Discrepancies between Intraocular Lens Implant Power Prediction Formulas in Pediatric Patients

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Purpose: The SRK II, SRK/T, Holladay I, and Hoffer Q intraocular lens power prediction formulas have been claimed to be interchangeable in their predicted postoperative refractive outcome among pediatric patients. In this study, we evaluated this clinical perception.

Design: Mathematical analysis.

Methods: Analytical prediction of implant power using keratometry values up to 55 diopters and axial length values as short as 16 mm was performed for 2 different refractive goals using the optimized intraocular lens constants for the SRK II, SRK/T, Holladay I, Hoffer Q, and Haigis formulas. Comparison graphs for the predicted implant power of each formula were constructed and differences between predicted results of the formulas were plotted.

Main Outcome Measure: Predicted implant power.

Results: Significant differences in intraocular lens power prediction were found among the Hoffer Q, Holladay I, and SRK II formulas in the pediatric range of axial length and keratometry values. The Holladay I and Haigis formulas were found to be similar in their intraocular lens power prediction. The SRK/T was comparable with the Holladay I and Haigis formulas, but still differed in the high keratometry values.

Conclusions: This analysis demonstrates differences in the intraocular lens power prediction among commonly used formulas for axial length and keratometry values in the pediatric range. It is unclear under what circumstances each of these formulas may be preferred in the pediatric population.

Materials and Methods

An analytical prediction of IOL power over a wide range of keratometry (K) and axial length (AL) values was performed using the SRK II, SRK/T, Holladay I, Hoffer Q, and Haigis equations.5–9 A spreadsheet was generated with all the possible combinations of K values from 40 to 55 diopters (D) and AL values from 16 to 28 mm. For each combination (e.g., K = 45 D, AL = 19 mm), an IOL prediction was made with each equation for desired refractive outcomes of plano and +6.00 D. The equations were implemented as functions in a spreadsheet program (Microsoft Excel VBA; Microsoft, Redmond, WA) with AL and K as input parameters and predicted IOL power as output. The optimized IOL constants for the SA60AT lens (Alcon Laboratories, Fort Worth, TX) with a nominal A constant of 118.4 were used.10 The results of these calculations were confirmed to match the analytical definition of the equations5–9 and were validated against results from the IOL-Master (Carl-Zeiss Meditec, Dublin, CA) over a wide range of values. Pairwise comparisons were made among the 5 equations for a desired refractive outcome of plano and +6.00 D. Contour plots of the comparisons then were made for a refractive outcome of plano.

Results

The contour plots illustrate differences between the predicted IOL powers for a postoperative target refraction of plano using the SRK II, SRK/T, Holladay I, Hoffer Q, and Haigis equations (Fig 1). The contour plots show how the prediction formulas diverge as a
function of the AL and K values. Significant differences in IOL power prediction are found among the Hoffer Q, Holladay I, and SRK II formulas in the pediatric range of axial length and keratometry values (Fig 1A–D). The Holladay and Haigis formulas were found to be similar in their IOL prediction (Fig 1E). The SRK/T was comparable with the Holladay and Haigis formulas, but still differed in the high K values (Fig 1F). The differences between the formulas were found to be similar when a target refraction of +6.00 D was chosen.

Discussion

The placement of an IOL in children undergoing cataract surgery is gaining wider acceptance. In addition, with improved surgical equipment and techniques, the acceptable age for IOL implantation is becoming progressively younger. With the trend toward implanting IOLs in infants with shorter AL values and higher K values, there is a need to understand the accuracy and the differences between prediction formulas at lower extremes of ALs and at the higher extremes of Ks. As shown by Gordon and Donzis, the average AL is 16.8±0.6 mm in normal newborns, 19.2±0.7 mm in the 0- to 1-year age group, 20.2±0.3 mm in the 1- to 2-year age group, and 21.4±0.1 mm in the 2- to 3-year age group. The average K value is 51.2±1.1 D in normal newborns, 45.2±1.3 D in the 0- to 1-year age group, 44.9±0.9 D in the 1- to 2-year age group, and 44.1±0.3 D in the 2- to 3-year age group. Flitcroft et al reported that the mean AL in eyes with congenital cataracts was 18.57 mm, with a range of 16.44 to 20.00 mm at a mean age at surgery of 24 weeks (range, 4–94 weeks). The mean K value before surgery for the congenital cataract group in this study was 47.78 D, with a range of 43.55 to 57 D. These findings are shown in Figure 2.

Previous reports suggest that there is no important difference among the SRK II, Hoffer Q, Holladay I, and SRK/T equations when used in children. However, these reports most likely were not adequately powered to find meaningful differences in the short axial length group, if they exist. Andreo et al stated that there was little difference between SRK II, SRK/T, Holladay I, and Hoffer Q formulas in short, medium, and long eyes in providing adequate predicted refraction. The mean errors noted in that study were between 1.23 to 1.33 D in long eyes, 0.98 to 1.03 D in medium eyes, and 1.41 to 1.8 D in short eyes. But only the mean of a small number of patients (n = 17) with ALs less than 22.0 mm (range, 18.6–22.0 mm) was evaluated in the group with short eyes, perhaps obscuring differences at shorter ALs.

Mezer et al found that prediction formulas, including Hoffer Q, Holladay I, SRK/T, SRK, and SRK II equations, provide similar outcomes in patients between 2 and 17 years of age. All formulas were found to be similarly unsatisfactory (as defined by Mezer et al) in achieving the target refraction. The average differences between predicted and actual postoperative refraction using mean errors ranged from 1.06±0.79 D to 1.79±1.47 D. However, only the mean error for all patients was reported. Patients were not subgrouped, and differences as a function of ALs and K values were not defined.

Neeley et al also found that the SRK II, SRK/T, and Holladay I formulas had no significant difference in lens power predictability in pediatric patients and that the Hoffer Q formula showed a positive bias of 1.2 D. The authors also showed that the SRK II, SRK/T, Holladay I, and Hoffer Q formulas were increasingly less accurate at predicting the needed IOL implant power at smaller axial lengths.

Only a small number of adult patients with short ALs have been studied and reported in the literature. In a study by Hoffer’s of 500 eyes, only 36 eyes had ALs less than 22 mm, and the average AL was relatively large (by pediatric standards), 21.43±0.69 mm. Apart from the small numbers reported, the different characteristics of these short

Figure 1. Intraocular lens power prediction comparison for an emmetropic refractive goal (Rs = 0) for the SRK II, SRK/T, Holladay I, Hoffer Q, and Haigis equations. Equal difference points are connected by lines and labeled. The optimized intraocular lens constants for the Alcon SA60AT lens with a nominal A constant of 118.4 were used: a0 = 0.357, a1 = 0.261, a2 = 0.153, personalized anterior chamber depth = 5.37, surgeon factor = 1.60, A = 118.7 for SRK/T, A = 119.0 for SRK II. The difference between formulas’ predictions at a few typical axial length and keratometry values are marked on the plot. D = diopters.

Figure 2. Typical pediatric axial lengths and keratometry values. Mean and 1 standard deviation shown except for congenital cataract eyes in which the mean and range of 35 eyes are shown (derived from data reported in Gordon and Donzis and Flitcroft et al). D = diopters.
adult eyes may make it difficult to extrapolate conclusions to the pediatric population.

Our mathematical comparison of the predicted IOL power among the SRK II, SRK/T, Holladay I, Hoffer Q, and Haigis formulas over a range of ALs from 16 to 28 mm and over a range of K values from 40 to 55 D for different refractive goals (plano and +6.00 D) demonstrates that only a narrow range, more typical of older children and adult eyes, is insensitive to the formula chosen. Addressing this question analytically gives the advantage of studying every specific AL and K value combination without having had enough patients with this specific value combination. This would be especially difficult in infants and newborns. In addition, clinical studies introduce other factors such as AL and K value measurement errors, surgeon factors, and refractive changes of the eye with time that may cause problems with interpreting the results. Currently, the pediatric ophthalmologist must rely on these IOL power prediction formulas drawn largely from studies on adult eyes. Which formula to use in infants and children and when to use it remain matters of conjecture.

References