared by using the Cochran Q test. P value <0.05 was considered statistically significant.

Results

A total of 110 patients (110 eyes) were included; Group I had 110 eyes, and Group II had 100 eyes. In Group II, 75 patients had epiretinal membranes, 20 had a full-thickness macular hole, and 5 had vitreomacular traction. The difference in Group I and II biometric measurements was not statistically significant.

The outcomes of formulas in Groups I, II, and III are outlined in Tables I, II, and III, respectively. Regarding formulas ME, the difference between Group I (P=.934) and Group II (P=.971) was insignificant. In Group I, the Kane formula had the best outcome, and the highest percentage of eyes in ±0.50D was present in the Barret Universal II. Absolute errors of the formulas were significantly different (P=.005). Post-hoc analysis showed that the Kane formula performed better than SRK/T (P=.03). The percentage of eyes within ±0.50D among all formulas was significantly different (p=.03).

In Group II formulas, MAE and proportion of eyes within ±1.00D, ±0.50D, and ±0.25D did differ significantly. The Kane formula had the highest percentage of eyes in ±0.25D and the lowest MAE. The Kane formula had the lowest MAE in Group III, though the difference was not statistically significant. Haigis formula has the highest portion of eyes in ±0.50D. In Group III, all formulas had significantly different ME from zero (P<0.05). Universally, Kane's formula (highest rank and lowest MAE) has proven accurate, irrespective of Group.

Table I Overall Formula Outcomes in Group I

Formula	Mean Prediction Error	Mean Absolute Error	Percentage of eyes in			Rank
			±1.00D	±0.50D	±0.25D	
Kane	.000±0.383	.306	99.0	81.4	46.4	1.2
PEARL-DGS	.000±0.385	.312	99.0	81.4	46.5	2.0
Barrett UII	.000±0.398	.326	99.0	85.6	42.3	2.7
EVO 2.0	.000±0.391	.313	99.0	80.4	45.4	3.2
Holladay 1	.000±0.410	.336	99.0	74.2	45.4	3.3
Haigis	.000±0.420	.344	97.9	76.3	41.2	4.7
Hofer Q	.000±0.435	.357	99.0	73.2	39.2	5.0
SRK/T	.000±0.436	.363	97.9	74.2	35.1	6.5

Table II Overall Formula Outcomes in Group II

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Formula	Mean Prediction Error	Mean Absolute Error	Percentage of eyes in			Rank
			±1.00D	±0.50D	±0.25D	
Kane	.000±0.471	.364	95.7	71.6	48.3	1.7
PEARL-DGS	.000±0.486	.377	95.7	74.1	44.8	1.8
EVO 2.0	.000±0.485	.375	94.0	72.4	41.4	2.5
Barrett UII	.000±0.508	.393	96.6	69.0	41.4	3.5
Haigis	.000±0.525	.392	90.5	71.6	40.5	4.8
Holladay 1	.000±0.532	.406	91.4	70.7	42.2	4.8
SRK/T	.000±0.532	.411	93.1	66.4	37.1	5.7
Hofer Q	.000±0.554	.419	91.4	69.8	38.8	6.0

Table III Overall Formula Outcomes in Group III

Formula	Mean Prediction Error	Mean Absolute Error	Percentage of eyes in			Rank
			±1.00D	±0.50D	±0.25D	
Kane	−.140±0.472	.374	95.7	68.1	46.6	2.8
Barrett UII	-.137±0.509	.402	94.8	69.8	43.1	3.2
PEARL-DGS	−.169±0.489	.396	93.1	69.8	44.8	3.3
EVO 2.0	− .1510.491	.393	94.8	69.0	47.4	3.7
Haigis	−.126±0.528	.403	91.4	70.7	46.6	4.5
Hofer Q	-.133±0.562	.417	92.2	69.8	38.8	5.0
Holladay 1	−.132±0.532	.403	92.2	68.1	46.6	5.2
SRK/T	−.155±0.533	.423	91.4	69.0	41.4	6.8

Discussion

In the current study, we compared new-generation formulas like Kane, PEARL-DGS, and EVO 2.0, along with vergence-based formulas like Barrett UII, Hofer Q, Haigis, SRK/T, and Holladay 1 in patients undergoing combined phacovitrectomy or phacoemulsification alone. Results of the previous studies show that phacovitrectomy has good refractive outcomes and is mostly comparable with the refractive outcomes of phacovitrectomy(Ercan et al., 2017; van der Geest et al., 2016). This study calculated formula accuracy using recommended guidelines for IOP power formulas(Hoffer et al., 2015). Moreover, new formulas such as PEARL – DGS and EVO 2.0 were evaluated. The current study showed that the Kane formula had the best rank and lowest MAE among all in the phacoemulsification group. This finding is in line with the results of a previous study conducted by Savini et al(Savini et al., 2020). Moreover, among PEARLDGS, Kane, Barrett UII, and EVO 2.0 proportion of eyes in ±0.50D was more than 80%. It is comparable to the findings of a previous study conducted by Melles et al. (Melles et al., 2019).

In Group II, which had patients with combined phacovitrectomy, though the difference between formulas was not statistically significant, Barrett UII, PEARL-DGS, EVO 2.0, and KANE had superior performance than vergence-based formulas. Again, the Kane formula showed the best performance (lowest MAE, highest proportion of eyes in ±0.25D, and best rank), in agreement with the previous study(Vounotrypidis et al., 2020). Group I and II comparisons showed that even though optimized lens constants were used, refractive outcomes in phacovitrectomized eyes were still worse compared to phacoemulsification alone. Each formula in Group II had a higher MAE and a lower proportion of eyes in ±0.50D.

In Group III, new-generation formulas had better ranks due to fewer refractive surprises and MAE. This finding is in line with the previous which stated that these formulas have lesser prediction error and predict the worst possible results(Kane et al., 2016). Moreover, unlike previous studies, each formula had persistent myopic shift (− .126 up to − .169), which had different myopic shifts (Hötte et al., 2018; Shiraki et al., 2018). The use of gas tamponade may explain this difference. Some studies show that IOL gas tamponade cause a positive effect resulting in anterior positioning of IOL(Savini et al., 2021); on the other hand, gas tamponade may cause zonular elasticity causing posterior positioning of IOL with the hyperopic shift. Other studies show that using gas tamponade does not affect refractive outcomes(Tan et al., 2021; van der Geest et al., 2016). The limitation of this study is that it had a retrospective design, and as two surgeons performed the procedure, data may be biased. However, it represents more generalized results and real-world scenarios.

Conclusion

It is observed that the Kane formula consistently had the best rank, independent of the Group. Moreover, in phacovitrectomy, IOL power should be carefully selected due to induced myopic shift.

Conflict of interest

The authors declared absence of conflict of interest.

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