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COMPARATIVE STUDY OF SRK/T, HOLLADAY I, OLSEN AND BARRETS UNIVERSAL II IOL POWER CALCULATION FORMULAE FOR PATIENTS OF SENILE CATARACT WITH AXIAL MYOPIA

Ophthalmology

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ABSTRACT

Purpose: To compare the accuracy of SRK/T, Holladay I, Olsen and Barrets Universal II IOL power calculation formulae in patients of senile cataract with axial myopia..

Methods: A prospective clinical study was carried out on 50 eyes of 35 patients with an axial length from 24.5 to 31.87 mm including 21 (60%) males and 14(40%) females. Calculation of the IOL power to be implanted was done by SRK/T, Holladay I, Olsen and Barrets Universal II formulae. Mean error 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 errors of the four formulae used (p value 0.996). In patients with axial length > 26 mm, SRK/T formula showed least mean error (0.26 ± 0.60) but with a statistically insignificant difference (p value 0.854).

Conclusion: Cataract surgery in high myopes is challenging. 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.

KEYWORDS

myopia , cataract, mean error, IOL power calculation formulae.

INTRODUCTION:

Patients with axial myopia have prevalence of lens opacities and develop cataract at an earlier age than emmetropes.[1]

Intra-ocular lens (IOL) power calculation poses difficulties for cataract surgeon planning surgery in such eyes.[2,3] 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.[4] In patients with posterior staphyloma, ultrasound techniques can produce a falsely longer axial length as a result of eccentric measurements to the depth of staphyloma , rather than to the fovea in contrast to interferometry [Lenstar (LS900 Haag-Streit AG, USA)] which measures the distance from the corneal vertex to the retinal pigment epithelium .So, determining the power of the intra-ocular lens to be implanted is a crucial factor in postoperative refractive status and visual acuity.[5]

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.[6,7]

This work was amalgamated in 1980 and yielded the Sanders Retzlaff Kraff I (SRK-I) formula.[8]

The second generation formulae were designed by combining linear regression analysis and stepwise adjustment for long and short eyes according to anterior chamber depth.[9,10]

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.[11, 12] However most of these IOL power calculation formulae are useful for axial length between 22mm - 24.5 mm but are less accurate for axial length outside this range. Recently two new formulas have been introduced i.e. Barretts Universal II formula and Olsen's formula to improve the accuracy of IOL power calculation in myopic eyes.

This study is being conducted to evaluate the accuracy of SRK/T, Holladay I, Olsen's and Baretts Universal II formula in patients with axial myopia undergoing cataract surgery.

AIMS AND OBJECTIVES:

To compare the accuracy of SRK/T, Holladay I, Olsen and Barrets Universal II IOL power calculation formulae in patients of senile cataract with axial myopia.

MATERIAL AND METHODS :

This prospective observational study was conducted on patients admitted to ophthalmology ward of tertiary care hospital for cataract surgery between October 2016 to October 2017 diagnosed to have axial myopia.

50 eyes of 35 patients were studied.

Both male and females patients with senile cataract diagnosed to have axial length > 24.5 mm calculated by Lenstar (LS900 Haag-Streit AG, Switzerland) were included in study while those having traumatic cataract, corneal scars/post-keratitis or any other corneal opacities, keratometry values <40 and >47, those undergoing combined cataract and glaucoma surgery and those with history of any previous ocular/refractive surgeries or posterior segment surgery with silicone oil implantation and those with eventful cataract surgery were excluded from the study.

Patients fulfilling the inclusion criteria were prospectively enrolled in this study. Thorough assessment of selected patients was done with a detailed history, general & comprehensive ocular examination.

Pre-operative assessment included visual acuity testing by Snellens chart, non-contact tonometry, slit lamp evaluation, fundus examination with +90 D lens and indirect ophthalmoscopy, keratometry (manual/automated) and refraction. Axial length measurement and IOL power calculation was done by SRK/T, Holladay I, Olsen and Barrets Universal II IOL power calculation formulae using Lenstar (LS900 Haag-Streit AG, Switzerland).

All patients underwent clear corneal phacoemulsification with foldable posterior chamber IOL implantation by a single trained surgeon.

Post-operative evaluation included visual acuity testing by Snellen's chart and refraction, slit lamp biomicroscopy and fundus examination with +90D lens and indirect ophthalmoscopy.

Patients were followed up on post operative day 1 and at 4 weeks and mean error was calculated by difference between formula predicted refraction and actual refraction at the end of 1 month. ($p < 0.05$ was considered significant).

Statistical analysis was done using SPSS software (version 17.0, SPSS, Inc., Chicago, IL, USA) and comparison between the mean error of all four formulae was done by Kruskal-Wallis test.

RESULTS :

This study was carried out on 50 eyes of 35 patients with an axial length >24.5 mm, including 21 males (60%) and 14 females (40 %) with their age ranging from 58 to 74 years (mean 66.44± 3.967). (Table1).

Table 1 : Demographic data.

Patients total number	
Males (No./percentage) Females (No./percentage	21 (60 %) 14 (40%)
Age (years)	66.44± 3.967
Minimum age (years) Maximum age (years)	58 74

The mean K of the studied eyes was (44.25 ± 1.28) with a minimum of 41.50 D and a maximum of 46.50 D. The mean axial length was 25.78 ± 1.34 mm, with a minimum of 24.51 mm and a maximum of 31.87 mm. Posterior staphyloma was found in 3 eyes not involving fovea.

All formulae tended to cause a hyperopic refractive error postoperatively which was comparable. The Olsen formula caused the smallest mean error (+0.26 ± 0.52 D) compared to SRK/T (0.28 ± 0.60), Holladay I (0.29 ± 0.56) and Barrets Universal II formulae (0.30 ± 0.55) but no statistically significant difference was observed in the mean errors of the four formulas used (p value 0.996). In a subset of patients with axial length > 26 mm (15 eyes), SRK/T showed least mean error (0.26 ± 0.60) compared to Holladay I (0.52 ± 0.49), Olsen (0.40 ± 0.45) and Barrets Universal II formulae (0.41 ± 0.45), however difference in the mean errors of these formulae was not statistically significant (p value 0.854).

Table 2: Mean error of formulae. (all patients)

IOL calculation formula	No of eyes	Mean error ± SD	P value
SRK/T	50	0.28 ± 0.60	0.996
Holladay	50	0.29 ± 0.56	
Olsen	50	0.26 ± 0.52	
Barratts	50	0.30 ± 0.55	

Table 3: Mean error of formulae: (axial length >26 mm)

IOL calculation formula	No of eyes	Mean error ± SD	P value
SRK/T	15	0.26 ± 0.60	0.836
Holladay	15	0.52 ± 0.49	
Olsen	15	0.40 ± 0.45	
Barratts	15	0.41 ± 0.45	

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.

Other fourth-generation formulas include the Holladay II, Barretts Universal II, and Olsen. These formulas take into account other variables. The Holladay 2 formula uses seven variables: axial length, keratometry, ACD, white to white, lens thickness, preoperative refraction and patient's age. The Olsen formula uses five variables: axial length, ACD, keratometry, lens thickness, and patient's age. The Barretts Universal II formula accounts for the varying principal planes among different-powered IOLs. The ACD and a lens factor related to the physical position and the location of the principal planes of the IOL is used in the calculation of ELP. Barretts Universal II recognizes the negative vergence, in the negative-power IOL, in calculating the ELP and takes into account the change in principal planes when moving from a low-positive meniscus IOL to a negative IOL.

Hoffer [13] examined the mean absolute error in 317 eyes using the SRK/T, Holladay I, Holladay II, and Hoffer-Q formulas and found that SRK/T formula showed a trend towards the lowest mean absolute error in medium long (24.5–26.0 mm) and very long (>26.0 mm) eyes.

Zaldivar et al.[14] 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. They concluded that in eyes with axial length longer than 27 mm current third and fourth generation lens calculation formulae tend to over minus patients between -1 and -4 spherical equivalent leaving the patients with postoperative hyperopia.

Narvaez et al.[15] compared the accuracy of intra-ocular lens power calculations using SRK/T, Holladay I, Holladay II, and Hoffer-Q formulas in 643 eyes and found no significant difference in the accuracy of the four formulas. However, this study used two different IOLs types which may have affected the outcome.

Chua et al.[16], in their study comparing the mean absolute error of SRK/T, Holladay II and Hoffer-Q formulae in patients with axial lengths >25 mm, 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) formulae for eyes with axial lengths greater than 25 mm.

In the present study, all the four IOL power calculation formulae showed a tendency towards hyperopic refractive error post-operatively which was comparable. The Olsen formula caused the smallest mean error (+0.26 ± 0.52 D) compared to SRK/T (0.28 ± 0.60), Holladay I (0.29 ± 0.56) and Barrets Universal II formulae (0.30 ± 0.55) and no statistically significant difference was observed in the mean error of the four formulas used (p value 0.996).

Similar to studies by Hoffer et al.[13], Zaldivar et al. [14] and Chua et al. [16], in our study, SRK/T showed the least mean error (0.26 ± 0.60) compared to Holladay I (0.52 ± 0.49), Olsen (0.40±0.45) and Barrets Universal II formulae (0.41±0.45) in a subset of patients with axial length > 26 mm, however with a statistically insignificant difference (p value 0.854).

Yichi Zhang et al. [17], in their study of 219 patients found that Barretts Universal II formula produced the lowest and least variable predictive error compared with the SRK/T, Haigis, Holladay I, and Hoffer Q formulas and concluded that Barretts Universal II formula may be a more suitable choice in high myopic eyes.

Chong E.W. , Mehta J.S. [18], in their study found improved predictive results with the Barretts Universal II (software constants), Haigis (ULIB), SRK/T, Holladay 2 (software constants) and Olsen (software constants) formulae in eyes with axial lengths greater than 26.0 mm and IOL powers greater than 6.0 D. They recommended that in eyes with axial lengths greater than 26.0 mm and IOL less than 6.0 D, the Barretts Universal II formula (software constants) and the Haigis (axial length adjusted) and Holladay I formula (axial length-adjusted) should be used.

In our study, in 3 eyes with axial length greater than 26.0 mm and IOL power less than 6.0 D, no statistically significant difference was noted between Barrets Universal II formula and other IOL power calculation formulae (p value 0.959).

CONCLUSION:

To conclude, cataract surgery in myopes is challenging. To meet the patient's expectation following cataract surgery, adequate counselling and preoperative planning and choice of appropriate IOL power is important. Calculation of IOL power in patients with high axial myopia using the third or the fourth generation formulae help in improvement of the accuracy of the calculation and decreasing the post operative refractive error.

In our study, all four formulae showed a hyperopic refractive error with no statistically significant difference between mean errors of the four formulae used. However the sample size used in our study was small and we recommend further studies to evaluate the performance of these IOL power calculation formulae with larger sample size.

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