Original article:

Efficacy of SRK-T ,Holladay 1 and Hoffer Q Iol Formula Calculations in Ammetropes after Phacoemulsification

Dr Easha Ramawat*, Dr Subhash Sharma**, Dr Swati Tomar **,Dr Arjun Gupta*

*Resident, **Professor, Department of Ophthalmology, NIMS University, Jaipur, 303121, India

Corresponding author – Dr Easha Ramawat

Abstract

Background: To compare the efficacy of third generation IOL calculation formula SRK T ,Holladay1 and Hoffer-Q in eyes with axial length <22mm (short eyes),22-24.5 mm(normal eyes) and >24.5mm(long eyes).In addition, to compare the curvatural ametropia in these patients and relationship between corneal diopteric power and axial length.

Materials and Methods: 225 eyes were divided into three groups according to axial length after which it was subdivided into 3 groups with 25 patients each, where in SRKT, Holladay1 and Hoffer-Q formulae were used in each group respectively.

Results: Least correction (0.447) was required in long eyes when SRK T formula was used followed by, Hoffer-Q (0.525) and then Holladay1 formula (0.609). In normal eyes least correction (0.404) was required when Holladay1 formula was used, followed by Hoffer-Q (0.466) and then SRKT formula (0.533). In short eyes least correction (0.428) was required when SRK T formula was used followed by Holladay1 (0.433) and then Hoffer-Q formula (0.501).

Conclusion: SRKT & Hoffer-Q scores were significantly lower (p<0.05) than Holladay1 with respect to the difference in UCVA & BCVA, Log MAR in Long Eye group. SRKT was lower than Hoffer-Q, however this difference was not statistically significant. In normal & short eye groups, none of the formulae showed statistically significant difference with each other with respect to difference in UCVA & BCVA Log MAR. However, Holladay1 in normal eye group and SRKT in short eye group showed best results.

Keywords: SRK T, Holladay1, Hoffer-Q, Phacoemulsification

Introduction

In modern day ophthalmic practice the buzz word seems to be precision. Precision with a view to achieving perfection and one the greatest challenges to this quest is the restoration of normal or near normal vision after cataract surgery. This could only be possible if we had the ability to predict the power of the IOL with an unprecedented degree of accuracy. But thirty years ago, before 1980s, IOL power calculations could be at best described as educated guesses based primarily and solely on the patient's previous refractive status before the onset of cataractous changes. If the patient was an emmetrope before the onset of cataractous changes then he received an 'Idem lens' "Cataract", is the leading cause of blindness in our country (70% cases). Surgical management by means of SICS and Phacoemulsification with implantation of IOLS in capsular bag is the established mode of management in developing countries.

"Aphakia" is the first and the most common after cataract operation, as stated by Theodore.[1] The problems of image magnification, aneiseikonia, spherical aberration, ring scotoma, the jack in box phenomenon, various degree of tolerance to contact lenses, are well known to ophthalmologist. [2,3,4]To

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overcome this problem IOL'S are routinely implanted throughout the world nowadays.The IOL material which are widely used and show good tolerance in the eye are PMMA (Polymethyl Methacrylate), Polypropylene, Polyamide, Silicon and Polyhydroxyethylmethacrylate. Different types of IOL'S show different properties in terms of The IDEM Lens

The IDEM lens or the "ideal emmetropia lens", was that IOL power which when implanted within the eye restored emmetropic status after cataract surgery. The power of this lens was mathematically deduced to be +17.0 D for an AC lens, +19.0D for an iris fixated lens and +21.0D for a posterior chamber lens.

The Standard lens Since the preferred practice pattern at that time was to make the patient myopic by about 1.0D, in order to strike a balance between distance and near vision, a "Standard Lens" was implanted. This lens had +1.25D added to the IDEM lens power, this add being the adjustment for moving the 1.0 D of myopia from the spectacle to the IOL plane.

The Emmetropia lens If the patient had previous ammetropia, he received an "Emmetropia Lens" which would effectively take care of the pre existing error and restore the patient to an emmetropic status after cataract surgery. The power of such a lens was calculated by multiplying the pre existing refractive error with a conversion factor of 1.25 and algebraically adding it on to the IDEM lens power.

Aims and Objectives

1. To test the efficacy of SRK-T, Holladay1 and Hoffer-Q formulae in IOL power calculation of high axial ametropes.

2. To study effect of curvatural ametropia on the efficacy of SRK-T, Holladay1 and Hoffer-Q formulae.

Material and Methods

Type of study – hospital based comparative analysis

Study design is longitudinal

Location of study - This study was conducted in the Department Of Ophthalmogy, NIMS Medical College & Hospital, Shobha Nagar, Jaipur. 225 patients were selected among the patients who came to the outpatient department of ophthalmology. Management, surgery, and follow up assessment for each patient was performed or supervised by one surgeon throughout the study period.

Period of study- 18 months or until desired sample size achieved (which ever earlier)

Sample size – was calculated at 80% study power and alpha (α) error of 0.05 assuming SD o 1.15D as observed in petermei K et al(ref no)

for minimum detectable difference of 1 D in efficacy,27 eyes in each group were required as SS ,it was enhanced and rounded off to 30 eyes in each group. Assuming 10% dropout /loss to follow up.

however due to time constraint of dissertation it was required 25 eyes in each group as final sample size.as present study includes 3 different sized eyes and 3 scores had to compared in each sub group total 225 eyes were presented in this study.

Statistical Analysis

null hypothesis states (H0) that there is no significant difference with respect to correction required (Efficacy) between all three formulae used in long ,short and normal eyes.

Alternate hypothesis (H1) states that there is significant difference with respect to correction required (Efficacy) between all three formulae used in long ,short and normal eyes.

Continuous variables were summarised as mean and SD ,while nominal and categorical variations as proportions (%)

Parametric tests as one way ANOVA test followed by pos hoc Turkey HSD . where as chi square test was used for analysis of nominal /categorical variables.

P value < 0.05 was taken as significant. Medcale 12.2.1.0 version software was used for all statistical calculations.

Subject Of Study

Three types of formulas for calculating the power of IOL were used in the study. The lens implanted in study were Foldable Hydrophilic Acrylic Intraocular lense,Ultima PLUS.

Patients were divided into three groups A, B & C, each having 90 patients (Total 270 Patients).

Group - A: Patients AL <21 mm

Group - B: Patients AL between 21-24 mm

Group - C: Patients AL >24 mm

Keratometry

Keratometry was done using Topcon 8900 AUTOKERATO-REFRACTOMETER.Three readings were taken in two principal meridians. Average of these three readings in each principle meridian was automatically taken by the machine to calculate median value of diopteric power of cornea.

Biometry

Ultrasonic autobiometry of eye was done to get the axial length as well as other ocular parameters, including anterior chamber depth;

Echo Scan US100 Nidek A-scan apparatus with probe diameter of 10mm and probe-frequency of 10 MHz was used for time amplitude USG. Direct contact method was used, following topical anaesthesia with paracaine eye drops,the probe is disinfected with Betadine 7% solution,followed by surgical spirit till airdryed. Where possible the patient was asked to fixate the other eye on target, in the primary position of gaze. Probe was applanated

directly on the central cornea in the direction of visual axis. Due care was taken not to indent the cornea, otherwise a false low reading may be obtained. Unusually low readings of biometry, which might be because of indentation of cornea were excluded and a average of three readings was taken as a working biometry reading.

Inclusion Criteria:

i. Age between 4-75 years

ii. Immature senile cataract (Nuclear/PSCC/Cortical Grade -3)

iii. Cataract with glaucoma controlled on medication

iv. Cataract with history of previous inflammatory disease with no sign of active inflammation.

Exclusion Criteria:

1. Proliferative diabetic retinopathy

2. Recurrent or chronic uveitis

3. Uncontrolled glaucoma

4. Corneal endothelial dystrophy

5. Previous Corneal transplant

6. Corneal opacities impairing the visualisation of the IOL

7. Patients receiving anti-inflammatory or anti-coagulant drugs

8. Patients with traumatic cataract

9. Cataract with pseudoexfoliation syndrome

10. Patients without any retinal diseases

History & Examinations

A detail pre-operative examination was done consisting of best corrected visual acuity, IOP of both eyes by Applanation Tonometry, Slit lamp biomocroscopy of anterior segment, other routine ocular examinations including assessment of pupillary dilatation, & funduscopy. B-scan ultrasonography done if required.

IOL power calculations were performed using the SRK-T, Hoffer Q, and Holladay1 ,in 90 patients

respectively.The patients were further divided in three groups

Group 1 (SRK-T)- 75 patients (25 group A, 25 group B, 25group C)

Group 2 (Holladay11)- 75 patients (25 group A,25 group B, 25group C)

IOL formulas for calculation

Group 3 (Hoffer Q)- 75 patients (25 group A,25group B, 25group C)

Information about the status of the fellow eye was also recorded. In all the patients routine investigations - BP, Blood Sugar (Fasting & Postprandial) were done before surgery.

IOL FORMULA	1 (SRK T)	2 (Holladay1)	3 (Hoffer Q)
A (AL<22 mm)	Group A1	Group A2	Group A3
B (AL 22-24mm)	Group B1	Group B2	Group B3
C (AL >24 mm)	Group C1	Group C2	Group C3

Operative Procedure

All patients undergoing Phacoemulsification with implantation of posterior chamber IOL from November 2014 to April 2015 was done in this study. All surgeries were performed by a single surgeon using the same surgical procedure. Firstly, a 2.5 mm straight scleral incision was made. After incision, a continuous curvilinear capsulorrhexis, measuring approximately 5.5 mm in diameter, was accomplished using a cystotome made from a 26 gauge needle bent at tip and Capsulotomy forceps with use of hydroxypropylmethylcellulose used as a viscoelastics during surgery. After hydrodissection, endocapsular Phacoemulsification of the nucleus and aspiration of the residual cortex were carried out. The lens capsule was inflated with HPMC, after which the IOL was placed into the capsular bag. After insertion, the viscoelastics material was thoroughly evacuated. In this series, surgeries were uneventful and the IOLs were accurately implanted

in the capsular bag. Subconjuctival gentamycin & dexamethasone (0.5cc) was given and pad & bandage applied. Patients with any posterior capsule plaque or rupture (pre-operative), IOL implantation in the sulcus and any significant macular disease were excluded from the study.

Post-Op Interpretation

Postoperatively the patients received Dexamethasone 0.1% & Moxifloxacin 0.3%, 2 hourly for the first three days followed by QID for 1months, and then BD for 15 days. Additional corticosteroids were used when required & their use was recorded.

POST OPERATIVE FOLLOW UP

Patients were followed up regularly for 2 months post-op. when final visual acuity assessment and retinoscopy was done.

At 2 month post-operative both uncorrected and corrected visual acuity was recorded. Retinoscopy and keratometry was done. Where· possible a repeat

post-operative biometry was done and post-op. anterior chamber depth was recorded.

Evaluation Of Post Operative Data

After recording the final visual acuity and the final retinoscopy, the refractive error was calculated. The spherical equivalent was calculated. The refractive error so calculated was then applied to the formula[5]:

$$E = \frac{Pe - Pc}{1.25}$$

E = Refractive error

Pe = IOL power for emmetropia

Pc = IOL power calculated and implanted.

Optimal power of IOL for emmetropia Pe, the error of power calculation Ep = Pc-Pe and surgeon specific A constant A' were calculated for each case, using the formulae[6]

Pe = 1.25 E + Pc

Ep = Pc-Pe = -1.25E

A' = Pe + 0.9 K +2.5 L

Observation and Results

The various observations of the study are as follows,

Table no.1 Distribution of patients in the group with Long Eyes (>24mm) in terms of UCVA,BCVA & difference between the two

	Formula	N	Mean	Std. Deviation	ANOVA	
					'F' Ratio	'p' value
UCVA (Log MAR)	SRKT	25	0.645	0.306	0.948	0.392
	Holladay1	25	0.730	0.253		
	Hoffer –Q	25	0.746	0.274		
BCVA (Log MAR)	SRKT	25	0.198	0.217	6.810	0.002
	Holladay1	25	0.039	0.083		
	Hoffer –Q	25	0.221	0.232		
Difference (Log MAR)	SRKT	25	0.447	0.233	7.064	0.002
	Holladay1	25	0.690	0.233		
	Hoffer –Q	25	0.525	0.234		

Table no.1 depicts least correction (0.447) is required in long eyes when SRK T formula is used followed by offer Q (0.525) and then Holladay1 formula (0.609).

When ANOVA test was applied it showed all three corrections were not alike (P=0.002)

In post hoc analyses using Turkey HSD SRK T formula was found having significantly lower correction than Holladay1 Formula (P=0.001) but not with Hoffer Q formula (P= 0.472).

Hoffer Q was also having significantly lower correction than Holladay1 formula, therefore it can be be concluded that Holladay1 formula provides significantly higher corrections than SRK T and Hoffer q formula.

Table no.2 Distribution of patients in the group with Normal Axial length (22-24.5mm) in terms of UCVA,BCVA & difference

	Formula	N	Mean	Std. Deviation	ANOVA	
					'F' Ratio	'p' value
UCVA (Log MAR)	SRKT	25	0.565	0.285	1.043	0.358
	Holladay11	25	0.649	0.204		
	Hoffer –Q	25	0.666	0.299		
BCVA (Log MAR)	SRKT	25	0.032	0.078	17.954	<0.001
	Holladay11	25	0.245	0.160		
	Hoffer –Q	25	0.200	0.145		
Difference (Log MAR)	SRKT	25	0.533	0.251	1.552	0.219
	Holladay11	25	0.404	0.223		
	Hoffer –Q	25	0.466	0.296		

Table no.2 depicts least correction (0.404) is required in normal eyes when Holladay11 formula is used followed by Hoffer Q (0.466) and then SRK T formula (0.533).

When ANOVA test was applied it showed all three corrections were alike (P=0.002)

Therefore it can be concluded that there is no significant difference with regards to correction required between the three formulae.

However Holladay1 is providing least correction.

Table no.3 Distribution of patients in the group with short Eyes (<22mm) in terms of UCVA,BCVA & difference .

	Formula	N	Mean	Std. Deviation	ANOVA	
					'F' Ratio	'p' value
UCVA (Log MAR)	SRKT	25	0.586	0.205	0.439	0.647
	Holladay11	25	0.610	0.190		
	Hoffer –Q	25	0.558	0.194		
BCVA (Log MAR)	SRKT	25	0.158	0.179	3.807	0.027
	Holladay11	25	0.178	0.174		
	Hoffer –Q	25	0.058	0.139		
Difference (Log MAR)	SRKT	25	0.428	0.131	1.591	0.211
	Holladay11	25	0.433	0.165		
	Hoffer –Q	25	0.501	0.184		

Table no.3 depicts that least correction (0.428) is required in short eyes when SRK T formula is used followed by Holladay1(0.433) and then Hoffer-Q formula (0.501).

When ANOVA test was applied it showed all three corrections were alike (P=0.002)

Therefore it can be concluded that there is no significant difference with regards to correction required between the three formulae.

However SRK T is providing least correction.

Discussion

In eyes with medium AL (table no.1), IOL power prediction results have varied, depending on the formula used for optical biometry data analysis [7,8.] A previous study found no significant difference in refractive outcome as assessed by the Holladay1 , Olsen, and SRK/T in 77 eyes [7]. In 100 eyes with average AL of 22.89mm, the IOL power calculation using theHolladay1 formula produced better results than did the SRK/T and Hoffer Q formulas [8]. In a study consisting 8018 eyes, the Holladay1 performed slightly better or equivalent as the Hoffer Q and SRK/T for AL between 22 and 26mm[9].

In our study similar results were found , with 75 eyes with average AL 23.19mm no significant difference were seen with regards to correction required between the three formulae SRK T ,Holladay1,and Hoffer Q. However least correction (0.404) is required in long eyes when Holladay1formula is used followed by hoffer Q (0.466) and then SRK T formula (0.533) in terms of post operative refraction required and BCVA.

A study consisting of more than 300 long eyes ,demonstrated the performance of the SRK/T better than the Holladay1 and Hoffer Q for AL more than 27mm[9]. Our study shows that least correction (0.447) is required in long eyes when SRK T formula is used followed by hoffer Q (0.525) and then Holladay1 formula (0.609). When ANOVA test was applied it showed all three corrections were not alike (P=0.002)

In post hoc analysis using Turkey HSD SRK T formula was found having significantly lower correction than Holladay1 Formula (P=0.001) but not with Hoffer Q formula (P= 0.472). Hoffer Q was also having significantly lower correction than Holladay1 formulae, therefore it can be concluded

that Holladay1 formula provides significantly higher corrections than SRK T and Hoffer Q formula.

Roessler and associates revealed the Haigis provided the best predictability of postoperative refractive outcome than the Holladay1 and SRK/T for 37 eye with AL more than 26.5mm[10]. In extremely myopic eyes, in which minus powered IOLs were required, there was evidence suggesting the Haigis formula performs best in these cases[11,12]. The Haigis performed betterthan the Hoffer Q, Holladay1, and SRK/T formulas in 44 eyes with AL more than 26mm receiving myopic refractive lens exchange [13]. Bang and associated reported the Haigis formula was the most accurate in predicting postoperative refractive error comparing with the Hoffer Q, Holladay1 Holladay2, and SRK/T for 53 eyes with AL more than 27mm [14]. In a study by Wang JK, Hu CY, Chang SW ,they analyzed 34 eyes with an AL of 28mm or longer and found that the Haigis was better than the SRK/T [15]. Szaflik J, Kamińska A, Gajda S, Jedruch A (2005)[16] Compared of the SRK II, SRK/T, Holladay1 and Hoffer Q formulas accuracy, in calculating IOL power in hyperopic patients(table no.2). 34 eyes of 22 hyperopic patients, 15 women and 7 men, at the age from 19 to 85 years old, after phacoemulsification with PCIOL implantation and the differences between the target and obtained refraction for all the formulas were compared. Resulting best accuracy of IOL power calculation was obtained with the Hoffer Q formula. The Holladay1, SRK/T and SRK II formulas gave worse results respectively. They concluded for the purpose of IOL power calculation in hyperopic patients the Hoffer Q or Holladay1 formula should be chosen. Our study gave similar results in patients with short eyes with AL <22mm, least correction was required

in the group where Holladay1 1 formula was used followed by Hoffer Q and SRK T. However when ANOVA test was applied it showed all three corrections were alike (P=0.002)

Therefore it can be concluded that there is no significant difference with regards to correction required between the three formulae.Several studies evaluating the accuracy of various IOL power calculation formulas used optical biometry data obtained from assessments in eyes with short AL [9,17,18,8,19]. Aristodemou and coauthors reported significantly more predictable refractive outcomes using the Hoffer Q for more than 600 eyes shorter than 22mm than the Holladay1 and SRK/T [9]. Roh and associates found the performance of the Haigis formula better than the Hoffer Q and SRK/T in 25 eyes with AL shorter than 22mm[17]. Gavin and Hammond showed the Hoffer Q had better ability to predict refractive outcome than the SRK/T in 41 eyes with AL less than 22mm [18]. MacLaren and colleagues collected 76 eye undergoing cataract surgery with IOLs ranging in power from 30 to 35 D. They found the Haigis was more accurate for open-loop, whereas the Hoffer Q was more accurate for plate-haptic lenses [19].

Table no.3 showed that there was a myopic shift in patients of all groups except for the group with medium eyes using SRK-T formula had a hypermetropic shift. Asaad A Ghanem, Hosam M El-Sayed(2010)[20] studied the accuracy of different recent intraocular lens (IOL) calculation formulas in predicting a target postoperative refraction ± 1.0D (Diopters) in patients with long eyes (axial length $\geq$ 26.0 mm) undergoing phacoemulsification. The mean postoperative refractive SE when implanting a plus power IOLs was -0.3 ± 0.51D ($P <$ 0.001) while the mean postoperative refractive SE

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when implanting a minus power IOLs was +1.21 ± 0.11D denoting a highly significant tendency toward hyperopia ($P < 0.001$).Although post ANOVA it was determined that in our study none of these shifts were significant.

Narváez J, Zimmerman G, Stulting RD, Chang DH (2006)[21] studied accuracy of intraocular lens power prediction using the Hoffer Q, Holladay1, Holladay2, and SRK/T formulas. This study was a retrospective comparative analysis. Immersion ultrasound biometry (axial length, anterior chamber depth, and lens thickness), manual keratometry, and postoperative manifest refraction were obtained in 643 eyes of consecutive patients who had routine uneventful cataract surgery with implantation of 1 of 2 IOLs using the same operative technique by the same surgeon. Biometric data were entered into each of the 4 IOL power calculation formulas, and the results were compared to the final manifest refraction. An optimized lens constant was used for each formula. Results were also stratified into groups of short, average, medium long, and very long axial length <22.0 mm, 22.0 to <24.5 mm, 24.5 to 26.0 mm, and >26.0 mm, respectively).No formula was more accurate than the others as measured by mean absolute error.

Similar results were found with our study ,SRKT & Hoffer –Q scores were significantly lower (p<0.05) than Holladay1 with respect to difference in UCVA & BCVA Log MAR in Long Eye group. SRKT was lower than Hoffer –Q, however this difference was not statistically significant. In normal (AL 22-24.5mm) & short eye (<22mm) groups, none formulae showed statistically significant difference with each other with respect to difference in UCVA & BCVA Log MAR.

However, Holladay1 in normal eye group and SRK-T in short eye group were lowest.

Conclusion

Therefore it can be concluded, that in our study SRK T, formula provides significantly higher correction than Hoffer Q and Holladay1, formula in eyes with

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axial length >24.5 mm. In eyes with Axial length 22-24.5 mm and <22mm there is no significant difference with regards to correction required between the three formulae. However, Holladay1 and SRK T provided least correction in normal and short eyes group respectively.

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