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ORIGINAL ARTICLE

Intra-ocular lens power calculation in patients with high axial myopia before cataract surgery

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KEYWORDS

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Abstract *Purpose:* To evaluate the accuracy of different formulas used for IOL power calculation in patients with high axial myopia undergoing cataract surgery.
Methods: A prospective clinical study was carried out on 53 eyes of 51 patients with an axial length from 25.5 to 31.4 mm including 21 males (41.2%) and 30 females (58.8%). Calculation of the IOL power to be implanted was done by three available IOL power formulas; Haigis formula, SRK/T formula, and Holladay I formula. The mean error (ME) was calculated from the difference between the formula predicted refractive error and the actual post operative refractive error.
Results: There was no statistically significant difference between the mean error of the three formulas used in the overall performance or in the axial length subcategories. SRK/T formula caused the smallest mean error, (+0.17 D). Haigis formula showed a higher ME (+0.21 D) and Holladay formula caused a myopic postoperative refractive error (−0.20 D).
Conclusion: The calculation of IOL power in patients with high axial myopia using the third or the fourth generation formulas help in improvement of the accuracy of the calculation and decreasing the post operative refractive error. SRK/T formula showed the lowest mean error, however, there was not statistically significant difference between the three formulas used, neither in the overall performance, nor in axial length subcategories.

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1. Introduction

Patients with high axial myopia have prevalence of lens opacities and develop cataract at an earlier age than emmetropes (Kaufman and Sugar, 1996).

Intra-ocular lens (IOL) power calculation poses difficulties for cataract surgeon planning surgery in such eyes (Drews, 1986; Olsen et al., 1995). The two main problems encountered are the measurement of the proper axial length to be used in calculation due to the presence of the posterior staphyloma, and the lack of accuracy of the available formulas that calculate the power of the intra-ocular lens in cases of high myopia (Hafez, 2004). So, determining the power of the intra-ocular lens to be implanted is a crucial factor in postoperative refractive status and visual acuity (Tsang et al., 2003).

Formulas for IOL power calculation had past four generations, first generation formulas were theoretical and based on the same fundamental constant with no respect to anterior chamber depth. Since then, Binkhorst, Holladay, Hoffer and Shammas had refined the existing theoretical formulas where each of them developed his regression formula based on analysis of their previous IOL cases (Binkhorst, 1981; Shammas, 1988).

This work was amalgamated in 1980 and yielded the Sanders Retzlaff Kraff I (SRKI) formula (Sanders et al., 1981).

The second generation was designed by combining linear regression analysis and stepwise adjustment for long and short eyes according to anterior chamber depth (Binkhorst, 1987; Saunders et al., 1988).

The third and fourth generation formulas, started by Holladay in 1988, all aimed at better calculation of the IOL power in eyes with extreme axial length where another term had appeared which is IOL specific anterior chamber depth (Hoffer, 1993; Retzlaff et al., 1990).

The accuracy of third and fourth generation formulas for IOL calculation in patients with high axial myopia had not been fully evaluated (Tsang et al., 2003). For that, the need for more studies conducted to evaluate such accuracy is crucial.

This study was conducted to evaluate the accuracy of different formulas used for IOL power calculation in patients with high axial myopia undergoing cataract surgery.

2. Patients and methods

This study was conducted on patients admitted in Mansoura Ophthalmic Center in the period from May 2006 to April 2007. Patients scheduled to undergo cataract operation with axial length 25 mm or more were included in this study, where patients with previous ocular surgeries, combined surgical procedures, eventful cataract surgeries and corneal surface irregularities were excluded.

Routine pre-operative ocular examination was done. Calculation of the IOL power to be implanted was done by the same person using three available IOL power formulas; Haigis formula, SRK/T formula, and Holladay I formula.

The corneal power was measured by computerized colored video keratometer. The keratometry measurement was done prior to axial length measurements. Axial length measurement was done using immersion A-scan technique by Hansen scleral shell and B mode with horizontal macular scanning COMPACT II (Quantel Medical, Clermont-Ferrand, France).

The patients were divided according to the axial length into three groups; group I: with axial length from 25 to 27 mm (15 eyes), group II: with axial length from more than 27 to 29 mm (23 eyes), group III: with axial length from more than 29 to 31.4 mm (15 eyes).

Phacoemulsification was done through a sutureless 3.2 mm incision, the site of the incision was selected according to the pre-operative corneal astigmatism, if present, with implantation of foldable IOL (I-Medical, Weinheim, Germany) in the capsular bag. The minimum IOL power implanted was +1.0 D and the maximum power was +15.0 D.

All the patients were examined at 1 day, 1 week, 2 weeks, 1 month, 2 months and 3 months postoperatively to asses uncorrected and best corrected visual acuity, slit lamp biomicroscopy, refraction using Canon (R-30) autorefractometer and fundus examination.

All the pre- and postoperative data were collected in a specific sheet for each case and statistical analysis was done using SPSS program 11.01 with P value >0.05 considered significant.

The mean numeric error is calculated as follows: formula predicted postoperative refraction – actual postoperative refractive error.

3. Results

This study was carried out on 53 eyes of 51 patients with an axial length from 25.5 to 31.4 mm, including 21 males (41.2%) and 30 females (58.8%) with their age ranging from 39 to 67 years (mean 55.04 ± 7.73). (Table 1).

Two types of cataract were present in this study; senile cataract in 36 eyes (68%), and presenile cataract in 17 eyes (32%).

Fundus changes were observed in 46 eyes including myopic degenerations in 19 eyes. About 31 of all studied patients were glass wearers while one patient used contact lens.

The mean K of the studied eyes was (44.33 ± 1.28) with a minimum of 41.50 D and a maximum of 47.29 D. It showed negative correlation with the axial length as it decreases with the longer axial length. Pre-operative anterior chamber depth (ACD) was 3.397 ± 0.37 mm with a positive-nonsignificant correlation with the axial length.

The mean axial length was 28.20 ± 1.57 mm, with a minimum of 25.47 mm and a maximum of 31.40 mm. Posterior staphyloma was found in seven eyes.

The overall performance of the three formulas in eyes with axial length longer than 25 mm is demonstrated in Table 2. SRK/T formula and Haigis formula tended to cause a hyperopic refractive error postoperatively.

The SRK/T formula caused the smallest mean error (+0.17 D). The Haigis formula showed a higher ME than

Table 1 Demographic data.

Patients total number	51
Males (No./percentage)	21 (41.2%)
Females (No./percentage)	30 (58.8%)
Age (years)	55.04 ± 7.73
Minimum age (years)	39
Maximum age (years)	67

Table 2 Overall performance of formulas for AL > 25 mm.

IOL formulas	Mean error (ME)	Eyes (%) with mean absolute error (MAE) < 1.0 D
SRK/T	+0.17 D	83.01
Haigis	+0.21 D	83.01
Holladay I	–0.20 D	84.90

P value > 0.1.

Table 3 Performance of formulas in AL subcategories.

IOL formula	Mean error (ME)		
	Group I 25–27 mm	Group II > 27–29 mm	Group III > 29–31.4 mm
SRK/T	+0.04	+0.15	+0.33
Haigis	+0.03	+0.17	+0.46
Holladay I	−0.18	−0.29	−0.07

P value > 0.1.

the SRK/T formula (+0.21 D). The Holladay I formula caused a myopic postoperative refractive error (−0.20 D).

In this study, there was no statistically significant difference between the mean errors of the three formulas used in the overall performance.

Table 3 shows the performance of each formula in the AL subcategories. The ME ranged from 0.04 to −0.18 D in group I, from 0.15 to −0.29 D in group II, and from 0.46 to −0.07 D in group III.

The study found no statistically significant difference between the mean errors of the three formulas in the axial length subcategories.

4. Discussion

Since the first theoretical formula for IOL power calculation was described by Fyodorov et al. in 1967, the following formulas have aimed to improve the refractive outcome especially for the extreme axial length.

First generation formulas depend on a single constant to predict the postoperative position of the IOL (ACD), while the second generation formulas used the term ACD not as a constant but as a value which varies with the axial length. Third generation formulas (Holladay I, SRK/T) incorporated the effect of corneal curvature aiming for better prediction of the IOL position.

Fourth generation formula (Haigis formula) does not consider a proportional relation between the distance from the cornea to the IOL position and the axial length. Instead, it uses three constants to set both the position and the shape of a power prediction curve.

In this study, SRK/T formula was the most accurate formula among the used formulas with the smallest postoperative mean error (+0.17), and this goes hand in hand with Donoso et al. (2003) who examined 212 eyes of different axial length with the SRK II, Binkhorst II, Hoffer-Q, Holladay, and SRK/T formulas and inferred that SRK/T formula may be the most accurate for the long eyes (>28.0 mm). However, the number of eyes in the longer axial length group was small (16 eyes).

Hoffer (2000) examined the mean absolute error in 317 eyes using the SRK/T, Holladay I, Holladay II, and Hoffer-Q formulas and he found that the SRK/T formula showed a trend toward the lowest mean absolute error in medium long (24.5–26.0 mm) and very long (>26.0 mm) eyes.

Zaldivar et al. (2000) had compared the IOL power using SRK/T, Hoffer-Q, Holladay I and Holladay II formulas in 50 highly myopic patients who underwent phacoemulsification with foldable IOLs. The conclusion of their study was, in eyes with axial length longer than 27 mm current third and fourth generation lens calculation formulas tend to over minus patients between −1 and −4 spherical equivalent leaving the patients with postoperative hyperopia.

Narvaez et al. (2006) compared the accuracy of intra-ocular lens power calculations using SRK/T, Holladay I, Holladay II, and Hoffer-Q formulas in 643 eyes and he found that there was no significant difference in the accuracy of the four formulas. However, this study used two different IOLs types which may affect the outcome.

Chua et al. (2007) had conducted a study comparing the mean absolute error of SRK/T, Holladay II, and Hoffer-Q formulas in patients with axial lengths >25 mm and concluded that the SRK/T (0.18 D) formula may be more accurate than Hoffer-Q (0.58 D) and Holladay II (0.75 D) for eyes with axial lengths greater than 25 mm.

This is even more so in eyes with axial lengths greater than 27 mm although there is a tendency toward more hyperopic surprises.

Holladay I formula came in the second place with respect to the postoperative mean error after the SRK/T and this is nearly the same findings reported by CSL Tsang et al. (2003) who conducted a study on Chinese patients with high axial myopia and found that Holladay and SRK/T formulas gave comparable results.

The present study found that Haigis formula came in the third place regarding the accuracy of calculation and unfortunately there were few published studies which had used Haigis formula in IOL power calculation for high axial myopia till this study have been carried out.

Olsen (2006) found that there is an improvement in IOL power calculation with the use of five-variables ACD prediction method rather than the use of two-variable method described by Haigis, which, if incorporated in the formula may give better outcome.

Ganesh et al. (2004) compared the accuracy of IOL power calculation in high myopes using Haigis and SRK II formula and inferred that the Haigis formula was very effective in eyes with axial length ranging from 25 to 32 mm.

However, in their study the use of the SRK II compared with the Haigis formula did not give a clear vision about the accuracy of the Haigis formula as all the recent studies had reached a fact that the SRK II formula does not give accurate prediction for IOL power to be implanted in high axial myopia.

In the present study, the range of the mean error was as much as +2.9, +3.0, +2.5 on the hyperopic side and −1.4, −1.4, −1.9 on the myopic side by the SRK/T, Haigis, Holladay I formula respectively.

The error seems to originate from the measurement itself with some sort of difficulty to locate the accurate position of the fovea with the presence of the posterior staphyloma in two cases.

The SRK/T and Haigis formulas had a tendency to over minus the power of the IOL to be implanted specially in group II resulting in postoperative hyperopia, while Holladay formula tend to over plus the power of the IOL implanted which result in a postoperative myopia.

The SRK/T formula was the most accurate among the used formulas with the smallest postoperative mean error, however, there was not statistically significant difference between the three formulas used in the study.

In conclusion, the calculation of IOL power in patients with high axial myopia using the third or the fourth generation formulas help in improvement of the accuracy of the calculation and decreasing the post operative refractive error. SRK/T formula showed the lowest mean error, however, there was not statistically significant difference between the three formulas used, neither in the overall performance, nor in axial length subcategories.

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