Accuracy of Intraocular Lens Calculation by SRK/T Formula in Pediatric Cataracts

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Objective: *To examine the accuracy of the intraocular lens calculation by SRK/T formula in pediatric cataract patients, by means of the prediction error after the cataract surgery.*

Material and Method: *A retrospective review of pediatric patients requiring cataract extraction with intraocular lens implantation, between January 2006 and December 2013 was performed. Post-operative spherical equivalent was compared with the predicted calculation value from pre-operative SRK/T measurement, defined as prediction error (PE).*

Results: *139 eyes from 106 patients were studied. The median age of patients at surgery was 4.56 years (IQR, 14). The two most common causes of cataract were idiopathic and traumatic; 85 eyes (61.2%) and 36 eyes (25.9%), respectively. Primary intraocular lens (IOL) implantation was performed in 87 (62.6%) eyes. The mean PE was -1.32±1.89 D (-7.78, 2.24). At one to three months after surgery, the mean PE of IOL in bag and sulcus were -0.87 D and -2.02 D, respectively. In non-traumatic group, the mean PE of IOL in bag and sulcus were -1.1 D and 2.28 D, respectively, whilst the traumatic group was -0.33 D and -1.16 D, respectively. Post-operative PE within ±1 diopter was found in 30 eyes (37.97%) at one to three months of follow-ups.*

Conclusion: *The majority of post-operative refraction was more myopic than the targeted refractive error, which was calculated by SRK/T formula. Aiming for a more hyperopic target and IOL implantation in the bag would decrease the post-operative prediction error in the use of the SRK/T formula in pediatric cataract patients.*

Keywords: *Intraocular lens calculation, SRK/T formula, Pediatric cataract*

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Pediatric cataract is one of the leading etiologies of blindness in children, especially in developing countries. It is responsible for 10% of world childhood blindness[1]. The etiology can be congenital or acquired. Because of the treatable nature of the disease, many management approaches have been applied. In children aged more than two years, cataract surgery and primary intraocular lens implantation (IOL) had been documented as a safe and effective procedure[2,3].

The accuracy of the formula in calculation for IOL is an important factor for the precise post-operative visual outcome. Blurred vision in children may lead to irreversible poor visual development and amblyopia. There is a variety of formulas used to calculate power of the IOL. The Sanders-Retzlaff-Kraff theoretic (SRK/T) formula was reported to be the most accurate method in some studies[4,5]. Another study showed that SRK II was better than other formula in patients under two years of age[6]. In our setting, the SRK/T formula has been routinely used. Therefore, we measured the accuracy of the intraocular lens calculation by SRK/T formula in pediatric cataract patients, in terms of the prediction error after the cataract surgery.

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Material and Method

The present study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Khon Kaen University Ethics Committee for Human Research. Medical records were retrospectively reviewed in all cataract patients aged under 15 years, who underwent cataract extraction with IOL implantation calculated by SRK/T formula at the Eye Center, Srinagarind Hospital, Khon Kaen University during an eight-year period, from January 1, 2006 to December 31, 2013. Patients who had a history of corneal transplantation, silicone oil injection, nanophthalmos, glaucoma, any ocular conditions

precluding adequate retinoscopic examination were excluded.

Demographic data were obtained, including: age; gender; laterality; causes of cataract; associated ocular abnormalities; keratometry readings (Diopters; D); axial length (millimeters), which was measured by the immersion A scan ultrasonography; OcuScan® RxP (Alcon, Texas, USA) and partial coherence interferometry; IOL master (Zeiss, California, USA); primary or secondary IOL implantation; anterior or posterior-approached cataract surgery; IOL location placement; IOL power; and predicted postoperative refraction.

All post-operative refractions were performed with manual retinoscopy and the actual post-operative refraction was recorded in spherical equivalent form. The accuracy of the formula was determined by prediction error (PE) and absolute prediction error (APE). Prediction error (in diopters) was calculated by predicted post-operative refraction (in diopters) minus actual post-operative refraction (in diopters). Absolute prediction error (in diopters) was the absolute value of the prediction error.

All statistical tests were performed under the Statistical Package for the Social Sciences (SPSS) version 16.0. All clinical data were reported in mean (SD), median (IQR) or frequency. The mean PE and mean APE compared with zero value was analyzed by one-sample t-test. The *p*-values less than 0.05 were considered statistically significant.

Results

The medical records of 139 eyes from 106 patients who underwent cataract extraction and IOL implantation were reviewed. Unfortunately, all of the post-operative refraction data in every period of follow-ups from many patients could not be completed. So the number of eyes would varied at each follow-up period. The sample size of 204 eyes was calculated by the hypothesis tests for a population mean (two-sided test). The baseline characteristics were summarized in Table 1. The median age at surgery was 4.56 years (IQR, 14). The major causes of cataract were idiopathic, followed by trauma.

A diversity of surgical approaches was performed. Primary IOL implantation was done in 87 eyes (62.6%), mostly in the capsular bag. Secondary IOL was implanted mostly in the ciliary sulcus. Posteriorly approached cataract surgery combined with pars plana vitrectomy was done in an eye with traumatic cataract. Prominent corneal scars were found in 23 eyes from 36 eyes with traumatic cataract. Amblyopia was found in 16 eyes of 139 eyes, mostly from unilateral idiopathic cataract.

Table 1. Baseline characteristics

Age at surgery (years)	4.56 (IQR14)
Gender; males	57 (53.8%)
Eye; OD	62 (44.6%)
Causes of cataract (n (%))	
Idiopathic	85 (61.2)
Trauma	36 (25.9)
Congenital ocular anomaly	5 (3.6)
Down syndrome	6 (4.3)
Hereditary	4 (2.9)
Intrauterine infection	3 (2.2)
Keratometry readings (diopters)	M43.52 (SD2.76)
Axial length (millimeters)	M22.40 (SD1.81)
IOL power (diopters)	M22.50 (SD5.04)
Post-operative predicted refraction (spherical equivalent)	M1.12 (SD1.53)
Cataract surgery approach (n (%))	
Anterior	138 (99.3)
Posterior	1 (0.7)
IOL placement (n (%))	
Capsular bag	75 (54)
Sulcus	57 (41)
Scleral fixation	7 (5)

OD = right eye; IOL = intraocular lens

The mean predicted post-operative refraction was +1.22±1.53D. At one to three months after surgery, the mean actual postoperative refraction was -0.20±1.80D, the mean PE was -1.32±1.89D (ranged -7.78 to 2.24D), the mean APE was 1.70±1.53D (ranged 0 to 7.78D). Table 2 shows the PE and APE in the various follow-up periods, displaying separately in all and non-traumatic causes. The mean PE was statistically significantly different from the ideal error, zero, (*p*-value <0.05) in every period of follow-ups. Compared between the traumatic and non-traumatic cause groups, the mean difference of PE was statistically significant at one to three months, six to twelve months and >24 months of follow-ups, but unfortunately inconclusive.

At one to three months after surgery, the mean PE of IOL in bag was -0.87D (-1.36, -0.38) and the mean PE of IOL in sulcus was -2.02D (-2.82, -1.23) which was about two-folds more than in the bag. In subgroups, the mean PE of IOL in bag and sulcus in non-traumatic group was -1.1D and -2.28D, respectively, whilst in the traumatic group was -0.33D and -1.16D, respectively. The mean APE was also demonstrated in Table 3.

Fig. 1 demonstrates the distribution of PE in range for each follow-up period. The majority value is

-3 to +1D in every period. The accepted post-operative PE was ±1D, which counted for 30 eyes (37.97%) at one to three months of follow-ups. This period had the highest number of follow-up patients. At one to six months after the surgery, the accepted PE was found in 42 eyes from 101 eyes (41.58%).

Discussion

We evaluated the accuracy of the intraocular lens calculation by SRK/T formula in pediatric cataract patients and found that the mean PE of IOL in bag in non-traumatic group was -1.1±1.83D and the mean APE was 1.64±1.33D. The present findings are consistent with the study of Long et al, which also studied in patients with the similar age of 4.75 years and using a formula of SRK/T after undergoing IOL implantation in the bag. The mean PE reported by this study was -0.22±1.12D at three months of follow-up[7]. Although both studies were performed on Asian eyes, the different factors, i.e., IOL type, techniques of biometry measurement, surgery and post-operative refraction measurement may contribute to the discrepancy in the magnitude of PE.

Notwithstanding, the study from Neely et al[8], which followed the patients aged 4.8 years for a period of two months, it had a different result. The mean PE from both SRKII and SRK/T formulas was 0.30±1.5D and the mean APE from SRK/T formula was 1.12D. Some

Table 2. Prediction error and absolute prediction error in all and non-traumatic causes of cataracts

Post-op duration	All causes, mean (SD)	Non-traumatic cause, mean (SD)
1-4 weeks	n = 77	n = 57
PE	-1.30 (1.69)	-1.34 (1.68)
APE	1.72 (1.25)	1.75 (1.25)
1-3 months	n = 79	n = 58
PE	-1.32 (1.89)	-1.54 (2.09)
APE	1.70 (1.53)	1.98 (1.67)
3-6 months	n = 54	n = 40
PE	-1.14 (1.93)	-1.23 (2.13)
APE	1.71 (1.45)	1.86 (1.61)
6-12 months	n = 46	n = 32
PE	-0.71 (1.58)	-1.01 (1.42)
APE	1.32 (1.11)	1.36 (1.08)
12-24 months	n = 36	n = 29
PE	-1.22 (1.34)	-1.36 (1.32)
APE	1.45 (1.07)	1.55 (1.08)
>24 months	n = 21	n = 16
PE	-2.37 (2.37)	-1.76 (1.84)
APE	2.59 (2.13)	2.02 (1.51)

PE = prediction error, APE = absolute prediction error

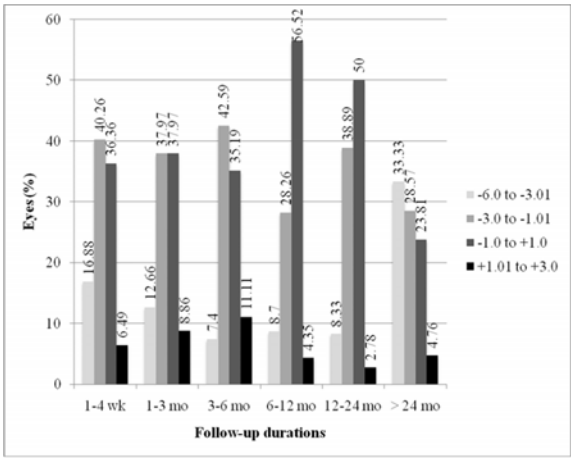

Fig. 1 Distribution of prediction error (diopters) for each follow-up duration.

Table 3. Prediction error and absolute prediction error in bag and sulcus

	All cause		Non-trauma		Trauma	
	Bag (n = 47)	Sulcus (n = 30)	Bag (n = 33)	Sulcus (n = 23)	Bag (n = 14)	Sulcus (n = 7)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
PE	-0.87 (1.66)	-2.02 (2.13)	-1.10 (1.83)	-2.28 (2.33)	-0.33 (1.01)	-1.16 (0.93)
95% CI	-1.36, -0.38	-2.82, -1.23	-1.74, -0.45	-3.3, -1.28	-0.92, 0.25	-2.02, -0.3
APE	1.41 (1.22)	2.27 (1.84)	1.64 (1.33)	2.6 (1.95)	0.85 (0.6)	1.19 (0.87)
95% CI	1.05, 1.77	1.59, 2.97	1.17, 2.12	1.76, 3.45	0.5, 1.2	0.4, 2

PE = prediction error, APE = absolute prediction error

studies reported that SRKII formula had more post-operative hyperopic error compared to SRK/T formula[9,10]. This may explain the more positive value of mean PE from the previous studies, which calculated from both SRKII and SRK/T formulas.

The Infant Aphakic Treatment Study[11] also provided the mean absolute prediction error of 1.4±1.1D at one month of follow-up when calculated by SRK/T formula, but the mean age of infants of only 2.5 months maybe too young to compare with our study.

We assumed that the patients with traumatic cataract usually had corneal lacerations needed repair would result in corneal astigmatism from sutures after the surgery and scars in long term. A comparison between the non-traumatic and traumatic causes showed a significant difference of PE at some periods of follow-up but inconclusively. The inconclusive result on the affects of trauma to the post-operative refraction in our study may due to the limitations in the number of patients.

Many studies reported that the rate of myopic shift in pseudophakic eyes in the younger patients at the age of surgery is higher as compared to the older, in which is due to the more axial elongation[2,3,12-14] and remains until around the age of eight[12,14]. In this study, the mean PE seemed to be close to zero at the period of three to six months after surgery, but then showed more myopic with times as the axial length increased. Moreover, non-traumatic cataracts, which underwent surgery, showed more myopic shift than the traumatic cataracts. This maybe explained by the median age of traumatic cataract patients, which was higher than those non-traumatic cataract patients (6.54 vs. 4 years).

Notwithstanding, contributing factors of the prediction error are various. The biometry measurement; keratometry and axial length values, which mainly depend on patient's cooperation and technician's measurement techniques, also play an important role in the accuracy of IOL calculation, together with the post-operative refraction technician who is the key person in the refractive evaluation.

Limitations in the present study were the retrospective nature of the data and limited number of the patients.

Conclusion

The present study demonstrated the post-operative myopic results from IOL calculation using SRK/T formula. The more PE and myopic shift was observed in the non-traumatic cataracts compared to the traumatic cataracts, due to the younger age at surgery. The PE of IOL implantation in sulcus showed two folds more than in the bag. After six months of follow-up, just below half of the patients achieved the accepted prediction error, which was related to target refraction. These findings suggest that we should aim pre-operatively for more hyperopic targets and consider IOL implantation in the bag to decrease the postoperative prediction error in the use of SRK/T formula for pediatric cataract patients.

What is already known on this topic ?

There are few studies that proposed the value of prediction error of IOL calculation by SRK/T formula in pediatric cataracts, and the values are still on the contrary.

What this study adds ?

This study shows the prediction error in subgroups of pediatric cataract patients: traumatic; non-traumatic; bag; and sulcus implantations, making the comparisons more obvious and proposes the suggestions for the accurate refraction after the surgery using SRK/T formula.

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Potential conflicts of interest

None.

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ความแม่นยำในการคำนวณค่าเลนส์แก้วตาเทียมจากสูตร SRK/T ในผู้ป่วยเด็กที่เป็นต้อกระจก

สุขุมาล ธนไพศาล, พรรณทิพา ว่องไว, วรัชญา พันธุ์พฤกษ์, สิรินยา สุวรรณราช

วัตถุประสงค์: เพื่อศึกษาความแม่นยำของการคำนวณค่ากำลังเลนส์ตาเทียมในเด็กจากสูตร SRK/T โดยแสดงเป็นค่าความคลาดเคลื่อนของค่ากำลังสายตา

วัสดุและวิธีการ: การศึกษาแบบย้อนหลังในผู้ป่วยเด็กที่ได้รับการผ่าตัดต้อกระจกและใส่เลนส์ตาเทียมปี พ.ศ. 2549-2556 โดยเทียบค่ากำลังสายตาหลังการผ่าตัดที่วัดได้จริงกับค่ากำลังสายตาที่คาดการณ์ไว้จากการคำนวณด้วยสูตร SRK/T เรียกว่าค่าความคลาดเคลื่อนของค่ากำลังสายตา

ผลการศึกษา: จากผู้ป่วยทั้งหมด 106 คน คิดเป็น 139 ตา อายุเฉลี่ยขณะผ่าตัด คือ 4.56 ปี (ค่าพิสัยควอไทล์ 14) สาเหตุของต้อกระจกได้แก่ ไม่ทราบสาเหตุ 85 ตา (ร้อยละ 61.2) รองลงมา คือ จากอุบัติเหตุ 36 ตา (ร้อยละ 25.9) มีการใส่เลนส์ตาเทียมพร้อมกับการผ่าตัดต้อกระจก 87 ตา (ร้อยละ 62.6) ค่าเฉลี่ยของค่าความคลาดเคลื่อนโดยรวมคือ -1.32±1.89 ไดออปเตอร์ (ช่วงเชื่อมั่น 95%; -7.78 ถึง 2.24) และเมื่อคิดตามที่ 1-3 เดือนหลังการผ่าตัดพบค่าความคลาดเคลื่อนโดยรวมในการใส่เลนส์ในถุงหุ้มเลนส์และร่องหลังรูม่านตา -0.87 และ -2.02 ไดออปเตอร์ตามลำดับ ในกลุ่มต้อกระจกที่ไม่ใช่จากอุบัติเหตุมีค่าความคลาดเคลื่อนในการใส่เลนส์ในถุงหุ้มเลนส์และร่องหลังรูม่านตา -1.1 และ -2.28 ไดออปเตอร์ตามลำดับ ในขณะที่กลุ่มต้อกระจกจากอุบัติเหตุมีค่าความคลาดเคลื่อนคิดเป็น -0.33 และ -1.16 ไดออปเตอร์ตามลำดับ ค่าความคลาดเคลื่อนหลังการผ่าตัดที่อยู่ในช่วง +/-1 ไดออปเตอร์ถือว่ายอมรับได้ ซึ่งคิดเป็นร้อยละ 37.97 เมื่อวัดที่ระยะเวลา 1-3 เดือน

สรุป: ค่าสายตาหลังการผ่าตัดทำให้ได้ค่าสายตาสั้นกว่าที่คาดการณ์ไว้ ดังนั้นการเลือกค่าเลนส์ที่มีค่าสายตายาวมากขึ้นและการใส่เลนส์ในถุงหุ้มเลนส์จะช่วยลดค่าความคลาดเคลื่อนของค่าสายตาเมื่อคำนวณจากสูตร SRK/T ในผู้ป่วยเด็กที่เป็นต้อกระจก