·Clinical Research·

Refractive accuracy after intraocular lens implantation in pediatric cataract

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Abstract

• AIM: To analyze the factors that influence the prediction error (PE) after intraocular lens (IOL) implantation in pediatric cataract.

• METHODS: The medical records of cataract patients of no more than 14 years old who had primary IOL implantation were reviewed from 2006 to 2010. The PE, absolute value of PE (APE), and predictability between in different axial length, mean corneal curvature, corneal astigmatism, and age at the surgery were analyzed.

• RESULTS: Seventy-five children (119 eyes) were included, with a mean age of (5.09± 2.54) years. At the follow-up of (1.19± 0.69) months, the mean postoperative PE was (-0.22± 1.12) D, and APE was (0.87± 0.73)D. The PE in eyes with an axial length >20mm but ≤22mm were significantly under-corrected than that in eyes with longer axis, and the APE in eyes with an axial length ≤20mm was more obvious compared with the others. The correlations between PE and axial length, as well as corneal astigmatism, and between APE and axial length were significant. The predictability was significantly poorer in the eyes with an axial length ≤20mm than the others.

• CONCLUSION: The axial length is closely related with the PE after IOL implantation in pediatric cataract patients, especially when it is ≤ 20mm, PE is more significant. The formula that is more suitable to very short axial length should be explored.

• KEYWORDS: cataract; children; refraction; intraocular lens

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INTRODUCTION

It has become a common sense that extraction of cataract combined with intraocular lens (IOL) implantation is an effective treatment for this eye disease in children. Due to the varied biological characteristics [1,2], the surgical procedure in pediatric patients differs from that in adults. Not only the accuracy of postoperative refraction[3-7], but also the myopic shift [8-11] should be taken into consideration during the surgery for pediatric cataract. Moreover, postoperative target refraction remains controversial [12-14] because of the existence of myopic shift.

The eye of children, especially infants, has features of short axial length[15], steep corneal curvature [16], and the different proportion of eye in children from that in adult[17], which can impair the accuracy of refraction after IOL implantation in pediatric patients. Hoevenaars *et al* [14] indicated that the predicted error (PE) was mainly correlated with the corneal mean curvature (K value), contrary to the report by Tromans *et al* [15]. The factors that may affect the PE were investigated in this study.

SUBJECTS AND METHODS

Subjects Patients with pediatric cataract treated by cataract extraction combined with posterior capsulotomy, anterior vitrectomy and primary IOL implantation in the capsule at our institution from January 2006 to December 2010 were included in this study. Those who had combined persistent hyperplastic primary vitreous, traumatic cataract or congenital glaucoma, IOL implantation in the ciliary sulcus, incomplete data or loss of the follow-up were excluded. The postoperative refraction was recorded in 3 months after surgery avoiding to myopia shift.

Methods The axial length from anterior surface of cornea to anterior surface of retina, was measured by DGH 5100e A-scan ultrasound (DGH Technology Inc. Exton, PA), and the mean speed was 1529mm/s. Keratometry was also performed (OM-4, Topcon Co. Itabashi-ku, Tokyo, Japan or KM-500, Nidek, Hiroishi Gamagori, Aichi, Japan). General anesthesia was given to young children who were not cooperative through 10% chloral hydrate (0.5mL/kg). The SRK/T formula was used to predict the refractive outcome after the implantation of IOL. All patients had the surgery under general anesthesia. The procedure was performed as previously reported [18]. A foldable hydrophilic acrylic IOL (Akreos Adapt; Bausch and Lomb, San Dimas, California, USA) was implanted in the capsular bag.

Data of age at surgery, gender, axial length, corneal mean curvature, corneal astigmatism, predicted refraction and actual postoperative refraction were obtained. Postoperative PE was actual postoperative refraction subtracted by predicted refraction, which hinted the value of error and over-correction or under-correction. Meanwhile, APE was the index of the error degree. The predictability of refraction was graded as follows: APE ≤0.5D (Good), >0.5D but ≤1.0D (Moderate), and >1.0D (Poor).

Statistical Analysis The effects of axial length, age at surgery, K value and corneal astigmatism on PE and APE were analyzed by analysis of variance. If homogeneity of variances was not rejected, least significant difference (LSD) test was performed, while Dunnett's T3 test was carried out if homogeneity of variance assumption was not met. The multiple stepwise regression analysis was performed to evaluate the variables that better predicted PE and APE, in which the P of entering was 0.05, while the removing was 0.10. The partial correlation of Pearson's was made to evaluate the correlation between any two factors. The effect of the four factors on the predictability was analyzed by Chi-square test. SPSS 13.0 was used for statistical analysis, and $P\leqslant0.05$ was considered significant.

RESULTS

Among the total 75 patients (119 eyes) in this study, 37 (49.33%) were male, including 17 with unilateral cataract (17/31, 54.84%) and 20 with bilateral cataract (20/44, 45.45%). The biological data (Table 1) were measured with general anesthesia in 21 patients (28.00%) who were too young to cooperate. Predicted refraction was significantly correlated with postoperative actual refraction (the coefficient =0.969, R^2=0.418, P<0.001, Figure 1).

There was significant difference in PE between eyes with an axis >20mm but ≤22mm in length and those with a longer axis. Although there was no significant different in PE between axis≤20mm and the other axis, the variability of the former was more obvious than that of the latter. Age at surgery, corneal mean curvature and corneal astigmatism were not related with PE (Table 2).

The effects of the factors on the APE were also investigated. Axial length was found to significantly affect APE, and APE in eye with an axis length of ≤20mm was significantly larger than the others (Table 2).

Table 1 Information of the included patients

Parameters	mean±SD	Median	95%CI
Age at surgery (a)	5.09±2.54	4.75	1.25-12.50
Axial length (mm)	22.43±1.72	22.38	18.78-26.16
Mean curvature (D)	43.40±2.08	43.16	39.88-50.22
Cornea astigmatism (D)	1.70±1.00	1.58	0.15-4.20
Predicted refraction (D)	0.08±0.98	-0.09	-1.00-4.07
Actual refraction (D)	0.30±1.46	0.25	-2.75-3.12
Follow-up (month)	1.19±0.69	1.00	0.50-3.00
Predicted error (D)	-0.22±1.12	-0.25	-2.39-2.55
Absolute value of predicted error (D)	0.87±0.73	0.75	0.01-2.57

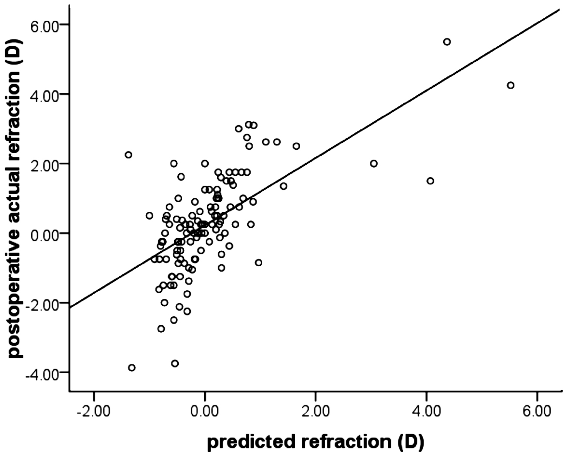

Figure 1 Correlation between the predicted refraction and the postoperative actual refraction.

Through multiple linear regression, PE was observed to be positively correlated with axial length and corneal astigmatism; the coefficient was 0.244 (P<0.001) and 0.230 (P=0.018), respectively, and the R^2 was 0.163 (P=0.018). APE was only negatively correlated with axial length; the coefficient was -0.121 (P=0.002), and the R^2 was 0.081 (P=0.002). Partial correlation analysis showed that there was significant correlation between corneal mean curvature and age at surgery, axial length, corneal astigmatism, respectively, as well as between axial length and age at surgery; the R^2 was -0.195 (P=0.017), -0.213 (P=0.010), 0.190 (P=0.019) and 0.252 (P=0.003), respectively.

The predictability was good in 36.1% of the eyes and moderate in 28.6%. The effect of axial length on the predictability of error was significant (P=0.016). The predictability was poorest in the shortest axial length group (Figure 2).

DISCUSSION

The eye with pediatric cataract is usually featured with soft eye wall, thin sclera, short axis and steep corneal curvature in children. The younger the patient is, the more obvious the features are. The change in corneal curvature in infants at postnatal 6 months is most significant, and slows down after

Table 2 Influences of different factors on the predicted error and absolute predicted error

Parameters	Predicted error (PE)		Absolute predicted error (APE)	
	$\bar{x}\pm s$	*P*	$\bar{x}\pm s$	*P*
Age at surgery (a)		0.462		0.879
≤2 (*n*=9)	-0.54±0.98		0.90±0.60	
>2 but ≤4 (*n*=33)	-0.28±1.21		0.95±0.78	
>4 but ≤6 (*n*=48)	-0.28±1.00		0.82±0.63	
>6 (*n*=29)	0.05±1.23		0.87±0.86	
Axial length (mm)		<0.001		0.003
≤20 (*n*=11)	-0.31±1.87		1.59±0.91[a,c,f]	
>20 but ≤22 (*n*=38)	-0.84±0.81[b,d]		0.91±0.73	
>22 but ≤24 (*n*=52)	0.00±0.94		0.71±0.61	
>24 (*n*=18)	0.51±0.98		0.83±0.71	
Mean curvature (D)		0.461		0.269
≤42 (*n*=28)	-0.28±1.27		0.95±0.87	
>42 but ≤46 (*n*=81)	-0.25±1.02		0.81±0.67	
>46 (*n*=10)	0.20±1.42		1.18±0.72	
Cornea astigmatism (D)		0.028		0.203
≤1.0 (*n*=34)	-0.35±0.79		0.70±049	
>1.0 but ≤1.59 (*n*=26)	0.13±1.11		0.79±0.78	
>1.59 but ≤2.45 (*n*=28)	-0.66±1.15		0.97±0.90	
>2.45 (*n*=31)	0.03±1.28		1.05±0.71	

[a]*P*=0.005 *vs* >20mm but ≤22mm group; [c]*P*=0.005 [b]*P*<0.001 *vs* >24mm group; [d]*P*<0.001 [f]*P*<0.001 *vs* >22mm but ≤24mm group.

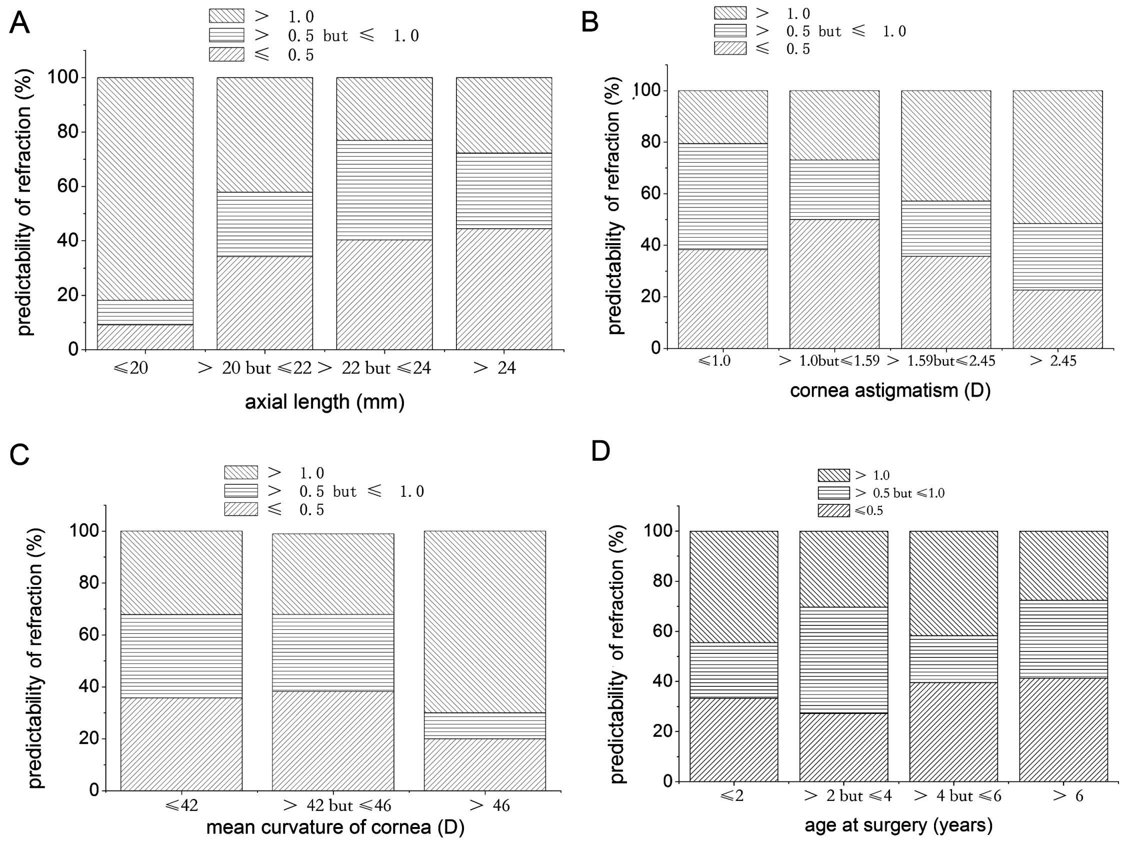

Figure 2 Effect of different factors on the predictability of refraction A: Different axial length; B: Different cornea astigmatism; C: Different mean curvature of cornea; D: Different age at surgery.

age of 6 months [2]. The axis increases rapidly in the first 2 years, and reaches the adult level at approximately 15 years old [7]. With respect to the formula, the theoretical formula seems to be most accurate, especially in eyes with a very long or very short axis [19]. However, the accuracy of the formula in the surgery for pediatric cataract is still being elucidated[6].

In our study, PE was mainly correlated with axial length. Although the PE in eyes with an axis length of ≤20mm was not significantly different from the others, the variability in these eyes was largest. This suggests that the formula of SRK/T may not be suitable to the short axis, possibly because the change in axial length of the eye mainly resulted from the change in axial length of vitreous cavity [17,20], and consequently the IOL position in very short eyes is significantly different from the predicted position according to the formula. Many accuracy formulas of the third or fourth generation have been used to evaluate the IOL position for adult patients according to each parameter of the eye [21], which may also be unsuitable for pediatric patients with a very short axis, and even adult patients with microphthalmos[22]. In addition, the diameter of acrylic IOLs is 10.5mm-11.0mm, which is designed for adults. In children whose eyes are in development, the diameter of their lens is 6.00mm at birth, 6.80mm at 2 months old, 7.1mm at 3 months, 7.66mm at 6-9 months, 8.4mm at 21 months, 8.5mm at 2-5 years, and 9.3mm at 16 years [23]. Therefore, implantation of an IOL into pediatric eyes would stretch the anterior capsule into an oval shape, parallel with the IOL haptics [24]. It is possible that the haptics become more distorted compared with in adults, so that the position of the optics of IOL changes, leading to the more PE in pediatric eyes.

In terms of APE, the results reported by Tromans *et al*[15] are similar to our findings, but Hoevenaars *et al* [14] argued that the postoperative APE was mainly correlated with corneal mean curvature. It may be attributed to the interaction between the factors of corneal mean curvature, corneal astigmatism, axial length and age at surgery in the multiple linear regression. In addition, the sample number in the groups with a very short or very long axis was small, and as a result the variability in the group with an axial length ≤20mm was more than the other groups.

Along with the increase in axial length, the mean PE shifted from negative to positive. The PE in the axis >20mm but ≤22mm was significantly different from that in the longer axis, suggesting that the refraction of implanted IOL is liable to be over-corrected in the eyes with a comparatively long axis, but under-corrected in those with a very short axis in children. On the other hand, the increase in axial length can decrease APE. The APE was highest in eyes with a very short axis, indicating the lowest accuracy. The result can be verified through the effect of a short axis on the predictability. The multiple linear regression may also manifest the effect of axial length on PE and APE.

In this series, there were other factors that may introduce PE. The visual axis could not be exactly determined when the pediatric patients were under general anesthesia. The axial length measured by contact A-scan ultrasound can also introduce the error because of the thinner and softer eye wall in children that is prone to deformation under pressure[25]. The refraction may have a change of 2.5D-3.0D following 1mm of change in axial length. The younger the patient was, the shorter the axial length was, which also increased the effect of axial length on the PE. Moreover, measurement of the corneal curvature in uncooperative children using a hand-held keratometer cannot ascertain the real centralization and orthotropia.

In conclusion, the PE is probably correlated with axial length in pediatric eyes with cataract surgery and IOL implantation. Under-corrected refraction, errors and poor predictability more frequently occur in eyes with a very short axis. Measurement approaches that introduce fewer errors should be chosen. More accurate formulas are needed for such pediatric and infant patients.

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