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Research Article

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Factors Affecting the Refractive Accuracy of Intraocular Lens Power Calculation Formulas in Myopic Eyes

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Abstract: Aim Investigating the predicted error of refraction among various IOL formulas in myopic eyes is the aim, along with possible contributing factors, including anterior chamber depth (ACD), axial length (AL), keratometry, along with implanted IOL power. Patients & Methods: A month's postoperative refractive outcome at Ibn Al-Haitham Teaching Hospital among May 2024 and June 2025 was compared among two different IOL formulas (SRK/T and Haigis) for patients having AL greater than or equivalent to 24.5 mm who had uneventful phacoemulsification surgeries. Biometry was performed using IOL Master. The mean numerical error (MNE), referred to as the variance in the postoperative spherical equivalents (SE) and the mean absolute error (MAE), which was the difference between the absolute postoperative SE along with the absolute projected SE, were calculated for each formula. Findings: The MNE for the SRK/T and Haigis equations was -0.29+0.73 & -0.36±0.75 (p=0.106), whereas the MAE is 0.62±0.47 as well as 0.63+0.63 (p=0.829), respectively. No statistically significant difference was found between the equations in MNE as well as MAE for eyes having postoperative (SE) within 0.5D and 1.0D (p>0.05). About fifty percent of eyes are within 0.5D, and roughly 80% of eyes are within ID of the target refraction using both formulas. For eyes with AL greater than 28.75 mm, the MAE for the SRK/T and Haigis equations was 0.96±0.57 and 1.03±1.03, respectively. MAE was significantly correlated for implantable IOL power. Conclusion: The postoperative refractive errors generated by the SRK/T and Haigis equations are nearly identical in myopic eyes. Careful IOLpower choice is recommended since eyes having longer AL or when using minus-power IOLs are more likely to experience hyperopic outcomes.

Keywords: haigis, srk/t, axial myopia..

INTRODUCTION

Originally intended to simply remove a cloudy lens to restore vision, cataract surgery has developed into a far more complex procedure that yields precise and ideal visual outcomes (Koh, V. 2014). This accomplishment is based on a single, essential principle: the accurate determination of the intraocular lens's power, which determines the eye's post-operative condition of refraction. For certain patient subgroups, especially those with high axial myopia, achieving emmetropia—the ideal state in optics without refractive error—remains challenging, despite the fact that current IOL power calculation methods have proven extremely accurate for the general population (Goh, Y. W. *et al.*, 2015; Nangia, V. *et al.*, 2010)

Myopic eyes have also always been something of a challenge because of their anatomical and optical properties, and it is here that even the newer IOL formulas can be confused (Yin, G. *et al.*, 2012). The pursuit of refractive precision in such eyes is very important since myopic patients have extremely high expectations regarding becoming spectacle independent after long years of visual dependence on glasses (Pan, C. W. *et al.*, 2013; Chang, R. T., & Singh, K. 2016; Lin, S. C. *et al.*, 2016)

Yet they are disproportionately vulnerable to postoperative refractive surprises, the most common of which is a hyperopic shift, in which the outcome is farsighted, the opposite of the intended result. Such systematic error demonstrates the reality that myopic eyes are not just longer emmetropic eyes but possess individual biometric characteristics that influence formula performance. (Williams, K. M. *et al.*, 2015)

Multiple factors with complex causes combine to produce inaccuracy. First and foremost, the all-important assessment of axial length that may vary as a result of anatomical alterations associated with axial elongation, including posterior staphyloma with a deep vitreous chamber (Younan, C. *et al.*, 2002).

PATIENTS AND METHODS

Research Design

A prospective clinical experiment was conducted in Ibn Al-Haitham Teaching Hospital, Baghdad, Iraq, between 2024 and 2025. This study included 65 eyes of 65 patients with axial lengths of at least 24.5 mm who had both IOL implantation surgery & phacoemulsification. Keratoconus, endothelial dystrophy, glaucoma, uveitis, posterior segment

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issues, traumatic cataract surgery, and eyes with a history of vitrectomy or silicone filling were all considered exclusion criteria. Based on the AL values for further study, Group A comprised 15 eyes (AL 24.5mm -25.75mm), Group B comprised 21 eyes (AL = 25.76-27.25mm), Group C comprised 15 eyes (AL = 27.26- 28.75), and Group D comprised 14 eyes (AL >=28.76). Only one eye of each person was included in order to avoid data duplication in bilateral eyes. The preoperative assessment included Goldman applanation tonometry, slit lamp biomicroscopy, indirect ophthalmoscopy, and visual acuity. The findings were examined using an autorefraction one month after the surgery. The patient has to fixate on a target in order for the skilled operator to measure the biometric evaluation using the IOL Master, a non-contact laser interference device. The interference caused by the signal's reflection off the retinal pigment epithelium serves as its basis. Contact with a cornea isn't necessary, and inconsistencies caused by corneal compression are eliminated, as well as operator measurement inaccuracies are avoided. It gives the refractive axial length with regard to the anatomic axial length determined by ultrasound biometry, since it measures to the precise center of the macula.

The estimated IOL power for each patient was determined using the Haigis formula and the SRK/T formula. MNE and MAE were calculated as the difference between the anticipated refractive error from the calculation and the actual postoperative refractive SE error recorded one month after surgery. Eyes having an after-surgery SE of ±0.5D and +1.0D of the target refraction were analyzed for both formulations. For both formulations, the MAE was associated with average keratometry, age, AL, ACD, and implanted IOL power.

Surgical procedures

All of the operations were performed by a single surgeon. For the phacoemulsification therapies, a 2.8 mm sutureless superior clear corneal incision was made, followed by a continuous curvilinear anterior capsulorrhexis, which measured about 5.5 mm in diameter. All of the eyes in the capsular bag received Rayner SUPERFLEX type 620H hydrophilic acrylic foldable IOLs, with better square corners, measure 12.5 mm overall, and have an optic diameter of 6.25 mm. All outcomes were analyzed and identified by SPSS, V. 24.0.

RESULTS

The eyes of 65 individuals were included, and the AL range ranged from 24.51 mm - 31.51 mm with a mean of 27.28 +1.87 mm. The average age was between 16 and 81 years old, at 50.40±14.57 years. Of the patients, 38 (58.5%) were male and 28 (41.5%) were female. The implanted IOLs' strength varied from +21D through -3.0D (Figure 1).

Table 1. Preoperative parameters.

	All eyes	Group A	Group B	Group C	Group D	p
Keratometry (D)	43.11±1.65	42.52±1.76	43.01±1.74	43.12±1.59	43.87±1.26	0.148
Anterior chamber depth (mm)	3.61±0.28	3.50±0.36	3.57±0.27	3.68±0.21	3.75± 0.24	0.048
Axial length (mm)	27.32±1.86	25.04±0.42	26.56±0.44	28.09±0.39	30.12±0.62	0.040

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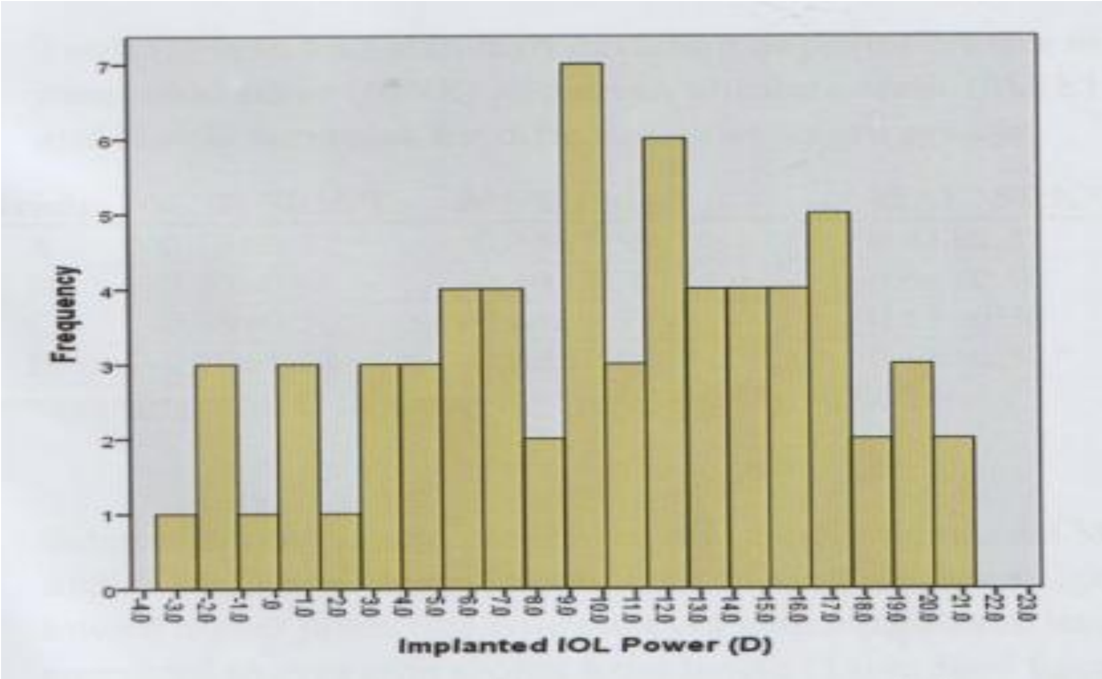

Figure 1. Frequency distribution of implanted IOL powers.

Table 2. Means and standard deviation into postoperative Mean Numerical Error (MNE) and Mean Absolute Error (MAE) related to SRK/T and Haigis formulas.

	SRK/T	Haigis	P value
MNE	-0.29±0.73	-0.36±0.75	0.106
MAE	0.62±0.47	0.63±0.63	0.829

Table 3. Mean and standard deviation of postoperative mean numerical error (MNE) and mean absolute error (MAE) for SRK/T and Haigis formulas for different axial length groups.

Group	MNE SRK/T	MNE Haigis	MAE SRK/T	MAE Haigis
A	-0.18±0.47	-0.25±0.36	0.41±0.27	0.33±0.28
B	-0.37±0.68	-0.30±0.78	0.58±0.50	0.66±0.50
C	-0.39±0.56	-0.44±0.52	0.57±0.36	0.56± 0.44
D	-0.19±1.13	-0.48±1.18	0.96±0.57*	1.03±1.03**

Subgroup analysis did not show a statistically significant MNE for the SRK/T and Haigis equations; however, for MAE, there was a significant trend for eyes with longer axial lengths to have greater prediction errors compared with eyes having shorter axial lengths (Table 3, Figures 2, and 3).

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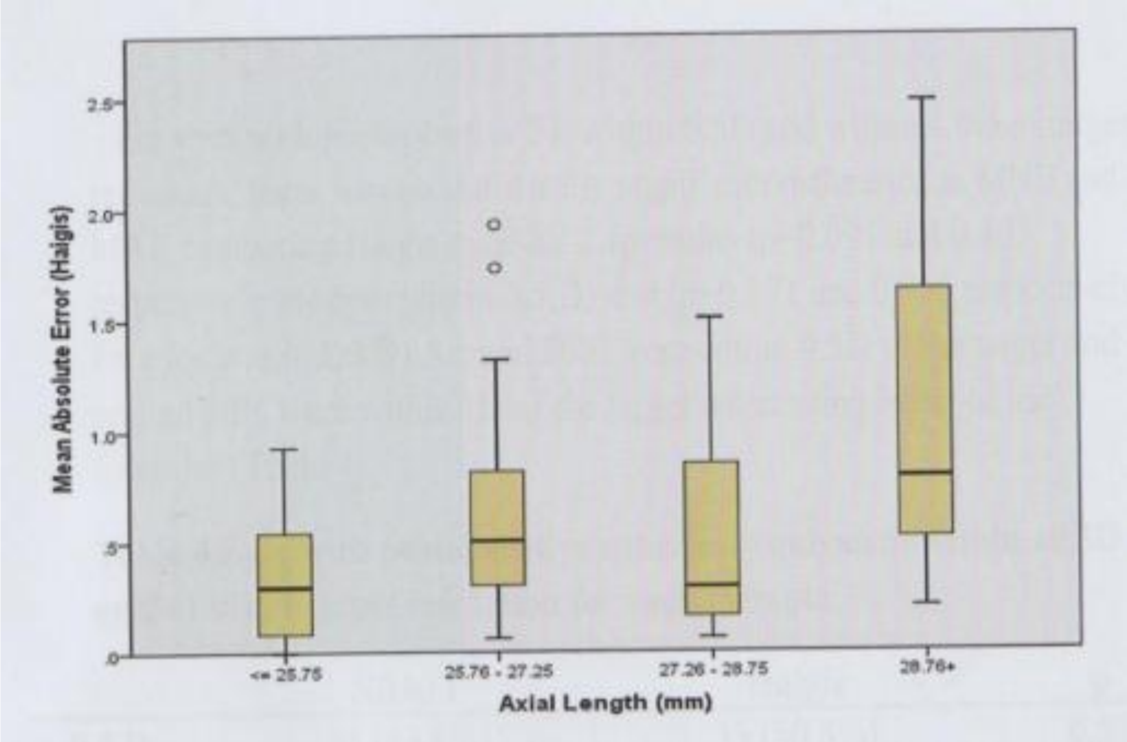

Figure. 2 Mean absolute error (haigis) axial length (mm)

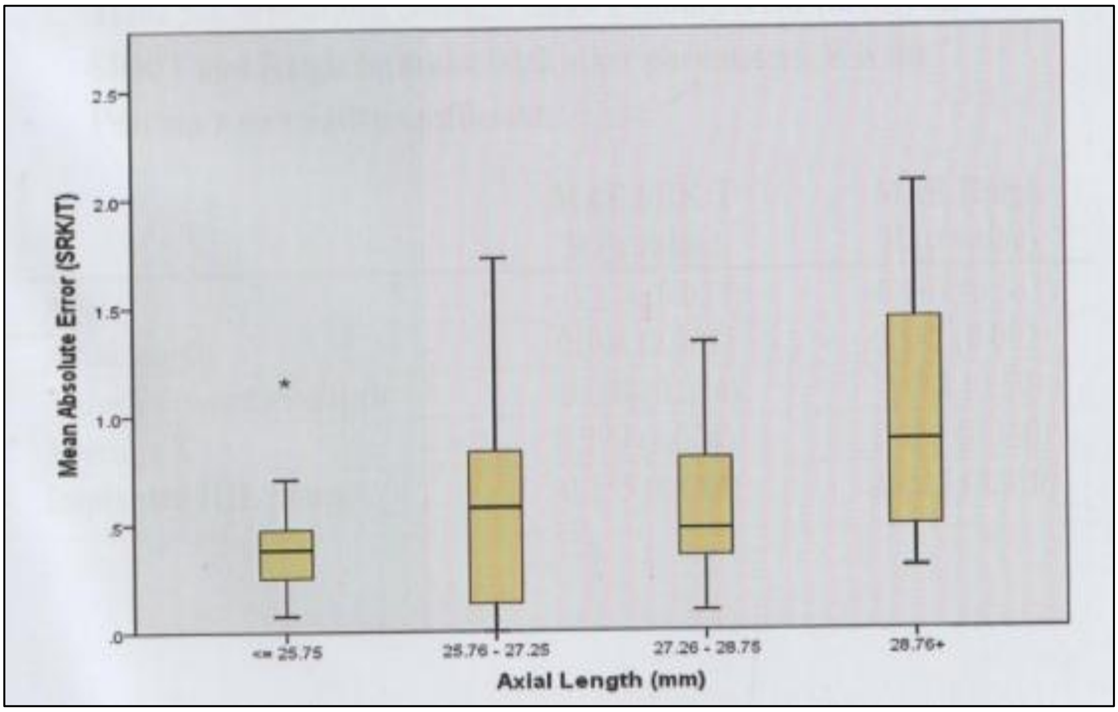

Figure 3: Mean absolute error (MAE) boxplot for the SRK/T formula in various groups of axial length (AL).

Asterisks (*) denote extreme values; circles (°) show outliers; the line in the box indicates the median; the box indicates the interquartile range. For eyes with postoperative SE < 0.5D and within 1.0D of target refraction, the difference of MNE and MAE among Haigis and SRK/T formulas was not statistically significant (p=0.091 and 0.493 for eyes below 0.5D and p=0.171 as well as 0.935 in eyes within 1.0D, respectively). About 50% were within 0.5D of the aim, and nearly 80% are within ID in the objective using both approaches (Table 4).

Table 4. Eyes with postoperative spherical equivalent within ±0.5D and +1.0D of target refraction for each formula.

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	SRK/T	Haigis	p
± 0.5 D	35 (53.8%)	33 (50.8%)	0.57
± 1.0 D	51 (78.5%)	54 (83%)	0.26

Table 5. Correlations between mean absolute error (MAE) for SRK/T and Haigis formulas with other parameters. R is Pearson's correlation coefficient.

	MAE SRK/T R (p value)	MAE Haigis R (p value)
Age	- 0.274 (**0.027**)	-0.167 (0.183)
Axial length	0.394 (**0.001**)	0.382 (**0.002**)
Anterior chamber depth	-0.004 (0.974)	0.068 (0.59)
Average K	0.279 (**0.024**)	0.164 (0.190)
Implanted IOL power	-0.355 (**0.004**)	-0.317 (**0.010**)

DISCUSSION

The cornea, lens, and AL all contribute to the optical power that determines the eye's refractive state (MacLaren, R. E. *et al.*, 2005). The AL measurement and the refractive power used for the IOL calculation deviated more drastically with increasing axial length and refractive power (Petermeier, K. *et al.*, 2009; Abulafia, A. *et al.*, 2015). The best method for calculating IOL power has been up for debate for a while. In Japanese study (AL ranged within 26-33 mm), Haigis, SRK/T, Hoffer Q, and Holladay 1 all carried out similarly in absolute errors within 0.5D for the target within roughly 20% of eyes, challenging the conventional wisdom that the SRK/T formula was the most accurate formula for those with high AL (Tsang, C. S. *et al.*, 2003; Wang, L. *et al.*, 2011; Rose, L. T., & Moshegov, C. N. 2003). The Haigis formula had 49.32% of the eyes within 1.0 D of the target, while the SRK/T approach had 47.97%. The proportion in eyes within 1.00D of the desired refraction were also reported to be equivalent using the SRK/T, Haigis, or Barrett Universal II equations in (Olsen, T. 2007). Furthermore, compared to the Haigis & Barrett Universal II formulas, the SRK/T, Hoffer Q, and Holladay equations offered lower percentages of eyes within 0.50D for the necessary refraction. This is partly consistent with a study that demonstrated that in severely myopic eyes, the Haigis IOL & SRK/T calculation methods yielded comparable results (Terzi, E. *et al.*, 2009).

According to some investigations (Ghanem, A. A., & El-Sayed, H. M. 2010; Roessler, G. F. *et al.*, 2012; Yokoi, T. *et al.*, 2013) postoperative hyperopia ranged from +0.5 D to +1 D in eyes having an AL of >28 mm. This implies that for biometry constants, various sets for IOLS (plus-IOLs along with minus-IOLs) should be handled differently. According to recent studies, the use of positive-power IOL constants with both positive-power & negative-power IOLs is the primary cause in postoperative hyperopic refractive errors. The current study demonstrated a significant correlation between MAE and both AL and implanted IOL power using both formulas. Age, keratometry, and the MAE were significantly correlated when using the SRK/T method alone. The angle widens as well as the frontal region deepens during cataract surgery, which removes the whole volume inside the lens. A 0.4 mm shift in the ELP due to a 1 mm ACD elevation to the Haigis formula will result in a refractive difference of 0.5 to 0.6 diopters. (El-Nafees, R. *et al.*, 2010) The SRK/T formula, on the other hand, is based in thin lens optics, in which thin lenses that have two

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refractive powers permanently replace the lens and cornea (crystalline or IOL). (Wang, J. K. *et al.*, 2008) The surgical refractive prediction error reduced with patient age. According to the cohort effect, older age groups might have smaller eyes as a result of worse general health and nutrition.

The surgical refractive prediction error reduced with patient age. This is explained in a number of studies by the cohort effect, that postulates as older age groups might have smaller eyes as a result of worse nutrition and general health. It emmetropization process reduces the AL with age, counteracting the rise in refractive power caused by lens alteration (Wang, J. K. *et al.*, 2008).

Over the whole range of data, an alteration of 0.11 D for keratometry is equivalent to a rate of 1.00 D changes in the SE . The cornea can preserve emmetropia and mild myopia by acting as an emmetropizing factor, but it cannot counteract the emmetropizing impact of excessive eye development. It was shown that when the mean refractive error lowers, the mean keratometry values improve (cornea steepens) because comeas are steeper for myopes than emmetrope eyes (Haigis, W. 2009; Barrett, G. D. 1993). Our findings corroborated earlier studies demonstrating that the expected error is typically larger when low-power IOLs are implanted into eyes with high myopia, even though the surgeon for this study aimed primarily for a little myopic postoperative refractive result rather than emmetropia.

CONCLUSION

In myopic eyes, the postoperative refractive errors produced by the Haigis and SRK/T formulae are almost the same. Because hyperopic results are more common in eyes with longer AL or when employing minus-power IOLs, careful consideration should be given to IOL power selection. Based on the results of the current study, it is advised that patients with longer AL use the Haigis or SRK/T formulas. Additionally, a postoperative target refraction of -1.0 to -2.00 D should be set in order to prevent hyperopic refractive outcomes, particularly for eyes with AL of >28.75mm, which can be avoided by implanting higher power IOLs. For individuals who used to have greater near visual acuity, this might prevent the disappointing visual results.

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