# Intraocular Lens Power Calculation Formulas In High Refractive Errors…. What To Choose And When?

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**Abstract** : Background & Objectives: Before performing the cataract surgery high level of expertise and knowledge is required to fulfil the ever increasing demands of patients. This makes a surgeon carry out detailed evaluation of a case and formulate a 'customized IOL'. Accurate IOL power calculation is the most important part of planning a cataract surgery. Most of the formula works well with normal axial length, but with high refractive errors, there are many discrepancies for selection of IOL formula. Methods: Study included 80 high myopic eyes divided into three groups and 20 high hypermetropic eyes divided into two groups according to various A scan formulas utilised. Post-operative spherical equivalent in relation to various formulas for all groups compared. Results: Performance of all 3 formulas in high myopic group showed SRK/T formula to be most accurate with smallest Mean Absolute Error (MAE) in all axial length subcategories above 24mm, followed by Haigis, and Holladay I respectively. In high hypermetropic patients, among 2 formulas, the lowest MAE was found with Hoffer-Q (-0.03D) compared to SRK/T (-0.96D) Interpretation & Conclusion: Erroneous IOL power calculation can spoil high quality results expected by patients in terms of post-operative vision in spite of excellent surgery. [Gupta P et al NJIRM 2013; 4(3) : 33-36]

**KEY Words:** Cataract surgery, High myopia, High hypermetropia, A scan , Intraocular lens power calculations

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**Introduction**: Cataract extraction with Intraocular lens (IOL) implantation is the most commonly performed surgery by an ophthalmologist. As technology advances, the newer machines provide improvised ways to calculate IOL power, which works on different principles. Modern technique in this field had given it a status of refractive surgery. There are different types and materials of IOL which are used and plenty of choices of surgeries available to be carried out, also premium IOLs are available which claims clear vision at all distance with perfect visual quality, but the ultimate aim of the surgeon is to make his patient emmetropic unaided. To achieve this, it is mandatory to know the exact power of IOL required for each patient. Various factors affect axial length measurement by A-scan machine which are density of cataract, anterior chamber depth, lens thickness, vitreous degeneration and retinal pigment epithelium thickness[1]. Also the post-operative refraction depends on the surgical technique, IOL placement, effective lens position, centeration of IOL, pre-operative refraction and the type of formula used to calculate IOL power, which make it difficult to attain emmetropia post operatively.

Since the current empirical formulas are based on the parameters acquired from the eyes with average axial length, these formulas are quite accurate for normal eyes but inaccurate for highly myopic eyes with longer axial length and posterior staphyloma which decrease the accuracy of preoperative biometry[2]. Apart from the difficulties in obtaining precise axial lengths, there are more problems specific to high hypermetropic eyes. The IOL position is critical in this patient. The refractive effect if the lens deviates from its anticipated position is 3 times more pronounced in a short eye than in a long eye[3]. Looking onto all these factors, the study aims to compare and assess various A-scan formulas to calculate accurate IOL power in patients with high refractive errors.

**Material and Methods:** The prospective study in a government set up was approved by human Research Ethics Committee.

Total 100 patients, 80 with high myopia and 20 with high hypermetropia who came to ophthalmology outdoor patients department for treatment of cataract in a Government hospital were included in the study. All patients were more than 30 years with axial length of eyeball more than 24mm and less than 21mm.Preoperative ocular evaluation was done. Distant vision by Snellen's acuity chart & Near vision by Roman's test type chart noted. Keratometry was conducted manually with Bausch & Lomb keratometer and the reading was noted in dioptres. For measuring the axial length, Echorule2 Biomedix contact A-Scan instrument was used. The high myopic patients were divided further into 3 groups and the high hypermetropic patients into 2 groups by systematic sampling as follows

**Group I** IOL power used according to SRK/T formula (28 patients),
P = A-2.5L -0.9K.
P = Emmetropic IOL power (dioptres)
A = constant derived for each type of lens and manufacturer.
L = axial length of eye (mm)
K = corneal dioptric power (dioptres).

**Group II** IOL power used according to Holladay I formula (27patients), where Holladay I used the axial length and keratometry to determine effective lens position using the Fyodorov formula to calculate corneal height.

**Group III** IOL power used according to Haigis formula (25 patients), where Haigis formula is D = a0 + (a1 x ACD + (a2 x AL)
ACD = Anterior Chamber Depth
AL = Axial Length
D = Effective Lens Position
a0 = same as lens constant for different formulas
a1 = measured anterior chamber depth
a2 = measured axial length.

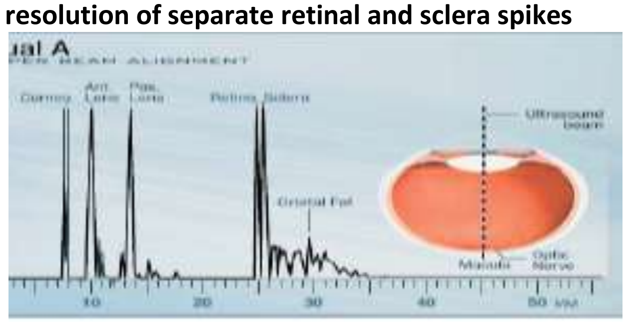
In hypermetropic patients:
**Group I** IOL power used according to SRK/T (10 patients) and

**Group II** IOL power used according to Hoffer-Q formula (10patients), where Hoffer-Q formula is P = f (A, K, Rx, pACD) which is function of
A = axial length
K = average corneal refractive power
Rx = refraction
pACD = personalized ACD ( ACD constant).

Each formula has an A-constant associated with predicting the estimated lens power. The Holladay I uses surgeon factor that is distance between the iris plane and plane of IOL, where the distance from cornea to iris plane is calculated as the dome height of cornea. The Haigis uses Anterior Chamber Depth (ACD) constant which is average distance between power plane of cornea and IOL. The SRK/T uses A-constant supplied by manufacture of IOL. The Haigis uses 3 constant a0, a1 and a2 as mentioned above.

B-scan was performed in high myopic eyes if posterior staphyloma was suspected.The aim of the post-operative refraction was to achieve emmetropia or myopia (-0.5D) depending on the patient's requirement.

**Figure 1 High quality contact A-scan of phakic eye.Note 5 high amplitude spikes, as well as good resolution of separate retinal and sclera spikes**



Surgery was carried out by superior scleral incision phacoemulsification with Foldable IOL. Patients were regularly followed on 1st, 15th, 30th and 40th post-operative day. At the end of 40th post-operative the final refraction was obtained in Spherical Equivalent (SE).Differences between actual post-operative refraction and assumed target refraction were analysed.

Each group of high myopic patients were further subcategorised according to axial length 24-27mm, greater than 27-29mm and greater than 29mm respectively.

The Mean Absolute Error was calculated by difference between the actual post operative SE and assumed target refraction by that individual formula and the results were analysed. The percentage of patients with SE and MAE within +/-0.5D and +/-1D were calculated and compared.

Statistical analysis: All data were analysed using SPSS 17.0 version. Values were recorded as Mean +/- SD. The mean axial length and biometry errors were calculated. Deviation of actual post-operative refraction from assumed target pre-operative refraction calculated and evaluated using two way analysis of variance (ANOVA). The confidence interval was 95% and p-value <0.05 was considered statistically significant.

**Result:** In our study of total 100 patients, maximum number of patients belonged to age group of 60-70 years.

The mean +/- SD of axial length among high myopic group was 25.71 +/- 1.72 mm, while the mean +/- SD of axial length in high hypermetropic group was 20.57+/-0.40mm.

The mean +/-SD of keratometry reading was 42.87+/-2.03D in high myopic group and that of high hypermetropic group was 46.31+/-1.72D.

The mean Anterior Chamber Depth (ACD) was 3.37+/- 0.39 in high myopic group & 2.69+/- 0.38mm in high hypermetropic group.

The performance of all 3 formulas in high myopic group in axial length subcategories is shown in Table 1, which shows that in axial length between 24-27mm the data is not statistically significant and all 3 formulas works equally, but as axial length increases above 27mm the difference is statistically significant (P value <0.05) and SRK/T formula was better than other 2 formulas in the study.

The post-operative Spherical Equivalent (SE) was within +/- 1D in 67.85%, 55.55% and 68% of cases when using SRK/T, Holladay I and Haigis respectively.

In high hypermetropic group with axial length less than 21mm, among 2 formulas, the lowest MAE was found with Hoffer-Q (-0.03D), while SRK/T predicted slightly towards myopic (-0.96D) Table 2. The difference between MAE is statistically significant (P value 0.04).

**Table 1: Comparision of MAE of all formulas in high myopia in axial length subcategories**

| IOL formula | Mean Absolute error (D) +/- SD | | |
|---|---|---|---|
| | **24-27mm** | **27-29mm** | **>29mm** |
| SRK-T | -0.59+/- 0.91 | -0.46+/- 0.24 | 0.24+/-0.05 |
| Holladay 1 | -0.35+/- 0.94 | -1.21+/- 0.12 | 1.46+/-1.4 |
| Haigis | -0.50+/- 1.06 | -0.78+/- 1.36 | 0.68+/-0.15 |
| | P value 0.76 | P value 0.04 | P value 0.03 |

**Table 2: Performance of both SRK/T and Hoffer-Q formulas in high hypermetropic group with axial length <21.00 mm**

| IOL formula | Mean Absolute Error(D)+/-SD | Eyes (%) with post-operative SE within +/- 1.0D |
|---|---|---|
| SRK-T | -0.96+/-1.24 | 80 |
| Hoffer-Q | -0.03+/-0.52 | 50 |
| | P value – 0.04 | |

**Discussion:** Accuracy of 3 formulas (SRK/T, Holladay I and Haigis) in axial length greater than 24mm was evaluated and attempts to find which formula to choose when observed that in high myopic group with axial length between 24-27mm, all 3 formulas had nearly similar Mean Absolute Error (MAE), which means that all formulas works well in this axial length, while in AL between 27-29mm and greater than 29mm the MAE was found lowest with SRK/T formula, followed by Haigis and Holladay I. The difference was also statistically significant in axial between 27-29mm and greater than 29mm (P value < 0.05). So the study observed that SRK/T was accurate in all axial length subcategories above 24mm.

In 2003 Donoso et al. examined different axial length with the SRK II, Binkhorst II, Hoffer-Q, Holladay, and SRK/T formulas and inferred that SRK/T formula to 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)[4].This subcategory in present study was also a small group, where SRK/T formula was more useful.

In 2010 Raouf El-Nafees et al. conducted a prospective clinical study on 53 eyes of 51 patients with an axial length from 25.5 to 31.4 mm, the IOL power of which was calculated by three available IOL power formulas; Haigis formula, SRK/T formula, and Holladay I formula found that 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) [5].

In high hypermetropic patients in present study, among 2 formulas, the lowest MAE was found with Hoffer-Q (-0.03D) compared to SRK/T (-0.96D) showing that Hoffer-Q was better than SRK/T in these patients.

In 2005 Szaflik J et al. studied comparison of the SRK II, SRK/T, Holladay and Hoffer Q formulas accuracy, in calculating IOL power in hyperopic patients with axial length ranging from 19.6 mm to 21.99 mm .The best accuracy of IOL power calculation was obtained with the Hoffer Q formula. The Holladay, SRK/T and SRK II formulas gave worse results respectively[6].

This study included both extremes of axial lengths and observed the effectivity of A scan formulas for different subcategories of AL and stressed on usefulness of one single formula to give best post operative results which helps an ophthalmologist in selecting correct formula instead of taking an average of all. Consideration of more patients of high hypermetropia and equal number of all axial length subcategories in cases of high myopia group (approx.1% incidence)in future shall make results more concrete.

**Conclusion:** Recent advances in IOL power calculations and machines have made it easier for a surgeon to choose premium IOL for his patients, but still meticulous works need to be done for choosing appropriate IOL formulas in patients with high refractive errors. It is especially important in these patients to apply high quality methods, procedures and techniques in surgery, as well as IOL calculation errors.

Present study emphasizes the optimal use of different IOL calculation formulas for high refractive errors .SRK/T formula for high myopic patients and Hoffer -Q formula for high hypermetropic patients in calculations of IOL powers for cataract patients is recommended .

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