Original Article

Comparison of Biometric Formulae for Intra Ocular Lens Power Calculation

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ABSTRACT

Purpose: To determine the accuracy of different biometric formulae for intraocular lens power (IOL) calculation in predicting a target postoperative refraction within ± 1.0 diopters in patients with long axial length undergoing phacoemulsification.

Study Design: Cross sectional study.

Place and Duration of Study: Department of Ophthalmology and visual sciences, Unit 1 Dow University of Health Sciences, Dr. Ruth KM Phau Civil Hospital Karachi from February 2019 to August 2019.

Methods: The study included 45 eyes with cataract and preoperative uncorrected visual acuity ranging from 6/60-6/12, axial length of 24.5 to 27.0 mm with no other ocular problem. IOL power was calculated with SRK-T, Holladay 1 and Haigis formula installed in optical biometer AL-Scan (Nidek Co, Ltd., Gamagori, Japan) and by Barrett universal 2 formula from http://www.apacrs.org/barrett_universal2/. Patients underwent phacoemulsification by single surgeon. Follow up included refractive status usingAutorefracto-keratometer,URK-700 (Unicos Co., Ltd., Korea) at 6th week post-operatively. Deviation of actual postoperative refraction from the predicted target preoperative refraction were calculated and values within ± 1.0 diopter were considered accurate. Data was analyzed using SPSS version 22.

Results: Outcome in terms of postoperative refractive error (+1D to -1D) with respect to biometric formula showed 100% accuracy using Haigis formula, 90% accuracy using SRK-T formula, 72.72% accuracy using Barrett universal II formula and 66.67% accuracy using Holladay-1 formula.

Conclusion: Haigis formula proved to be more reliable and accurate than SRK-T, Holladay 1 and Barrett universal II formulae for calculation of intraocular lens power in eyes with long axial length.

Key Words: Biometry, Intraocular Lens Power, Refraction, Axial Length.

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INTRODUCTION

Cataract surgery is by far the most common and one of the most successful of all surgeries in the field of medicine.[1] Cataract is the major cause of preventable blindness worldwide, accounting for approximately 65.2 million.[2,3] In Pakistan, approximately 570,000 persons are blind from cataract.[4] There may be debilitating problems like decreased contrast sensitivity and colour vision. However, some patients complain of glare making driving difficult especially at night.[5] The importance of early detection and timely intervention to save useful vision should be on priority and the main aim of cataract surgery is to achieve near normal vision and patient's satisfaction is based on postoperative refractive outcome. Appropriate

measures are taken before surgery to achieve satisfactory results.[6] One of the most crucial step is calculation of intraocular lens power, which is done by using biometric formula.

Harold Ridley was the first ophthalmic surgeon to invent and place IOL for aphakic correction.[7] In 1967, first phacoemulsification was done on human eye after years of experiments on animals by Dr. Charles Kelman.[8] After the first ultrasound A-scan accessibility in early 1970s, multiple studies were done and it resulted in evolution of the first theoretical and empirical intraocular lens power calculation formula, which was invented by Fyodorov and Kolinko. In 1995, the Food and Drug Administration suggested the term "effective lens position" to define lens position in the eye.

Axial length, K readings, radius of curvature of cornea and IOL position along with visual axis/ effective lens position (ELP) and Anterior chamber depth were required parameters, where refractive powers are in diopters and distances are in millimeters. ELP is the only variable that could not be estimated preoperatively. ELP is an important element because the improvement in predicting ELP results in more accurate biometric formulae developed in the past three decades. It is estimated that if IOL is displaced 0.5 mm from the estimated ELP, it will result in 1 diopter of postoperative refractive error.

With advancement in surgical techniques, devices and medical technology, cataract surgery and its pre-requisites like IOL power calculation have greatly improved and achieved accuracy using new optical biometry system. The calculation of IOL power in highly myopic eyes often leads to postoperative refractive surprise, particularly rendering patients to be hyperope. Optical methods utilize partial coherence interferometry (PCl) for axial length estimation.[9,10] It is a non-contact technique that uses diode laser infrared light at a wavelength of 830 nm. It has minimum chances of inaccurate axial length estimation due to the fact that the infrared light from PCl is reflected from retinal pigment epithelial layer in contrast to the sound waves used in a scan ultrasonography, which are reflected from internal limiting membrane. This method has now become a usual choice for IOL calculation. The optical biometry is more helpful in cases of extreme axial myopia or hyperopia and also in cases of silicon filled eyes. For unusual length of eyes, i.e. short eyes (less than 22.5 mm) and long eyes (greater than 24.5 mm), the predicted ELP is not accurate due to the reason that the anterior and posterior segments are not proportional in size. This results in underestimating or overestimating ELP. To overcome this issue, several other measures may be taken for predicting ELP, i.e. axial length, keratometry, horizontal corneal diameter, ACD, lens thickness, preoperative refraction and age.

There are certain limitations to get desired postoperative refractive outcome because of inability to predict accurate ELP. Despite all the advancements in IOL power calculation, the limitations were found to be postoperative capsular shrinkage, different calibration and varying operative techniques of individual surgeons. Therefore, more advanced fourth generation formulae were created. Most of these are modified versions of the previous generation's formulae. These include Haigis, Holladay 2 and Barrett universal II.

Formula choice is an important step before proceeding towards surgery. No single biometric formula is appropriate for all eyes regardless of any axial length. Different studies have been done to compare the efficacy of different biometric formulae for different patient groups including short, average and long axial length eyes. One detailed study compared accuracy of 3 formulae: Hoffer Q, Holladay 1, and SRK/T formulas in 8108 eyes.[11] It was observed in their study that for short axial eyes, Hoffer Q worked best and SRK-T for long axial length eyes. According to other studies fourth generation formula Haigis, is accurate for both short and long axial length eyes.[11] Another study found a new formula, Kane formula to be more efficient as compared to existing formulae using IOL master for predicting actual postoperative refraction.[12]

The aim of this study was to estimate accuracy in terms of postoperative refractive prediction errors of biometric formulae i.e. SRKT, Holladay 1, Haigis and Barrett universal II for the calculation of IOL power in cases of long eyes. This study adds to the national and international evidence for using an accurate biometric formula for the IOL power calculation in eyes with long axial lengths.

METHODS

It was a cross sectional study conducted at Department of Ophthalmology and Visual Sciences, Unit 1 Dow University of Health Sciences, Dr. Ruth KM Phau Civil Hospital Karachiafter approval of synopsis from

College of Physicians and Surgeons (Ref no: CPSP/REU/OPL-2016-183-1751). Patients with cataract and long axial length who had to undergo cataract surgery were included. Cataract surgery was done by a single experienced surgeon to avoid errors of personalized surgeon factor. All patients underwent a complete ocular examination including visual acuity, tonometry, refraction, slit lamp examination, fundoscopy and necessary investigations including blood sugar levels, HBV and HCV screening, complete blood count and blood pressure. IOL power of all the patient's was calculated by SRKT, Holladay 1 and Haigis formula installed in optical biometer, Nidek AL-scan and by Barrett universal 2 formula available on http://www.apacrs.org/barrett_universal2/ .[13] All the patients were operated for cataract using phacoemulsification technique. IOL was selected depending upon two factors, first; it would give a postoperative refraction closest to zero and second was availability of required IOL. The IOL formula that calculated IOL power with the above postoperative outcome was selected. The patients were examined on the first postoperative day, first week and then followed up after 6 weeks to assess the refractive status using Autorefractor-Keratometer Unicos URK-700. Deviation of the actual postoperative refraction from the predicted target preoperative refraction was calculated and post-operative error of within ± 1.0 dioptre was considered a target. Data was entered and analysed through SPSS version 22, mean and standard deviation were calculated for all continuous variables like age and axial length. Frequency and percentage were calculated for all categorical variables like gender, preoperative visual acuity, predicted refractive error using biometric formulae, postoperative refractive status and accuracy. Effect modifiers like preoperative visual acuity and axial length were addressed through stratification. Post-stratification Chi square test was applied. p-value less than or equal to 0.05 was considered as significant.

RESULTS

Forty five eyes of 31 patients were included in this study. The mean age of the patients was 54.67±5.34 years (Table 1). Axial length distribution showed that 34 out of 45 eyes had an axial length between 24.64 mm to 26.05 mm. Mean axial length of the eyes was 25.36±0.623 mm. Preoperative visual acuity indicated that 22 out of 45 (48.9%) eyes had 6/60 and the range of visual acuity was 6/12-6/60. Most of the IOL powers were between +16.00 D to +18.00 D, with maximum and minimum IOL power of +20 D and +10 D respectively. Outcome in terms of accuracy in postoperative refractive error (+1D to -1D) showed that 82.22% (37 out of 45) eyes achieved accuracy in targeted postoperative refractive error. Outcome in terms of accuracy in postoperative refractive error (+1D to -1D) with respect to biometric formula is shown in Table 2. It shows 66.67% (6 out of 9 cases) accuracy using Holladay-1 formula, 72.72% (8 out of 11 cases) accuracy using Barrett universal II formula, 90% (18 out of 20 cases) accuracy using SRKT formula and 100% (5 out of 5 cases) accuracy using Haigis formula. All formulas predicted 100% of the eyes within ± 2D of the target refraction. Stratification analysis of the patients was performed and seen that no significant change in accuracy in postoperative refractive error was observed with respect to preoperative visual acuity and axial length.

Table 1: *Descriptive statistics of age, axial length and IOL power (n=45).*

	Minimum	Maximum	Mean
Patient Age (years)	42	60	54.67±5.34
Axial length of eye (mm)	24.53	26.61	25.36±0.623
IOL power (diopters)	+10 D	+20 D	

Table 2: *Outcome in Terms of Accuracy in Postoperative Refractive Error (+1 D to -1D) With Respect to Biometric Formula Used N=45.*

Biometric formula used	Accuracy (+1D to -1D) Yes	No	Total
SRKT	18	2	20 (90%)
Holladay-1	6	3	9 (66.67%)
Haigis	5	0	5 (100%)
Barrett universal II	8	3	11 (72.72%)
Total	37	8	45 (82.22%)

DISCUSSION

Patient satisfaction and postoperative target refraction are important for determining the success of cataract surgery. The accurate intraocular lens (IOL) power calculation is a very essential aspect to achieve desirable postoperative outcome for both the patient and the ophthalmologist.[14] Latest IOL formulae are quiet accurate in IOL power calculation, yet there is ongoing controversy about which formula gives the most accurate refractive outcome. Biometric formulae work better for eyes with normal axial lengths as

compared to the long and short axial lengths. In this study, Haigis formula was found to be the most accurate for long eyes as it achieved the highest percentages of the eyes within ± 1D of the target refraction. Bang et al, also showed similar results.[15] Faramarzi et al, showed that SRKT was found to be more accurate in getting target postoperative outcome.[16] Similarly another study by Abulafia et al, concluded that SRKT showed promising refractive outcome in long axial length eyes.[17] A comprehensive meta-analysis by Wang et al, suggested Barrett universal II as the most efficient formula for long axial length eyes.[18] In more recent studies, mixed findings and results were seen where SRKT, Haigis and Barrett universal II were found to be accurate in IOL power calculation in myopic and long eyes.[19,20]

In a local study by Anwar et al, it was shown that SRKT was better than Holladay 1 for IOL power calculation in myopic patients.[21] However, another study from Pakistan by Hannan et al, described that fourth generation formulae were equally accurate for IOL power calculation regardless of axial length.[22] Terzi indicated that in refractive lens exchange in high myopes, Haigis formula performed better than Hoffer Q and Holladay-2.[23] Our study outcomes are also similar to the published literature, however, we had small number of cases and also the follow up duration was short. In this present study, the accuracy (+/-1D) of Haigis formula was higher (100%) but it also showed that all the 4 formulas showed 100% accuracy in getting within +/-2D of postoperative refractive error but not a single biometric formula can be superior to others and further studies using larger sample size are required with multiple study centers in Pakistan to confirm the results of this study and convey better outcomes at large.

Limitation of our study is the small sample size in each group. Further multicenter studies are suggested to find further evidence.

CONCLUSION

We concluded that Haigis formula is more accurate for the calculation of IOL power for eyes with long axial lengths (24.50 mm -27.0 mm), then other biometric formula included in our study i.e. SRKT, Holladay 1 and Barrett universal II formula in terms of postoperative refractive outcome.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(IRB-1718/DUHS/Approval/2020/271).**

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Maryam Ghaffar; Consultant Ophthalmologist: *Concepts, Manuscript preparation.*

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Muhammad Adnan Shaikh; Assistant Professor: *Literature Search, Data Analysis, Manuscript Editing.*

Mehvash Hussain; Assistant Professor: *Literature Search, Data Acquisition, Data Analysis, Manuscript Preparation.*

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