Comparison of intraocular lens power calculation formulas in primary angle closure glaucoma

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Objective: To compare the accuracy of intraocular lens (IOL) power calculation formulas in primary angle closure glaucoma (PACG) eyes. All the formulations in this study are common and widely used; SRK/T, Hoffer Q, Holladay I and Haigis.
Design: Retrospective chart review
Methods: Data collection was performed through the OPD cards of PACG patients who already had uneventful cataract surgery with monofocal IOL by a single surgeon. All the patients had pre-operative data collection of axial length (AL), anterior chamber depth (ACD), keratometry, and predicted refractive outcomes using SRK/T, Hoffer Q, Holladay I and Haigis by IOL Master (Carl Zeiss version 5) biometry. Post-operative data was also collected. Analysis of the accuracy of all formulas was done by comparison of the predicted refractive outcomes and the measured refractive outcomes using the mean error (ME) and mean error squared (MES). MES was calculated to account for postoperative refractive errors with positive and negative values neutralizing one another in the resulting mean error.
Results: The Hoffer Q formula produced the lowest ME (0.009±0.54 D), but not the MES (0.303 D) Whilst the most accurate formula with the least random error (MES=0.216 D) is SRK/T with also low ME (0.083±0.45 D). The Haigis formula produced the highest MES (0.323 D) this inaccuracy of the Haigis formula may be caused by biometric data (using ACD). However, there is no significant difference between all 4 formulas (within limits of a small sample size). AL is the most weighted variable with significant effect to the predicted refractive error (P=0.029). All four formulas have positive ME representing more hyperopic result than intended.
Conclusion: The most accurate formula in this study is SRK/T. Haigis was the least accurate formula, potentially attributed to postoperative ACD changes. There is no significant difference between all 4 commonly used formulas.
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Introduction

We do know that one of the most important factors for precise vision is accurate intraocular lens (IOL) power calculation that mostly depends on the IOL calculation formula. In 2011, Aristodemou P. et al.[1] concluded that Hoffer Q was the most accurate formula in eyes with short Axial length (AL) of 20.00-20.49mm, Hoffer Q and Holladay I were also accurate in eyes with AL 21.00-21.49mm and all modern IOL calculation formulas perform well over the normal AL range.

However, most of the angle closure glaucoma eyes have shorter AL and

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shallower anterior chamber depth (ACD) than normal eyes and these biometric data also change after cataract surgery. Notably, an increase in ACD and AL after cataract surgery from the studies of Nonaka A. et al. and Francis BA. et al. [2,3]

In 2009, Kang SY. et al.[4] summarized that after using the SRK-II formula, angle closure eyes having remaining refractive errors greater than 0.5D was 50%, that is significant when compared to normal eyes (26.67%).

In 2011, Jongsoo Joo. et al.[5] completed a retrospective study comparing the accuracy of IOL Power Calculation Formulas in Primary Angle Closure Glaucoma (PACG) using Hoffer Q, SRK/T and Haigis. The study showed that Haigis is the least accurate formula and Hoffer Q is the most accurate formula when compared to the postoperative refractive error between normal eyes and PACG eyes.

In our study, we aim to compare the accuracy between SRK/T, Hoffer Q, Holladay I and Haigis in PACG eyes that underwent cataract surgery (Phacoemulsification with monofocal intraocular lens) by only one surgeon in order to decrease the confounding factor from surgical induced astigmatism (SIA).

Materials and Methods

Retrospective data collection was performed through the OPD cards of 50 PACG eyes who already had uneventful cataract surgery from 2015 to 2017 in Thammasat hospital. All of the patients were diagnosed as primary angle-closure glaucoma by glaucoma specialists in Thammasat glaucoma clinic and did not have any other ocular diseases or previous ocular surgeries.

Preoperative measurement was performed with IOL Master optical biometer ver. 5 (Carl-Zeiss, Jena, Germany) with Signal to Noise ratio (SNR) more than 10 in all 50 eyes. These biometric data were used to compare with the automated keratometry result of corneal power. If the biometric data from IOL master was not closely related with the data from automated keratometry (> 10% error) then that eye will be excluded from the data collection.

All the PACG patients that underwent uneventful cataract surgery under topical anesthesia using monofocal IOL in the capsular bag (iSert250, SN60WF) by a single surgeon, Dr.Anuwat Prutthipongsit (glaucoma specialist) in order to reduce the effect of surgical induced astigmatism (SIA). The choice of IOL power was based on target refractive outcome (least minus refractive error) on all 4 formulas.

One month after cataract surgery was performed, refractive outcome was measured by an auto-refractometer (Carl Zeiss Meditech AG Goeschwitzer Strasse 51-52 07745 Jena, Germany) and this data was collected for analysis using STATA ver.14.2. The level of clinically significance was set at 0.05 to determine the difference between all 4 formulas using mean error (ME) and mean error squared (MES).

Results

Preoperative data of 50 PACG eyes was shown in Figure 1. Most of the patients were female and mean age was 67.76±9.09 years. Preoperative best-corrected visual acuity (BCVA) was 0.1508±0.2 in logMAR (about 20/28 in Snellen). Preoperative axial length (AL) and anterior chamber depth (ACD) was 22.64±0.86 mm. and 2.67±0.33 mm. respectively. Most of the IOL model were HOYA iSert 250 (N=40) and the rest were AcrySof IQ SN60WF (N=10).

Discussion

In our study, Hoffer Q produced the lowest ME (0.009±0.54D), but not the MES (0.303 D) (Figure 3). This result can be explained from the negative postoperative refractive error (myopia) and the positive postoperative refractive error (hyperopic)

Baseline characteristics	Distribution (N = 50)
Sex	Male = 13 Female = 37
Age	67.76 ± 9.09 (52-85)
IOL model	Isert250 = 40 SN60WF = 10
Pre-op BCVA (logMAR)	0.1508 ± 0.2 (0-0.69)
Pre-op IOP	17.1 ± 0.86 (10-30)
AL	22.64 ± 0.86 (21.11-24.53)
ACD	2.67 ± 0.33 (2.22-3.31)

Figure 1: Preoperative data in PACG patients.

IOL=intraocular lens; IOP=intraocular pressure; BCVA= best-corrected visual acuity; AL= axial length; ACD=anterior chamber depth.

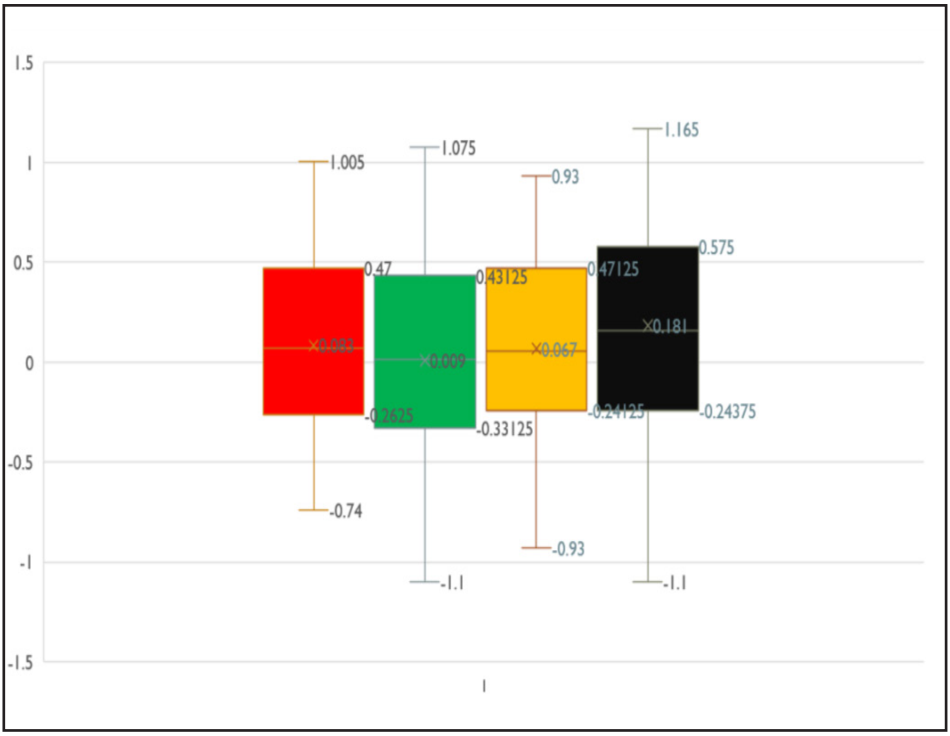

Figure 2: Mean Error (ME) in 4 formulas

Figure 2 shows Mean Error (postoperative refraction - target refraction) of each formula. Red represents SRK/T, Green represents Hoffer Q, Yellow represents Holladay I and Black represents Haigis

Formulas	MeanError (ME/D.)	MeanErrorSquare (MES/D.)
SRK/T	0.083±0.45	0.216
HofferQ	0.009±0.54	0.303
Holladayl	0.067±0.48	0.238
Haigis	0.181±0.53	0.323

Figure 3: Comparing the mean error (ME) and mean error square (MES) in 4 formulas

All 4 formulas produced positive ME, which meant more hyperopic result than intended. MES in Figure 3 was used in order to evaluate all of the negative (myopic) and positive (hyperopic) refractive error that could be neutralized by each other in ME.

Figure 4.1-4.4: Comparing predicted refractive error of 4 formulas with measured refractive error.

X-axis represents measured refractive error and Y-axis represents predicted refractive error in each formula.

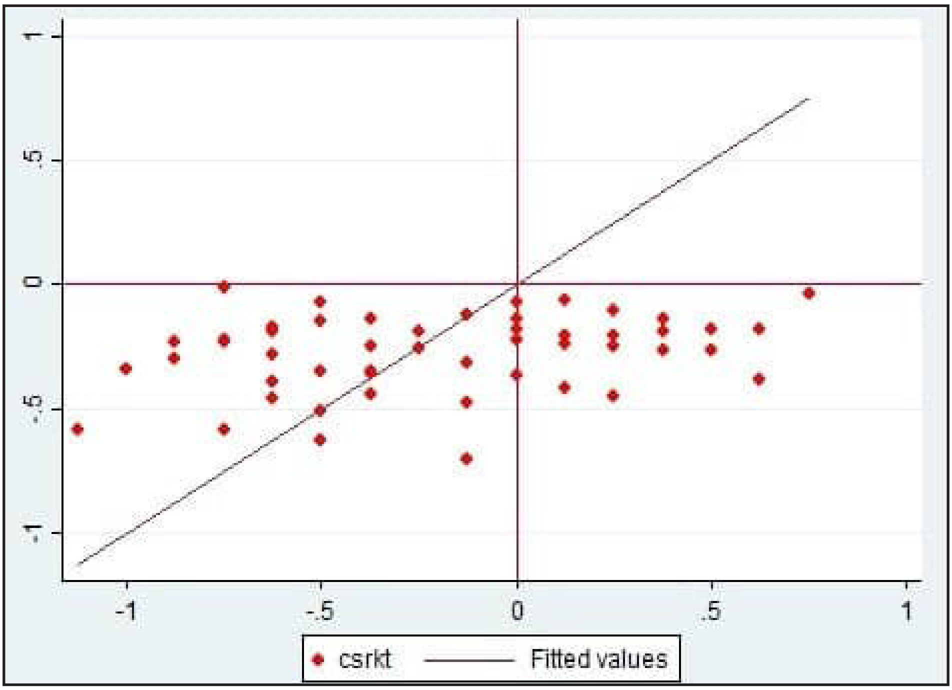

Figure 4.1: SRK/T formula

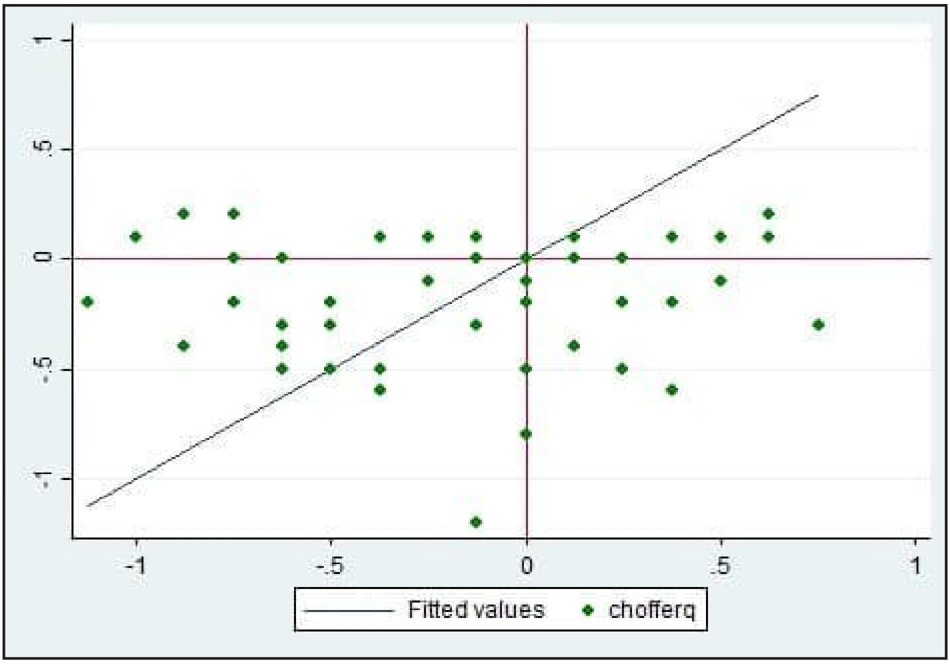

Figure 4.2: Hoffer Q formula

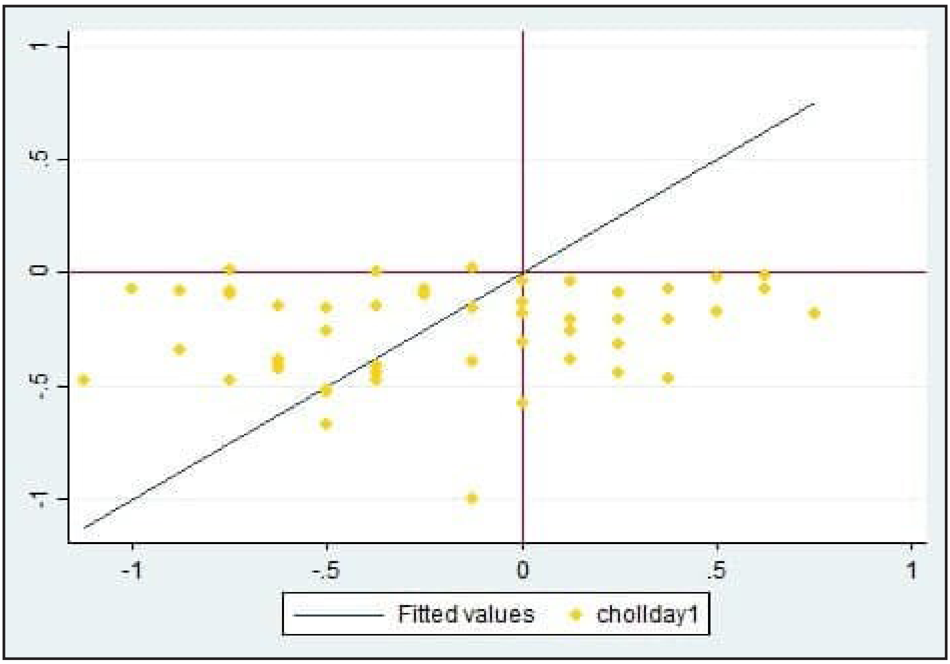

Figure 4.3: Holladay I formula

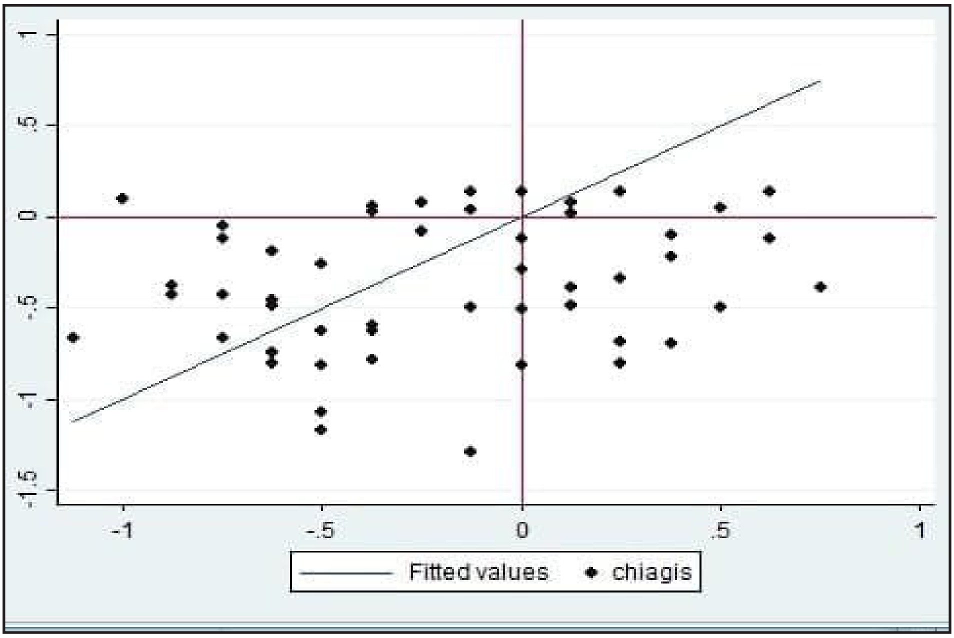

Figure 4.4: Haigis formula

Figure 5.1-5.4: Comparing inaccuracy in predicted refractive error of 4 formulas with measured refractive error

X-axis represents Mean Error (ME) and Y-axis represents predicted refractive error in each formula.

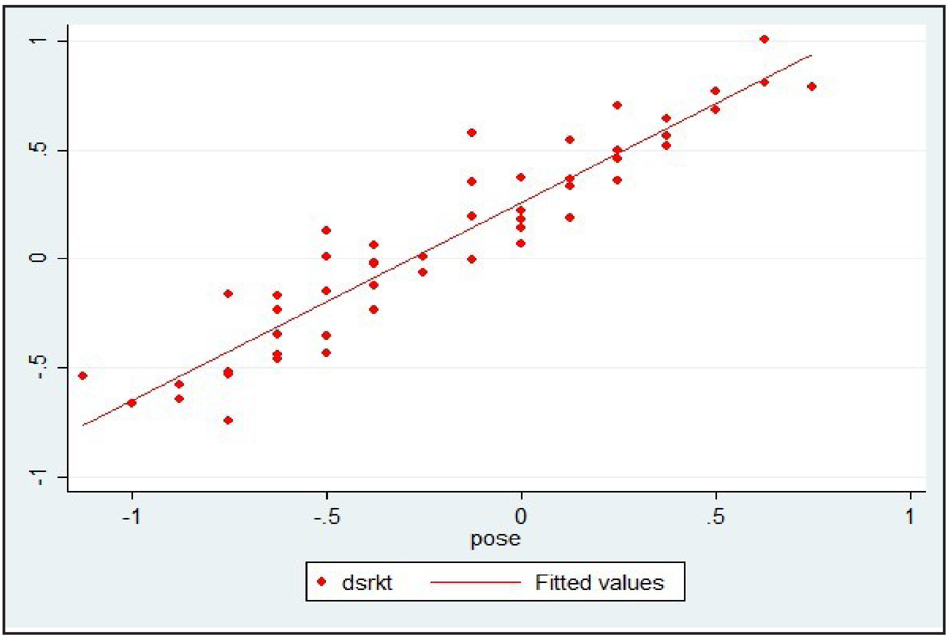

Figure 5.1: SRK/T formula

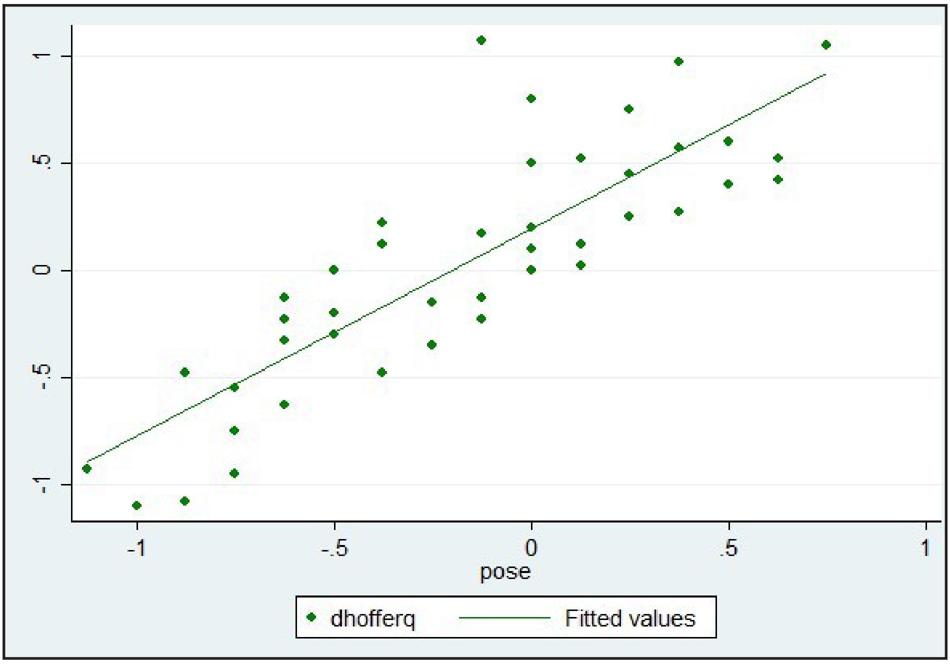

Figure 5.2: Hoffer Q formula

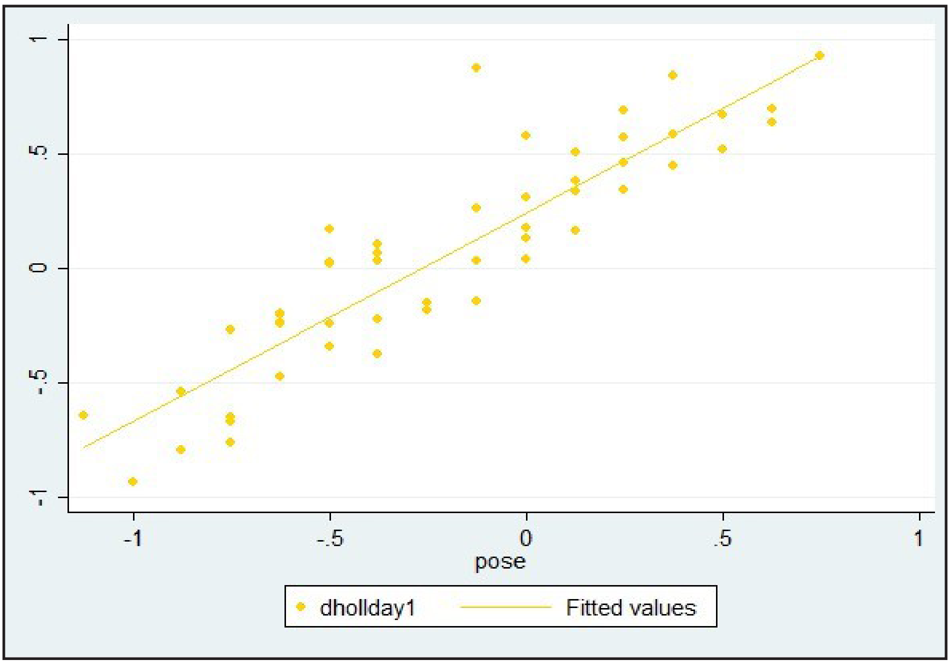

Figure 5.3: Holladay I formula

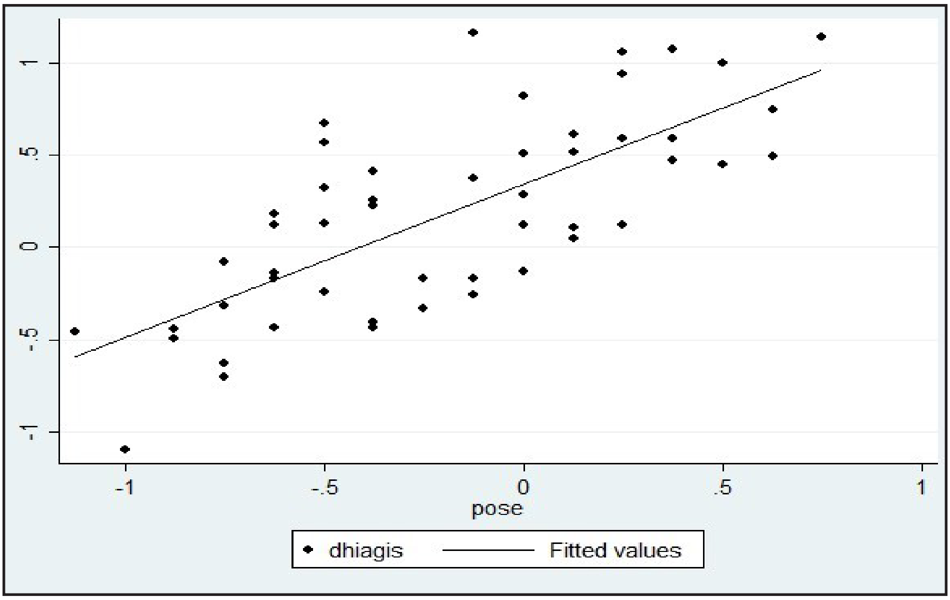

Figure 5.4: Haigis formula

errorsquare	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
method						
2	.0871761	.0649042	1.34	0.181	-.0409196	.2152718
3	.0219826	.0649042	0.34	0.735	-.1061131	.1500783
4	.1069109	.0649042	1.65	0.101	-.0211848	.2350066
pretn	.000997	.0060191	0.17	0.869	-.0108824	.0128765
al	-.0716618	.032474	-2.21	0.029	-.1357528	-.0075708
sex	.0668353	.0625012	1.07	0.286	-.0565178	.1901885
age	.0050405	.0031062	1.62	0.106	-.0010899	.0111709
acd	.0759762	.0880424	0.86	0.389	-.0977854	.2497378
_cons	1.19369	.6372577	1.87	0.063	-.0640094	2.45139

Figure 6: Comparing multiple factors that might affect the refractive outcomes including preoperative IOP, Axial length (AL), sex, age, anterior chamber depth (ACD), AL is the most weighted variable with significant effect to the predicted refractive error (*P* =0.029). Every 1 mm increase in AL is predicted to result in a 0.07 D decrease in mean error squared (coefficient -0.071).

that could neutralize each other in ME result. So we also have to pay attention at the MES which cannot be neutralized by the negative refractive error.

The most accurate formula is SRK/T, with the least random error (MES=0.216 D) and lowest ME (0.083+-0.45 D). The accuracy of Holladay I is very close to SRK/T in this study (low MES=0.238 D, low ME=0.067+-0.48 D)

Haigis produced the highest MES (0.323 D). This inaccuracy of the Haigis formula may be caused by biometric data using ACD and 3 lens constants that can be changed significantly after cataract removal,[6,7] especially in ACG patients which ACD/AL ratio could be altered from normal anatomy.

However, there is no significant difference between all the 4 formulas. This may be due to the small sample size. (When compare to SRK/T, *P* in Hoffer Q, Holladay I and Haigis are 0.196,0.746 and 0.091 respectively.)

Our result contrasts with a previous study by Jongsoo Joo et al.[8] which concluded that the Hoffer Q formula produced better results than the SRK/T formula in ACG group. This difference could be caused by the small sample size of our study.

AL is the most weighted variable with significant effect to the predicted refractive error (*P* =0.029). Every change of 1mm in AL resulted in reduced MES of 0.07 Diopter and the longer the AL(in this study), the more accurate of the predicted refractive error. This result can be use for subgroup analysis in larger sample size. (Figure 6.)

In a recent article entitled: “Accuracy of intraocular lens calculation formulas” published in the journal Ophthalmology by Ronald Melles et al, Ophthalmology 2018;125:169-178 by the American Academy of Ophthalmology, it shows that the most accurate IOL formula for prediction of refractive outcome at present is the Barrett Universal II formula, even for eyes with short axial length[8]

The main limitation to this study is the instrument used in performing biometry and IOL power calculations is not the most up to date. However, it represents the level of instrumentation that is widely used in routine clinical practice in the region of this study.

References

1.Aristodemou P, Knox Cartwright NE, Sparrow JM, Johnston RL. Formula choice: hoffer Q, Holladay 1, or SRK/T and refractive outcomes in 8108 eyes after cataract surgery with biometry by partial coherence interferometry. J Cataract Refract Surg. 2011;37(1):63–71.

2.Nonaka A, Kondo T, Kikuchi M, Yamashiro K, Fujihara M, Iwawaki T, et al. Angle widening and alteration of ciliary process configuration after cataract surgery for primary angle closure. Ophthalmology. 2006;113(3):437–41.

3.Francis BA, Wang M, Lei H, Du LT, Minckler DS, Green RL, et al. Changes in axial length following trabeculectomy and glaucoma drainage device surgery. Br J Ophthalmol. 2005;89(1):17–20.

4.Kang SY, Hong S, Won JB, Seong GJ, Kim CY. Inaccuracy of intraocular lens power prediction for cataract surgery in angle-closure glaucoma. Yonsei Med J. 2009;50(2):206–10.

5.Joo J, Whang WJ, Oh TH, Kang KD, Kim HS, Moon JI. Accuracy of intraocular lens power calculation formulas in primary angle closure glaucoma. Korean J Ophthalmol. 2011;25(6):375–9.

6.Yang CH, Hung PT. Intraocular lens position and anterior chamber angle changes after cataract extraction in eyes with primary angle-closure glaucoma. J Cataract Refract Surg. 1997;23(7):1109–13.

7.Hayashi K, Hayashi H, Nakao F, Hayashi F. Changes in anterior chamber angle width and depth after intraocular lens implantation in eyes with glaucoma. Ophthalmology. 2000;107(4):698–703.

8. Ronald B. Melles, MD, Jack T. Holladay, MD, MSEE, William J. Chang, MD: accuracy of intraocular lens calculation formulas. Ophthalmology. 2018;125(2):169–78.