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COMPARISON OF ACCURACY OF SRK T AND HOFFER Q FORMULA IN SHORT EYE BALLS

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Abstract

Background: There are many people in our society affected with cataract, belonging to several of age groups. So the power of the intra ocular lens (IOL) implanted should be accurate to avoid the post operative surprises and to ensure better vision for the patients who are undergoing cataract surgery. It is the responsibility of the eye surgeon to give better and quality treatment for the patient. To achieve optimum outcome, preoperative biometry must be accurate and an accurate IOL power formula must be used. This retrospective comparative study is a research to compare the accuracy of SRK T and HOFFER Q formula in short eyeball with axial length less than 22.00 mm by studying the post operative refraction. **Material and Methods:** Twenty patients were selected, who attended the Hospital, and who had undergone cataract surgery. 10 patients had their implanted IOL power calculated with HOFFER Q and the remaining 10 with SRK T formula. The post operative refraction was carried out after 2 weeks of surgery to get stable refraction. **Results:** Mean of absolute error is greater than 1.50 in HOFFER Q, but SRK/ T shows a mean absolute error of less than 0.50. **Conclusion:** SRK T formula yielded better results for post operative power prediction compared to HOFFER Q formula in short eyes with axial length less than 22.00 mm

Key words: SRK T formula, HOFFER Q formula, biometry in short eye ball.

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Introduction:

Cataract is one of the common diseases affecting the transparency of the crystalline lens of the eye. The treatment of cataract includes removal of the cataractous lens and implantation of a new intraocular lens instead of natural crystalline lens. To achieve maximum visual acuity after surgery, the preoperative biometry must be accurate and an accurate intraocular lens (IOL) power must be used[1]. The refractive power of the pseudophakes is final, and the patient must live with any mistake committed or be subjected to repeat operation, i.e. the removal or replacement of the IOL, with all the potential risks. Later correction in other words, can only be achieved with lens exchange or extra ocular aids like glasses, contact lenses or corneal refractive surgery. To ensure that our patients will have the optimal correction, the power of the lens to be implanted must be determined individually in every case. The development of modern ultrasonography units has made it possible to conveniently and accurately measure the axial length (AL) of the eye[2]. In the absence of ultrasonography in the past, IOL power was determined using an intelligent guess work approach. However, now various formulae have been developed to calculate the IOL power on the basis of various measurements (biometry). Ethically as well as legally guess work approach for calculating IOL power should not be employed since it is a far less accurate method and its widespread use may rapidly reveal occasional unexpected and unsatisfactory results, deviating widely from the targeted final refraction. Today we can calculate the IOL power accurately with the help of biometry and different IOL power calculating formulas. For calculating the IOL power we need the measurements such as keratometric value (K), axial length of the eye and anterior chamber depth (ACD) of the eye ball. Biometry consists of these all measurements and this information is fed into a variety of formulae for calculate IOL power. The A-scan ultrasound biometry is most commonly employed for this essential part of preoperative evaluation of cataract surgery patients.

There are mainly two methods in A-scan biometry - the contact method or applanation method and the immersion method. The contact method is accomplished by gently placing the probe on the corneal vertex and directing the sound beam through the visual axis. The immersion technique of biometry is accomplished by placing a small scleral shell between the patient's lids, filling it with saline, and immersing the probe into the fluid, being careful to avoid contact with cornea.

Common errors and challenging situations are - Corneal compression with contact technique, Misalignment of the probe placing on the cornea, fluid meniscus between the probe tip and the cornea caused from ointment use etc. Dense cataract can be a challenge because of absorption of the sound beam as it passes through the lens. Posterior staphylomas are among the greatest biometry challenges. Macular retinal detachments could also be a cause. So care must be taken to avoid errors and in case of challenging situations while doing biometry. The keratometric reading needed for calculating the IOL power can be measured with the help of keratometer. Manual and automatic keratometers are available now a days to measure the K value. IOL master is a combined biometric instrument that measures quickly and precisely parameters of human eye needed for IOL power calculation by a non-contact technique. It also incorporates the software to calculate the IOL power from various formulae[3]. In this the axial length measurement is based on the principle of interferometry, corneal curvature is determined on the principle of reflection. The ACD and white to white also can be measured with IOL master. On the basis of their deviation IOL power formulae are grouped into theoretical formulae and regression formulae. The theoretical formulae were derived from the geometric optics as applied to the schematic eyes, using theoretical constants. It is based on three variables the axial length of the eye ball, K reading and the estimated post operative anterior chamber depth (ACD). The regression formulae were developed to overcome the drawbacks of theoretical formulae. The regression formulae are based on regression analysis of the actual post operative results of implant power as a function of variables of corneal power and axial length (AL)[4].

Based on the time when they were evolved, the IOL power calculation formula have been grouped into various generations - First generation formulae, Second generation formulae, Third generation formulae, Fourth generation formulae

<u>The first generation theoretical formulae:</u>

1. **BINKHORST FORMULA**
   P=1336(4r-a)/ (a-d) (4r-d)
   P=IOL power in diopters, R= Corneal radius in mm (average), a=AL in mm, d=post operative ACD+ Corneal thickness
2. **COLENBRANDER-HOFFER FORMULA**
   p= 1336 / a-d-0.05 –1336/ (1336/K)-d-0.05
   K-average keratometry in diopters
3. **CLAYMAN'S FORMULA**
   Assume; Emmetropizing IOL=18D, Emmetropic AL=24mm, Emmetropic average K reading =42.0D, 1mm in AL=3D of IOL power, 1D in keratometry= 1D of IOL power, If IOL power >21 D, deduct 0 .25 for every diopter
4. **FYODOROV FORMULA**
   P= 1336-LK/ (L-C) – (CK/1336)

P=IOL power, L= AL in mm, K=corneal curvature in D, C=estimated post op ACD

There are many draw backs to these theoretical formulae:

Failed in long eyes and short eyes (reliable for eyes with AL between 22mm&24.5mm)

Cumbersome to apply without assistance of a calculator or a computer

Requires guess about the ACD

To overcome the draw backs of theoretical formulae, various regression formulae have been developed. They are:

- **SRK 1 formula**

P = A – 2.5L – 0.9K

P=IOL power, A=Constant specific for each eye, L=Axial length in mm, K=Average keratometry in D (Postoperative ACD is replaced by A constant), A constant varies from 113-119

<u>Second generation formulae</u>

1. Theoretical formula

Modified Binkhorst formula

Binkhorst in 1981 improved the prediction of effective lens position by using a single variable predictor, the AL, as a scaling factor for effective lens position & presented a formula to better predict ACD.

2. Regression formula

SRK-II

The basic equation of the formula is the same

P = A-2.5L – 0.9K

The A constant is modified on the basis of the AL.

- If L is <20mm :A+3.0
- If L is 20- 20.99 mm :A+2
- If L is 21-21.99 mm : A+1
- If L is 22-24.5 mm : A
- If L is >24.5 mm: A-0.5

Modified SRK –II formula

In this formula, based on the axial length, A constant is modified as

- If L is < 20mm : A +1.5
- If L is 20 – 21mm : A +1
- If L is 21 – 22mm : A + 0.50
- If L is 22 – 24.5mm : A
- If L is 24.5 – 26mm : A – 1.00
- if L is > 26mm : A - 1.50

<u>Third generation formulae</u>

Most of these are a hybrid of both theoretical and regression formulae. The third generation formulae include:-

1. **Holladay- 1 formula**

   In 1998, Holladay proved that the use of two variable predictors (AL and KR) could significantly improve the predictor of effective lens position.

   Proposed formulae based on the geometric relation of the anterior segment (third generation theoretical formula)

   The formula was modified and now the Holladay 1 formula

2. **Hoffer Q formula**

   Theoretical formula optimized with regression techniques for ACD.

   Modification of Cole brander –Hoffer formula

$$P = \frac{1336}{L - C - 0.05} - \frac{1336}{\frac{1336}{K+R} - \frac{C+0.05}{1000}}$$

<u>Fourth generation formulae</u>

1. **Holladay –II**

   Considered more accurate

   Software programmers are available in the modern biometers to use the Holladay formulae

2. **Haigis formula**

Haigis formula is a recent addition in the list of IOL power calculating formulae. In 1991, the Haigis formula evolved as one of two fourth-generation formulas in order to overcome these shortcomings. The Haigis formula does not depend on assumptions for the ACD and requires real measurement of it. In addition, the Haigis formula does not have just one "a constant" but three (a_0, a_1, a_2) derived by multi-variable regression analysis.

a_0 constant moves the power prediction curve up or down

a_1 constant is tied to the measured anterior chamber depth

a_2 constant is tied to the measured axial length

3. **SRK/T formula**

It is a non linear theoretical optical formula, empirically optimized for postoperative ACD, retinal thickness, and corneal refractive index. It has the advantage of both theoretical and empirical analysis.

A-constant

The A-constant was originally designed for the SRK equation and depends on multiple variables including IOL manufacturer, style and placement within the eye. Because of its simplicity, the A-constant became the value used to characterize intraocular implants.

A-constants are used directly in SRK II and SRK/T formulas. The constant is a theoretical value that relates the lens power to AL and keratometry; it is not expressed in units and is specific to the design of the IOL and its intended location and orientation within the eye.

Using A-constants is practical when a decision on the implant power has to be made during surgery because the power of the lens varies in a 1:1 relationship with the A-constants: if A decreases by 1 diopter, IOL power decreases by 1 diopter also. This straight relationship adds to the simplicity and popularity of the A-constant. Other constants used in modern IOL formulas include the ACD value in Binkhorst and Hoffer-Q formulas and the Surgeon factor (SF) in Holladay formulas. True anterior chamber depth (ACD) is measured between the posterior corneal surface and the anterior lens surface. This measure is not to be confused with the anterior chamber constant (ACD constant) used in IOL power calculation formulas. There are many people in our society affected with cataract, belonging to several of age groups. So the power of the IOL implanted should be accurate to avoid the post operative surprises and to ensure better vision for the patients who are undergoing cataract surgery. It is the responsibility of the eye surgeon to give better and quality treatment for the patient.

To achieve optimum outcome, preoperative biometry must be accurate and an accurate IOL power formula must be used.

This retrospective comparative study is a research to compare the accuracy of SRK T and HOFFER Q formula in short eyeball with axial length less than 22.00 mm by studying the post operative refraction.

Material and method:

This retrospective study was carried out at Department of Ophthalmology, MES Medical College, Perinthalmanna, in association with Al Salama group of Eye Hospitals, Kerala, during January 2013 to June 2013. Institutional ethics committee approval was obtained. Informed consent was taken according to Helsinki declaration. In our attempt to compare the predictive accuracy of SRK T and HOFFER Q formula in short eye balls, we analyzed the data by dividing into two groups, SRK T & HOFFER Q. We compared them mainly in terms of spherical equivalent (SE) and absolute error (AE) and prediction error (PE). The spherical equivalent (SE) is the value obtained by adding half of the cylindrical component of the refraction to the spherical component of the refraction. The absolute error is the absolute value obtained by subtracting the predicted spherical equivalent from postoperative SE, whereas the predicted error (PE) also gives the resulting direction of the refractive error in the form of sign of difference of the two. A negative PE indicates a tendency for myopic shift and positive PE was an indicator of hyperopic shift. The refractive error was determined with Topcon autorefractor and with subjective refraction. The keratometer reading was taken with manual keratometer. The measurement of axial length and ACD were determined by contact method using Biomedix ultrasound biometer (figure 1). For contact A-scan, the probe was placed gently over the cornea and an automated sequence of reliable readings with characteristic peaks was taken.

Unreliable readings were discarded and the mean was recorded (figure 2).

Figure 1

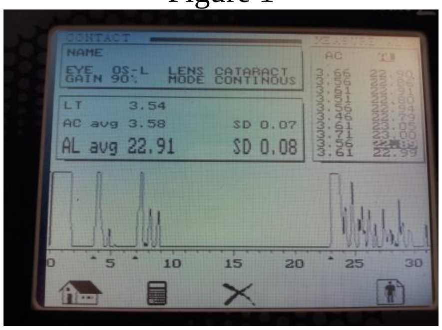

Figure 2

The inclusion criteria were: Patients who had undergone IOL implantation , IOL power calculated either with HOFFER Q or with SRK/T formula, Axial length less than 22.mm, Cases whose post operative refraction details were available, Age more than 40 years , Patients with better post operative visual acuity. The exclusion criteria were: Patients in whom IOL power was calculated with other formulas, Patients with history of corneal abnormality to avoid high cylindrical correction, Patients who underwent extra capsular cataract extraction (ECCE), Patients with a history of silicone oil filled eye, Age below 40 years, Patients unable to maintain fixation during measurement, Patients with incomplete post operative data and refraction details, Patients with per operative complications. 20 patients were selected, who attended the Hospital, and who had undergone cataract surgery. 10 patients had their implanted IOL power calculated with HOFFER Q and the remaining 10 with SRK T formula. The post operative refraction was carried out after 2 weeks of surgery to get stable refraction. Complete clinical history was taken from case sheets and electronic medical records. History of previous cataract surgery was also noted. All patients underwent a complete eye examination including visual acuity (pre operative and post operative), intraocular pressure by non contact tonometry, slit lamp examination and dilated fundus examination, biometry for IOL power calculation including keratometry measurement. Postoperative refraction was done after 2 weeks of surgery and the spherical equivalent (SE) of post operative refraction was taken. All measurements were executed by the same person. The data was then analyzed using appropriate statistical techniques. Mean, Median, Range, Standard deviation, and tests of significance were applied.

Results:

Out of the 20 patients recruited, 18 were females and 2 males. The mean of actual post operative spherical equivalent (prediction error) in SRK T group was 0.045 and that of Hoffer Q group was 1.502 (table 1). Even though the predicted SE of HOFFER Q was in the myopic range, the actual postoperative refraction showed the hyperopic shift . There was no significant change in post operative refraction SE and predicted SE in SRK T group (table 3). There was high absolute error of upto 2.17 in case of HOFFER Q whereas SRK T has an absolute error upto 0.56 (table 2). Mean of absolute error was 1.502 in HOFFER Q, but SRK/ T showed a mean absolute error of 0.347. The p value for discrepancy in IOL power predictability using SRK T and HOFFER Q in terms of post op SE was < 0.001, which was statistically significant. The p value for discrepancy in IOL power predictability using SRK T and HOFFER Q in terms of absolute error was < 0.001, which was statistically significant (table 4**)**

Table 1:Prediction error in HOFFER Q and SRK T

SL.NO.	Prediction error of SRK T	Prediction error of HOFFER Q
1	0.07	1.91
2	-0.02	1.76
3	-0.31	2.17
4	0.32	0.94
5	0.02	1.55
6	-0.5	1.47
7	-0.18	1.2
8	0.24	1.31
9	0.25	1.8
10	0.56	0.91
MEAN PE OF SRK T-0.045, MEAN PE OF HOFFER Q-1.502		

Table 2: Comparison of Absolute errors in HOFFER Q & SRK T

SL NO	Absolute error (SRK T)	Absolute error (HOFFER Q)
1	0.07	1.91
2	0.02	1.76
3	0.31	2.17
4	0.32	0.94
5	0.02	1.55
6	0.5	1.47
7	0.18	1.2
8	0.24	1.31
9	0.25	1.8
10	0.56	0.91

Table 3: Statistical distribution post op SE of HOFFER Q and SRK T formula

SL NO	VARIABLES	HOFFER Q	SRK T
1	MEAN	0.775	0.175
2	SD	0.614	0.294
3	MEDIAN	1	0
4	RANGE	I.75	1
5	P VALUE	0.00084	-

Table 4: Statistical distribution of Absolute Error in HOFFER Q and SRK T

SL NO	VARIABLES	ABSOLUTE ERROR IN HOFFER Q	ABSOLUTE ERROR IN SRK T
1	MEAN	1.502	0.347
2	SD	0.387	0.185
3	MEDIAN	1.51	0.215
4	MAXIMUM	2.17	0.56
5	MINIMUM	0.91	0.02
6	RANGE	1.23	0.54
7	P VALUE	0.00018	

Discussion

IOL power formulas are known to vary in their prediction accuracy. In the SRK T based IOL group, the mean axial length was 21.502 mm and ranged from 20.88 mm to 21.87 mm. The standard deviation of axial length was +_0.31mm.The uncorrected visual acuity of this group ranged from 6/12 p to 6/6. Four patients had myopic shift and rest six had hyperopic shift according to the predicted error. The PE showed myopic shift (up to -0.75 D) and hyperopic shift (up to 0.56). The mean prediction error was 0.045. Our findings are consistent with Roh Y[5], Basu S[6] and Day A[7].

In HOFFER Q based IOL group, the mean axial length was 21.651 mm and ranged from 20.72mm to 21.96mm. The standard deviation of axial length was +_ 0.428 mm. The post operative uncorrected visual acuity ranged from 6/18p to 6/6. All patients had hyperopic shift (2.17) according to the predicted error. The mean prediction error was 1.502. The mean SE of this group was 0.775. Similar observations were made by Narváez J [8] and Aristodemou[9].

Because a given measurement error is a large portion of the AL in a short eye, any measurement error in axial length of a short eye would have a larger effect on final refractive error. Compression of the eye is believed to be part of the cause of AL shortening error, and this result still occurs even with experienced operators, although to a lesser degree. The correlation coefficient for AL and postoperative SE was 0.0576 and the correlation coefficient for axial length and post operative absolute error was 0.1657, showing no significant correlation.

The mean absolute error (MAE) is often used as an indicator for the IOL formula prediction accuracy. The MAE showed that SRK T (0.347) formula was more accurate than that of the HOFFER Q (1.502). The proportion of AE less than 0.50D was greatest in the SRK T formula (90%) and in HOFFER Q it was 0%. The proportion of AE less than 1D was 100% in SRK T and 20% in HOFFER Q. While comparing the post operative mean SE of both SRK T and HOFFER Q, the SRK T shows SE of 0.175 and HOFFER Q shows SE of 0.775. The p values for discrepancy in IOL power predictability using SRK T and HOFFER Q formulae were statistically significant both in terms of the absolute error and the spherical equivalent, the $p<0.001$ (Mann Whitney U test) and $p<0.001$ (Student t test) respectively. Similar results were noted by Sheard R[10]. The retrospective nature, relatively small sample number, different IOL types and IOL constants which did not consider surgeon factors were limitations in the present study. Nevertheless, the present study showed the results of IOL power prediction in short eye balls using the A-scan ultrasound biometry and the SRK T formula was more precise than Hoffer Q formula.

Conclusion:

In IOL power calculation using the A-scan ultrasound biometry, the SRK T formula yielded better results for post operative power prediction compared to HOFFER Q formula in short eyes with axial length less than 22.00 mm according to our study. Further, there is a need for large scale prospective studies to assess the predictive accuracy of SRK T and HOFFER Q formula.

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