Clinical results in phacoemulsification using the SRK/T formula

Resultados clínicos na facoemulsificação utilizando a fórmula SRK/T

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ABSTRACT

Purpose: To evaluate the prediction of refraction using the SRK/T formula for intraocular lens (IOL) calculation in eyes with medium axial length after phacoemulsification. **Methods:** This prospective study enrolled 33 eyes with nuclear cataract that underwent phacoemulsification. All procedures were performed by one surgeon with the intraocular lens placed within the capsular bag. The same technician who was unaware of the purpose of the study made all the measurements. The achieved refractive error one month after surgery was compared to the predicted postoperative refractive error by the SRK/T formula. **Results:** The ocular axial length varied between 22.2 mm and 24.5 mm. The mean predicted refraction was -0.431 ± 0.181 D and the mean achieved postoperative spherical equivalent was -0.220 ± 0.732 D. Eighteen eyes (55%) had a refractive error between ± 0.50 D and thirty eyes (91%) between ± 1.00 D of the predicted refraction. There was a tendency toward hyperopic shift (mean ± SD: 0.211 ± 0.708 D, p=0.009). **Conclusion:** The SRK/T formula demonstrated a satisfactory accuracy to calculate the error of refraction in eyes with medium axial length.

Keywords: Biometry; Cataract extraction; Lens implantation, Intraocular/methods; Lens diseases; Phacoemulsification; Refractive errors/surgery; Refraction, ocular

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INTRODUCTION

Intraocular lens (IOL) power calculation formulas have evolved over the past 25 years. The most recent formulas (third and fourth generation) are the most useful and precise(1-6). These formulas vary with anterior chamber depth (ACD), axial length (AL) and corneal curvature. Third-generation formulas such as Holladay 1, Hoffer Q and SRK/T use constants associated with the expected position of the IOL. Holladay uses the "surgeon factor", the distance from the iris plane to the IOL's plane; Haigis uses 3 constants for better Effective Lens Position (ELP) prediction; Hoffer Q uses the ACD constant, average distance between the power plane of the cornea and that of the IOL; and SRK/T uses the A-constant to calculate the ACD, using the retinal thickness and corneal refractive index(1,3,5,7).

Prediction accuracy depends on three factors: accuracy of the biometric data (axial length and keratometry readings), accuracy of manufactured IOL power quality control and accuracy of the IOL power formulas(1,8-9).

Several previous published studies reported accuracy of ± 1.00 diopter (D) after cataract surgery using phacoemulsification technique that varies from 80 to 94.8%, depending on the AL and the IOL power calculation formula(1-4,10-11).

After introduction of phacoemulsification with small incision techniques, minimizing cylindrical error[12], and continuous curvilinear capsulorhexis technique, that allows better IOL capsular fixation and more predictable ELP[13], the correct IOL power became a crucial step for good refractive outcome in the preoperative examination of cataract surgery.

The purpose of this study was to evaluate the prediction of postoperative refraction using the SRK/T formula in phacoemulsification in eyes with medium AL.

METHODS

This prospective non-comparative study comprised 33 eyes of 33 consecutive patients with senile cataract who underwent phacoemulsification and in-the-bag IOL implantation between August and October 2002. Informed consent was obtained from all patients and the study protocol was approved by the Ethics and Research Committee of the Federal University of São Paulo - Paulista School of Medicine.

Inclusion criteria were age between 50 and 90 years, nuclear cataract greater than 2.5 based on the "Lens Opacities Classification System III" (LOCS III)[14], and axial length between 21.5 and 24.5 mm. Exclusion criteria were the presence of associated ocular pathologies, monocular patients, and intraoperative or postoperative complications.

Before surgery, simulated keratometry was obtained from corneal topography using axial map (EyeSys Technologies, Houston, TX, USA), and the axial length was recorded as the average of five readings taken using a 10 MHz A-scan ultrasound transducer (Zeiss Humphrey, Dublin, CA, USA) with contact technique under topical anesthesia with 0.5% proxymetacaine chlorhydrate. SRK/T formula was chosen to predict the IOL power. All examinations were performed by the same examiner who was unaware of the purpose of the study.

All patients had standardized uneventful small-incision phacoemulsification with in-the-bag IOL implantation performed by a single surgeon (FHC). Phacoemulsification was performed using 20000 Legacy® (Alcon, Fort Worth, TX, USA). The foldable IOL was implanted in the capsular bag, through a 3.0 mm incision, using a Monarch II® injector (Alcon, Fort Worth, TX, USA). The sutureless incision was placed superotemporally for right eyes and superonasally for left eyes. All IOLs used were Acrysof® (Alcon, Fort Worth, TX, USA) with constants of 118.4, as follows: one (3%) SA60AT, 11 (33%) SA30AT, and 21 (64%) SA30AL. The IOL requested for the patients predicted a postoperative refractive error between plano and -1.00 D.

Patients were examined 1, 7, 15, and 30 days after surgery. Each visit included uncorrected visual acuity, slit lamp examination of the anterior segment, intraocular pressure measurement by Goldmann applanation tonometry, and indirect ophthalmoscopy. Best spectacle-corrected visual acuity (BSCVA) was taken between 30 and 40 days after surgery using a Snellen's chart.

The implanted IOL power was used to calculate the predicted postoperative refractive error by SRK/T formula. The mean refractive error was calculated from the difference between the formula-predicted refractive error and the achieved postoperative refractive error based on spherical equivalent (SE). Paired t test was used to analyze statistical significance. *P* values of less than 0.05 were considered statistically significant.

RESULTS

Of the 33 patients, 17 were female and 16 were male; AL ranged between 22.2 mm and 24.5 mm. The right eye was operated in 19 (57.6%) patients and the left eye in 14 (42.4%). All surgeries were uneventful. All IOLs were implanted within the capsular bag and the incisions were not sutured.

Between 30 and 40 days after surgery, BSCVA was 20/25 or better in 23 (70%) eyes, between 20/30 and 20/50 in 10 (30%).

Mean IOL power used was 21.70 D ± 1.30 D (range, 19.0 D to 24.5 D). The mean predicted SE was -0.431 ± 0.181 D (range, -0.02 to -0.72 D). The mean achieved SE was -0.220 ± 0.732 D (range, +1.75 to -1.625 D). At 1 month, the mean postoperative spherical component of the refractive error was +0.227 ± 0.756 D (range, +2.0 to -1.25 D), and the mean postoperative cylindrical component was -0.894 ± 0.625 D (range, 0 to -2.25 D). The difference between predicted and achieved refractive error presented a slight hyperopic shift (mean ± SD: 0.211 ± 0.708 D, ranging from -1.07 D to + 2.33 D; p=0.09) as seen in table 1. The majority of the eyes (18 eyes, 55%) had an error of prediction within ± 0.50 D (Figure 1, Table 2 and 3) and thirty eyes (91%) had a predicted refraction between ± 1.00 D.

DISCUSSION

Few studies in literature have shown refractive results after phacoemulsification using SRK/T formula, but none of them has been made following more restricted criteria in order to avoid bias[1,3-4,15-18]. Our study showed a prediction accuracy of 55% for refractive errors of ± 0.50 D, using SRK/T formula in eyes with medium AL, and a prediction accuracy of 91% in errors of ± 1.00 D. This accuracy is very close to the results presented in other studies using the same formula[1,3-4,15-18].

SRK/T has been reported to present[1] a prediction error of ± 1.00 D in 94.5% of 325 eyes with medium AL (from 22.0 to

Table 1. Mean attempted versus achieved spherical equivalent correction in medium axial length eyes using SRK/T formula (n=33 eyes).

SE (D)	Mean ± SD (D)
Attempted	-0.431 ± 0.181
Achieved	-0.220 ± 0.732
Difference between attempted and achieved	0.211 ± 0.708 (p=0.09)*

*= paired t test
SE= spherical equivalent; SD= standard deviation; D= diopters

Table 2. Distribution of the prediction error (difference between attempted and achieved spherical equivalent) in medium axial length eyes using SRK/T formula (n=33 eyes)

Range of SE (D)	n (%)
± 0.25	8 (24)
± 0.50	18 (55)
± 1.00	30 (91)
± 2.00	32 (97)
> 2.00	1 (3)

SE= spherical equivalent; n= number of operated eyes

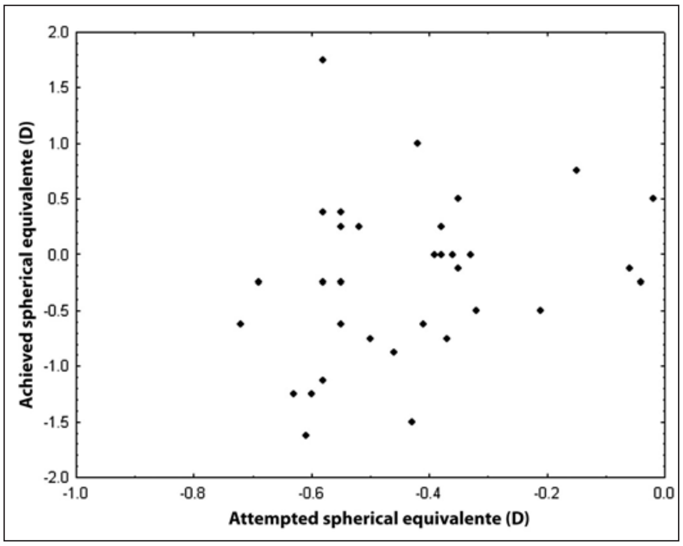

Figure 1 - Dispersion plot demonstrating attempted versus achieved spherical equivalent (SE) correction in medium axial length eyes underwent phacoemulsification using SRK/T formula

24.5 mm) using the SRK/T formula. However, all IOLs used in this study were unfoldable, made from polymethylmethacrylate, with a 6.0 mm optic diameter, and had to be implanted through a larger incision. Another study[3], also studying this formula, showed accuracy in ± 1.00 D prediction errors in 80% of cases. This study comprised the development of the SRK/T formula. Although the authors obtained the prediction of 80% within ± 1.00 D, this study considered a large group of cases with different axial length from different surgical centers using different IOLs operated on by different surgeons. Besides, this prediction of error is not only for eyes with medium axial length. The same group of authors published a comparison between SRK/T and other theoretical and regression formulas[15]. In this study, seven independent data sets were used for comparison. Each data source consisted of one or more surgeon's series of cases using different IOLs and different instruments to obtain biometric data. The authors reported 81% of cases within ± 1.00 D in 990 unselected patients. Despite 76% of patients being average eyes, the authors did not present results for this particular group, and only compared separately SRK/T with other formulas in short, moderately long, very long, and extremely long eyes[15].

A study of 1993[4] found the error to be within ± 1.00 D in 87% of cases that included long and short eyes. The authors included 11 different IOL types from 6 different companies with different A-constants and IOL designs. Furthermore, the axial length varied from 18.92 to 37.45 mm[4]. All these different parameters make it more difficult to compare with our data and increase the possibility for bias. Another study[16] used the SRK/T formula and found the error between ± 1.25 D in 76.4%, although they did not mention the preoperative AL of the eyes and did not describe the presence or absence of corneal suture. SRK/T has also been[18] reported with an error between ± 0.75 D in 78% of cases, however this study also did not mention the AL of the eyes and the authors used both unfoldable and foldable lenses, referring that the best results were obtained when using the latter (88% within ± 1.00 D). A study comparing IOLs[17] reported differences in the predictability of refractive outcomes between silicone and PMMA IOLs, concluding that PMMA IOL showed better refractive results, both using the SRK/T formula.

Some advantages of our study are the uniformity of the biometric data collection (same technician) and the surgery having been performed by a single surgeon, using sutureless corneal incision with IOLs implanted within the capsular bag in all cases, and also using the same IOL material type, decreasing the variables that might confuse the analysis of the IOL power prediction. One variable that we must comment is that, even in experienced hands, the AL measured by immersion ultrasound biometry can be more precise than the contact method, although it is more critical in eyes with longer AL[11,19].

SRK/T formula is a third-generation formula, as are Holladay 1 and Hoffer Q, that vary the ACD based on the patient's axial length and corneal curvature, and its accuracy of IOL power prediction has very satisfactory clinical results. A comparative study reported the accuracy of the Hoffer Q, Holladay 1 and 2, SRK-I and II and SRK/T formulas[1-2], and found a substantial better performance of the Holladay 1 and 2, Hoffer Q and SRK/T formulas when comparing them to the SRK-I and II. In one study[1], the predicted error within ± 1.00 D in medium eyes was 94.8% for Holladay 1, 93.2% for Hoffer Q and 94.5% for SRK/T. In a retrospective study with 317 eyes, Hoffer[2] published that Hoffer Q and Holladay 2 formulas would be better in eyes shorter than 22 mm (AL < 22 mm), Hoffer Q and Holladay 1 for average eyes (AL between 22.0 to 24.5 mm), SRK/T and Holladay 1 for medium-long eyes (AL between 24.5 and 26 mm) and SRK/T in very long eyes (AL > 26 mm). In eyes with medium AL (between 22 and 24.5 mm) the 3 Hoffer Q, SRK/T and Holladay 1 formulas showed equally high accuracy. Our data also confirm that SRK-T presents satisfactory accuracy and predictability for average axial length eyes.

Narvaez compared the 4 formulas (Hoffer Q, Holladay 1, Holladay 2 and SRK/T) in 643 eyes and found no difference in accuracy between them in 4 subgroups of axial length[20]. Fourth generation formulas, like Holladay 2, did not outperform those of third generation, especially in eyes with extreme AL[2,21].

Table 3. Attempted and achieved refraction, final spherical equivalent, final visual acuity, IOL model, K and diopters. Error between attempted and achieved refraction in medium axial length eyes using SRK/T formula (n=33 eyes)

Attempted	Achieved	Real SE	VA	IOL	K	Diopters	Error
-0.58	+2.00 -0.50 x 130	1.750	20/40	SA30AL	118.4	24.5	2.330
-0.06	+0.25 -0.75 x 180	-0.125	20/30	SA30AL	118.4	22.5	0.065
-0.50	-0.50 -0.50 x 110	-0.750	20/20	SA30AL	118.4	22.5	-0.250
-0.52	+0.75 -1.00 x 30	0.250	20/25	SA30AL	118.4	21.5	0.770
-0.43	-1.00 -1.00 x 125	-1.500	20/20p	SA30AL	118.4	20.5	-1.070
-0.60	-1.00 -0.50 x 55	-1.250	20/25	SA30AL	118.4	21.0	-0.650
-0.58	+1.50 -2.25 x 105	0.375	20/25	SA30AL	118.4	23.0	0.955
-0.55	+0.75 -1.00 x 100	0.250	20/20p	SA30AL	118.4	23.0	0.800
-0.55	+0.75 -0.75 x 105	0.375	20/20p	SA30AL	118.4	21.5	0.925
-0.35	+0.25 -0.75 x 105	-0.125	20/30	SA30AL	118.4	20.0	0.225
-0.55	-1.25 x 105	-0.625	20/20	SA30AL	118.4	21.5	0.075
-0.04	+0.75 -2.00 x 160	-0.250	20/40p	SA30AL	118.4	23.0	-0.210
-0.42	+1.00	1.000	20/30	SA30AL	118.4	19.0	1.420
-0.21	-0.25 -0.50 x 105	-0.500	20/25	SA30AL	118.4	23.0	-0.290
-0.69	+0.50 -1.50 x 105	-0.250	20/20	SA30AL	118.4	22.0	0.440
-0.61	-1.25 -0.75 x 145	-1.625	20/25	SA30AL	118.4	23.5	1.015
-0.46	-1.75 x 130	-0.875	20/40p	SA30AT	118.4	22.0	-0.415
-0.58	-0.75 -0.75 x 155	-1.125	20/20	SA30AT	118.4	22.5	-0.545
-0.55	-0.25	-0.250	20/20	SA30AL	118.4	21.5	0.300
-0.39	0	0	20/20	SA30AT	118.4	22.5	0.390
-0.72	-0.25 -0.75 x 120	-0.625	20/20	SA30AT	118.4	19.0	0.095
-0.58	+0.25 -1.00 x 110	-0.250	20/20	SA30AT	118.4	21.5	0.330
-0.38	+1.00 -2.00 x 105	0	20/30p	SA60AT	118.4	22.5	0.380
-0.36	0	0	20/20	SA30AT	118.4	20.0	0.360
-0.37	-0.50 -0.50 x 30	-0.750	20/20	SA30AT	118.4	21.0	-0.380
-0.15	+1.50 -1.50 x 90	0.750	20/50	SA30AL	118.4	23.0	0.900
-0.41	-1.25 x 95	-0.625	20/25	SA30AL	118.4	21.0	-0.215
-0.38	+0.25	0.250	20/20p	SA30AL	118.4	21.0	0.630
-0.32	-0.25 -0.50 x 105	-0.500	20/20	SA30AL	118.4	21.5	-0.180
-0.63	-0.25 -2.00 x 135	-1.250	20/40	SA30AT	118.4	22.5	-0.620
-0.02	+0.75 -0.50 x 85	0.500	20/25	SA30AT	118.4	20.0	0.520
-0.35	+1.00 -1.00 x 150	0.500	20/30	SA30AT	118.4	22.5	0.850
-0.33	+0.50 -1.00 x 100	0	20/20	SA30AT	118.4	20.0	0.330

SE= spherical equivalent; VA= visual acuity; IOL= intraocular lens; K= IOL constant; n= number of operated eyes

For these cases, optic biometry is useful, with limitation of needing good fixation and relative lens transparency[11,22]. Haigis examined eyes after refractive surgery and found a 61% percentage of a correct refraction prediction between +/- 0.50 D[6]. Due to restrictions of both methods (ultrasonic and optic), it is necessary to use the best available formulas, to improve the prediction error in postoperative refraction after phacoemulsification.

CONCLUSION

The results of this study support SRK/T formula as a good option to predict the refractive error after cataract extraction by phacoemulsification in eyes with medium axial length. To our knowledge, this study is unique in reporting eyes with one lens material from one manufacturer, implanted in the capsular bag by the same surgeon, with preoperative measurements obtained from the same instrumentation by the same method and same technician, using SRK/T formula for IOL power calculation in eyes with medium axial length that underwent phacoemulsification with foldable IOL implantation.

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RESUMO

Objetivo: Avaliar resultados refracionais utilizando a fórmula SRK/T no cálculo de lentes intraoculares (LIO) em olhos com comprimento axial médio após facoemulsificação. **Métodos:** Este estudo prospectivo envolveu 33 olhos com catarata nuclear que foram submetidos a facoemulsificação. Todas as cirurgias foram realizadas pelo mesmo cirurgião com lentes intraoculares no saco capsular. O mesmo tecnólogo, o qual não sabia o objetivo do estudo, realizou todas as medidas biométricas. O erro refracional atingido um mês após a cirurgia foi comparado ao erro refracional pós-operatório previsto pela fórmula SRK/T. **Resultados:** O comprimento axial variou entre 22,2 mm e 24,5 mm. A refração média prevista foi -0,431 ± 0,181 dioptrias (D) e o equivalente esférico pós-operatório alcançado foi -0,220 ± 0,732 D. Dezoito olhos (55%) obtiveram erro refracional de ± 0,50 D e 30 olhos (91%) entre ± 1,00 D da refração prevista. Houve tendência a um erro hipermetrópico (média±SD: 0,211 ± 0,708 D, p=0,009). **Conclusão:** A fórmula SRK/T demonstrou acurácia satisfatória no cálculo do erro refracional em olhos de comprimento axial médio.

Descritores: Biometria; Extração de catarata; Implante de lente intraocular/métodos; Doenças do cristalino; Facoemulsificação; Erros de refração/cirurgia; Refração ocular

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