· Clinical Research ·

Effects of pediatric cataract surgery on the axial length/corneal radius ratio and choroidal thickness in school-age children: a prospective cohort study

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Abstract

● **AIM:** To investigate the effects of cataract surgery on the axial length/corneal radius (AL/CR) ratio and choroidal thickness (CT) in school-age children and to analyze the underlying mechanisms.

● **METHODS:** This prospective cohort study enrolled school-age children who underwent phacoemulsification with intraocular lens (IOL) implantation between September 2024 and February 2025. The right eyes of bilateral cases and the affected eyes of unilateral cases were classified as Group A. Within this group, eyes implanted with trifocal IOLs were designated as Subgroup A1, whereas those receiving monofocal IOLs were designated as Subgroup A2. The contralateral healthy eyes of the unilateral cases formed Group B. Axial length (AL) and corneal curvature were measured using the IOL Master 700. CT was assessed using swept-source optical coherence tomography.

● **RESULTS:** A total of 50 eyes from 32 patients (Subgroup A1, n=21, 8.38±2.36y; Subgroup A2, n=11, 7.55±2.16y; Group B, n=18, 8.22±2.44y) were included in the study. Preoperatively, AL was markedly shorter in Group A compared to Group B (P<0.05), but there was no notable difference in the AL/CR ratio (P=0.144). During the follow-up period, neither the AL/CR ratio nor CT demonstrated any notable changes within Group A (all P>0.05). Conversely, Group B showed a considerable increase in the AL/CR ratio and a pronounced reduction in CT, both statistically significant (all P<0.05). No notable differences were observed between Subgroups A1 and A2 in any of the measured parameters. Correlation analysis revealed meaningful negative correlations between AL, AL/CR ratio, and central subfield choroidal thickness (CSCT) in Group A at 1mo postoperatively and at the final follow-up (P<0.05). Still, no correlation was found among the changes in these parameters over the follow-up period.

● **CONCLUSION:** In the early postoperative period, operated eyes of school-aged children show a stable AL/CR ratio and CT. Although a stable structural negative correlation between these two parameters is observed in operated eyes, the longitudinal coordinated relationship is disrupted, which may be related to the loss of accommodative function. Longer-term follow-up is needed to corroborate these findings.

● **KEYWORDS:** pediatric cataract; axial length/corneal radius ratio; choroidal thickness; intraocular lens

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INTRODUCTION

Pediatric cataract is a leading cause of vision loss and visual function impairment in children worldwide[1]. Currently, phacoaspiration combined with intraocular lens (IOL) implantation has become the standard treatment for cataracts. In contrast to the stable ocular anatomy of adults, the pediatric eye remains in a dynamic state of development. Surgical intervention and IOL implantation may interfere with its normal refractive development, with postoperative myopic shift being a particularly prominent concern[2]. This phenomenon is characterized by a progressive alteration in refractive status toward myopia, which can significantly compromise long-term visual prognosis. While the underlying mechanism is intimately linked to abnormal axial length

(AL) elongation, it is critical to note that corneal curvature in children also undergoes significant changes concurrently[3]. For this reason, the axial length/corneal radius (AL/CR) ratio is considered a superior and more holistic biometric parameter, as it facilitates a more comprehensive evaluation of the eye's overall refractive structural alterations[4].

Currently, monofocal IOLs with simple optical designs remain the mainstream choice for pediatric cataract surgery[5]. However, due to the loss of ciliary muscle accommodative function postoperatively, children often rely on optical aids such as spectacles to meet visual demands at different distances. Multifocal IOLs, utilizing diffractive or refractive optical designs to distribute light to multiple focal points, have been proven to effectively improve spectacle independence and quality of life in adult patients[6]. With advances in micro-incision surgical techniques and the increasing sophistication of multifocal IOL designs, their application is gradually extending to the pediatric population. Some researchers suggest that these lenses may slow AL growth through a myopic defocus effect[7]. Nevertheless, the mechanisms regulating ocular development after cataract surgery in children are far more complex than in adults. Furthermore, there is a lack of systematic research on key postoperative refractive biological parameters, specifically the AL/CR ratio and choroidal thickness (CT). Therefore, this prospective cohort study was designed to systematically observe early changes in the AL/CR ratio and CT in school-age children following cataract surgery with different types of IOL implantation. It also aims to explore the underlying physiological mechanisms, seeking new interventional directions to delay postoperative myopic progression.

PARTICIPANTS AND METHODS

Ethical Approval The study protocol was approved by the Ethics Committee of Beijing Children's Hospital (Approval No. 2024-Y-216-D) and the Ethics Committee of Shunyi Maternal and Children's Hospital of Beijing Children's Hospital (Approval No. 2024-047-1). This study followed the principles of the Declaration of Helsinki and was registered on the Chinese Clinical Trial Registry (ChiCTR identifier: 2500105441). Written informed consent was obtained from the parents of all enrolled children.

Participants This study prospectively enrolled children with cataract treated at Beijing Children's Hospital and Shunyi Maternal and Children's Hospital of Beijing Children's Hospital from September 2024 to February 2025. Subjects were eligible if they were between 5 and 14 years old, had a cataract requiring surgery, and were expected to comply with follow-up visits. Those with a prior history of ocular trauma or surgery, significant ocular or systemic comorbidities, or anticipated poor cooperation during examinations were excluded. The right eyes of bilateral cases and the affected eyes of unilateral cases were classified as Group A. Detailed information regarding the characteristics of both trifocal and monofocal IOLs was provided to the parents or guardians of all patients. The choice of IOL type was non-randomized and was made by the parents or guardians, primarily based on financial considerations. According to the selected IOL type, patients were categorized into two subgroups: Subgroup A1 comprised children who received trifocal IOLs, and Subgroup A2 included those who received monofocal IOLs. The contralateral healthy eyes of unilateral cases served as Group B.

Preoperative Examinations and Intraocular Lens Power Calculations A comprehensive ophthalmic and systemic evaluation was performed preoperatively to exclude any surgical contraindications. A detailed ocular examination was performed under mydriasis by the operating surgeon using a slit-lamp microscope and direct ophthalmoscopy.

Before dilation, a single trained investigator performed ocular biometry using the IOL Master 700 (Carl Zeiss Meditec AG, Germany) in the "Phakic" mode. The following parameters were measured: central corneal thickness, anterior chamber depth (ACD), lens thickness (LT), flat keratometry (K_{flat}), steep keratometry (K_{steep}), and AL. The AL/CR ratio was subsequently calculated by statistical software.

Two types of trifocal IOLs, AT LISA tri 839MP (Carl Zeiss Meditec AG, Germany) and AT LISA tri toric 939MP (Carl Zeiss Meditec AG, Germany), were used in patients of Subgroup A1. Patients of Subgroup A2 were implanted with monofocal IOLs, iSert® 250 (HOYA Medical Singapore Pte. Ltd., Singapore), and AT TORBI 709M (Carl Zeiss Meditec AG, Germany). A toric IOL was selected when the corneal astigmatism exceeded 1.50 diopters (D). The IOL power and axis were calculated using the Barrett Universal II formula available on the online calculator. Mild undercorrected hyperopia refraction was determined based on the child's age and the refractive power of the fellow eye[8].

Surgical Technique All patients were operated on under general anesthesia by the same experienced pediatric cataract surgeon (Leng F). An approximately 3.0 mm scleral tunnel incision was first created posterior to the limbus, and the anterior chamber was injected with sodium hyaluronate 1.5%. After performing a centered anterior continuous curvilinear capsulorhexis (approximately 5.5 mm), phacoaspiration of the lens material was completed, followed by irrigation/aspiration of cortical remnants and posterior capsule polishing. The IOL was then placed in the capsular bag and adjusted to achieve optimal centration. In the case involving a toric IOL, the IOL was rotated to align with the corneal markings. Finally, the scleral tunnel incision was sutured, and the position of the IOL was verified.

Table 1 Preoperative basic characteristics mean±SD

Parameters	Subgroup A1	Subgroup A2	Group B	*P*
Eyes (*n*)	21	11	18	
Age (y)	8.38±2.36	7.55±2.16	8.22±2.44	0.625
Central corneal thickness (μm)	551.10±37.12	553.91±44.90	549.72±43.28	0.965
ACD (mm)	3.58±0.25	3.43±0.42	3.54±0.25	0.425
White-to-white (mm)	12.01±0.54	11.97±0.40	12.14±0.43	0.571
LT (mm)	3.17±0.37	3.31±0.45	3.48±0.27	0.024[a]
AL (mm)	22.39±1.07	22.18±1.52	23.15±0.66	0.019[a]
K_{flat} (D)	42.60±1.30	42.49±1.49	42.33±1.54	0.842
K_{steep} (D)	44.61±1.79	44.79±2.25	43.69±1.89	0.229
AL/CR ratio	2.890±0.112	2.864±0.120	2.949±0.100	0.144

ACD: Anterior chamber depth; LT: Lens thickness; AL: Axial length; K_{flat}: Flat keratometry; K_{steep}: Steep keratometry; D: Diopter; AL/CR: Axial length/corneal radius; SD: Standard deviation. [a]$P<0.05$.

Postoperative Treatment and Examination Postoperative treatment included topical anti-inflammatory and antibiotic eye drops. Refractive correction with spectacles was initiated 1mo postoperatively. Eyes in Subgroup A1 received single-vision glasses, and those in Subgroup A2 received bifocal glasses. Patients were scheduled for follow-up at 1d, 1wk, 1mo, 3mo, 6mo, and every 6mo postoperatively. The surgeon assessed anterior segment recovery using a slit-lamp microscope at each visit. Ocular biometry with the IOL Master 700 was repeated following the preoperative protocol: the "Pseudophakic" mode was selected for operated eyes, and the "Phakic" mode for healthy eyes, and the AL/CR ratio was calculated accordingly. Following full pupil dilation with compound tropicamide eye drops (Shenyang Xingqi Pharmaceutical Co., Ltd., China), choroidal images were captured using swept-source optical coherence tomography (TowardPi Medical Technology, China). To minimize the effects of diurnal variation, measurements were conducted between 9:00 *a.m.* and 11:00 *a.m.* Only optical coherence tomography images centered on the fovea with a signal strength of seven or higher were included in the analysis. CT was defined as the vertical distance from the outer border of the retinal pigment epithelium to the inner border of the choroidoscleral interface. The mean CT was automatically measured using the device's software within three subfields centered on the fovea: the central subfield choroidal thickness (CSCT, 0–1 mm diameter), the inner subfield choroidal thickness (ISCT, 1–3 mm diameter), and the outer subfield choroidal thickness (OSCT, 3–6 mm diameter).

Statistical Analysis Statistical analysis was performed using IBM SPSS software (version 26.0). Continuous variables were summarized as mean±standard deviation (SD). For comparisons across the three groups, one-way analysis of variance (ANOVA) was employed. In instances where ANOVA indicated significance, post-hoc pairwise comparisons were subsequently carried out applying the Dunn-Bonferroni correction. Temporal changes within each group were evaluated using paired *t*-tests. The associations between variables were assessed using Pearson's correlation coefficient (*r*). A *P* value less than 0.05 was considered statistically significant.

RESULTS

Preoperative Characteristics A total of 32 congenital cataract patients (50 eyes) were enrolled in this study, including 18 unilateral cases and 14 bilateral cases. Among these, 21 eyes were assigned to Subgroup A1, 11 eyes to Subgroup A2, and 18 eyes to Group B. As shown in Table 1, the three groups were comparable in all preoperative characteristics except for AL and LT (all $P>0.05$). No statistically relevant differences were observed between Subgroup A1 and Subgroup A2 for any parameter (all $P>0.05$). The mean postoperative follow-up period was 7.89±3.63mo.

AL/CR Ratio Table 2 presents selected IOL Master parameters and the AL/CR ratio postoperatively. At 1mo postoperatively, compared to Group B, Group A demonstrated a notable deepening of the ACD and a reduction in LT postoperatively, with these changes contributing to marked inter-group differences (all $P<0.001$). Furthermore, AL decreased by 0.02±0.12 mm in Subgroup A1 and by 0.07±0.11 mm in Subgroup A2, whereas it increased by 0.03±0.04 mm in Group B. A significant difference in AL change was found among the three groups ($P=0.045$). In contrast, neither corneal curvature nor the AL/CR ratio differed across groups (all $P>0.05$).

From 1mo postoperatively to the final visit, all three groups exhibited substantial AL growth (all $P<0.05$). Regarding corneal curvature, only K_{flat} in Subgroup A1 decreased significantly ($P=0.022$), while no significant changes were observed in K_{flat} for Subgroup A2 and Group B, nor in K_{steep} for any group (all $P>0.05$). As for the AL/CR ratio, a distinctly different pattern emerged between the groups. The AL/CR ratio in Group B increased significantly ($P<0.001$) but remained stable in Group A. By the conclusion of the study, the disparity in the AL/CR ratio among the groups attained statistical

Table 2 Comparison of IOL master characteristics mean±SD

Parameters	Subgroup A1	Subgroup A2	Group B	*P*
Eyes	21	11	18	
ACD (mm), 1mo post-op	4.08±0.30	4.50±0.60	3.58±0.26	<0.001[b]
LT (mm), 1mo post-op	1.12±0.09	0.77±0.23	3.46±0.26	<0.001[b]
K_{flat} (D)				
1mo post-op	42.68±1.44	42.60±1.57	42.22±1.75	0.646
Final visit	42.53±1.36	42.37±1.64	42.32±1.57	0.908
P	0.022[a]	0.192	0.142	
K_{steep} (D)				
1mo post-op	44.68±1.86	44.86±2.27	43.61±1.97	0.162
Final visit	44.50±1.82	44.70±2.17	43.63±1.93	0.257
P	0.053	0.051	0.660	
AL (mm)				
1mo post-op	22.36±1.00	22.11±1.49	23.18±0.65	0.009[b]
Final visit	22.44±0.98	22.18±1.47	23.33±0.62	0.003[b]
P	0.001[b]	0.037[a]	0.001[b]	
AL/CR ratio				
1mo post-op	2.892±0.110	2.861±0.152	2.946±0.109	0.161
Final visit	2.891±0.107	2.856±0.148	2.969±0.104	0.029[a]
P	0.870	0.316	<0.001[b]	

IOL: Intraocular lens; ACD: Anterior chamber depth; LT: Lens thickness; K_{flat}: Flat keratometry; K_{steep}: Steep keratometry; D: Diopter; AL: Axial length; AL/CR: Axial length/corneal radius; SD: Standard deviation; post-op: Post-operative. $^aP<0.05$; $^bP<0.01$.

significance (P=0.029). However, a direct comparison between the two surgical subgroups (A1 *vs* A2) did not reveal any marked difference.

Choroidal Thickness On the first postoperative day, initial measurements indicated that Group A exhibited thicker CT than Group B across all measured subfields. These observed differences, however, were not statistically significant (all P>0.05). By the final visit, distinct inter-group differences in CT were observed in all subfields (all P<0.001). During the follow-up period, CT in Group B showed a progressive thinning in all subfields (all P<0.05). In contrast, CT remained stable in both Subgroup A1 and Subgroup A2, with no notable differences between the two surgical subgroups in any subfield (all P>0.05), as detailed in Table 3. As illustrated in Figure 1, the temporal trends of CT change were consistent across all subfields for each group. CT in Group A remained relatively stable at all postoperative time points, whereas CT in Group B exhibited a progressive decline.

Relationships between AL/CR ratio and CSCT The changes (Δ) were calculated as the value at the final visit minus the value at 1mo postoperatively. Marked negative correlations were found between ΔAL, ΔAL/CR ratio, and ΔCSCT only in Group B (all P<0.05), as shown in Table 4. No meaningful correlations were detected among the changes of these parameters within Group A. However, at individual postoperative time points within Group A, significant negative correlations were consistently observed between AL, AL/CR ratio, and CSCT (all P<0.05; Figure 2).

Table 3 Comparison of choroidal thickness across different subfields mean±SD

Parameters	Subgroup A1	Subgroup A2	Group B	*P*
CSCT (μm)				
1d post-op	365.86±84.87	378.45±118.41	325.17±73.10	0.226
Final visit	368.29±69.78	391.27±111.90	294.00±66.05	0.003[b]
P	0.816	0.253	0.012[a]	
ISCT (μm)				
1d post-op	351.67±78.25	366.00±110.64	316.17±67.59	0.238
Final visit	359.86±64.59	380.18±103.14	290.61±68.61	0.004[b]
P	0.398	0.169	0.034[a]	
OSCT (μm)				
1d post-op	322.90±67.24	329.18±94.29	292.28±71.12	0.291
Final visit	323.76±55.57	349.09±78.74	269.33±56.38	0.003[b]
P	0.926	0.138	0.008[b]	

CSCT: Central subfield choroidal thickness; ISCT: Inner subfield choroidal thickness; OSCT: Outer subfield choroidal thickness; SD: Standard deviation; post-op: Post-operative. $^aP<0.05$; $^bP<0.01$.

Table 4 Correlations of ΔAL and ΔAL/CR ratio with ΔCSCT

Parameters	ΔAL		ΔAL/CR ratio	
	r	*P*	*r*	*P*
ΔCSCT				
Group A1	0.048	0.837	-0.094	0.685
Group A2	0.181	0.593	0.056	0.870
Group B	-0.810	<0.001[b]	-0.657	0.003[b]

AL: Axial length; AL/CR: Axial length/corneal radius; CSCT: Central subfield choroidal thickness; Δ=value (final visit)-value (1mo post-op); post-op: Post-operative. $^aP<0.05$; $^bP<0.01$.

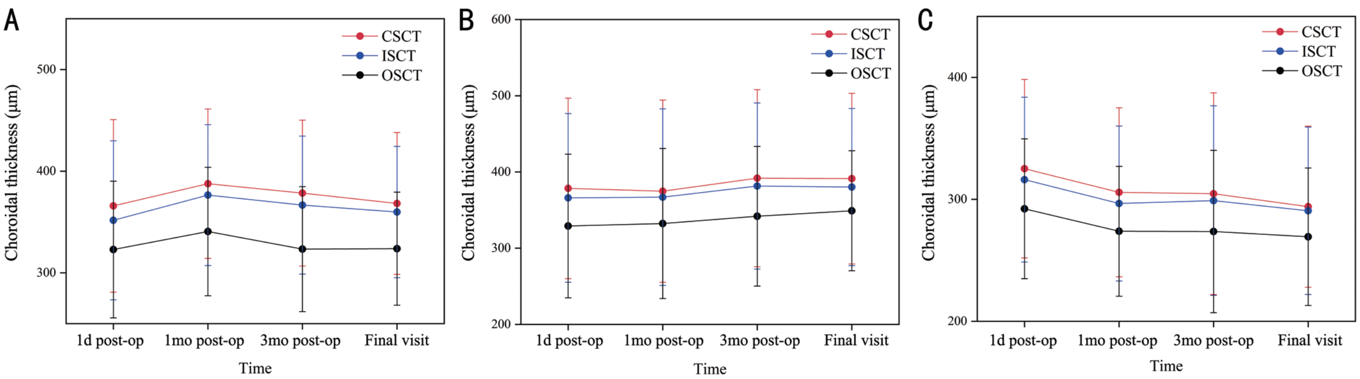

Figure 1 Line graphs of choroidal thickness across different subfields A: Subgroup A1: Implanted with trifocal IOL; B: Subgroup A2: Implanted with monofocal IOL; C: Group B: The contralateral healthy eyes of unilateral cases. CSCT: Central subfield choroidal thickness; ISCT: Inner subfield choroidal thickness; OSCT: Outer subfield choroidal thickness; IOL: Intraocular lens; post-op: Post-operative.

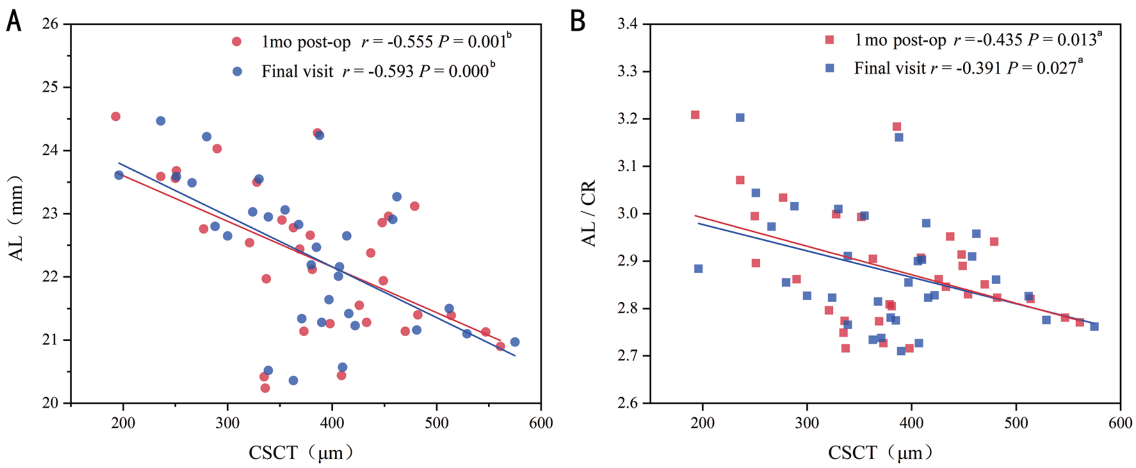

Figure 2 Scatter plots of correlations between AL, AL/CR ratio, and CSCT A: Relationships between AL and CSCT in Group A; B: Relationships between AL/CR ratio and CSCT in Group A. AL: Axial length; AL/CR: Axial length/corneal radius; CSCT: Central subfield choroidal thickness; post-op: Post-operative. $^{a}P<0.05$; $^{b}P<0.01$.

DISCUSSION

The management of postoperative refractive growth in children with cataracts remains a major clinical concern. A key challenge is effectively predicting and intervening in the myopic shift that often follows surgery. As these children lose ciliary muscle accommodation, conventional myopia control strategies based on accommodative theory may be less effective[9]. Clinically, the prevailing approach involves implanting an IOL with intentional hyperopic power to compensate for expected refractive alterations[10]. Nonetheless, the long-term accuracy of such predictions is inherently complex, as it is influenced by a multiplicity of dynamic and interrelated factors, including dynamic changes in AL and corneal curvature[8,11].

AL serves as a critical biometric parameter directly reflecting ocular elongation and is strongly correlated with refractive error variations[12]. Postoperative alterations in corneal curvature are known to occur, often attributable to factors inherent to the surgical procedure itself, such as incision size and location[13]. Therefore, the AL/CR ratio, which integrates these two pivotal optical components, is posited to furnish a more holistic and stable assessment of the eye's overall optical architecture[14]. This study observed the postoperative refractive development in school-age children with cataracts from the perspective of the AL/CR ratio and further analyzed potential underlying mechanisms.

Preoperative data showed that AL in Group A was significantly shorter than in Group B. This finding is inconsistent with the results of Capozzi *et al*[15]. This discrepancy may stem from differences in the severity of form deprivation and the age of onset[16]. The cloudy lens may lead to blurred retinal images, disrupt normal visual signaling, and thereby inhibit scleral growth, resulting in a developmental lag in axial elongation. A notable accompanying observation was that the AL/CR ratio itself demonstrated comparability across all three groups preoperatively. This may reflect a compensatory adjustment in corneal curvature aimed at preserving optical proportionality within the eye.

At 1mo postoperatively, Group A exhibited several anticipated changes: a considerable deepening of ACD, a corresponding reduction in LT, and a slight optical shortening of AL relative to preoperative measurements. The shortening of AL primarily reflected the impact of changes in intraocular refractive media after IOL replacement of the natural crystalline lens on optical biometry results. Therefore, the 1-month postoperative examination served as the baseline for assessing subsequent ocular growth in this study. Ultimately, all groups showed AL increase, but operated eyes grew more slowly than Group B, contrary to the expected catch-up growth. Specifically, the AL changes in Subgroup A1 were consistent with the findings of Du *et al*[17], while Subgroup A2 also showed slowed growth in this study. The reasons for these observed differences may include: 1) The period from 3 to 6y is a phase of rapid physiological AL growth in children, with growth entering a relatively slower phase after age 6[18]. The mean surgical age in Subgroup A2 was 7.55±2.16y, whereas Du *et al*'s[17] study involved children aged 3–6y. Similarly, Park *et al*[19] found that in unilateral cataract patients over 6 years old, AL growth in the pseudophakic eye was slower than in the contralateral phakic eye, aligning with our results. 2) Postoperative visual acuity improved significantly in Subgroup A2, with no cases of severe amblyopia, minimizing the interference from abnormal visual stimulation with ocular development[20]. 3) All children in Subgroup A2 were able to correctly wear and use their prescribed bifocal spectacles under guidance. The bifocal spectacles compensate for the loss of accommodative function by providing positive near addition, effectively reducing hyperopic defocus during near work, which may be an important reason for the slower axial elongation[21].

Furthermore, regarding the lack of a significant difference in AL between Subgroup A1 and Subgroup A2, we propose the following explanations. The strong compensatory effect of bifocal spectacles in Subgroup A2 may partially counteract the peripheral myopic defocus induced by the trifocal IOL in Subgroup A1[22]. In addition, AL development after pediatric cataract surgery is influenced by multiple confounding factors[23]. Consequently, the effect of a single IOL type may be diluted, ultimately leading to the failure to detect a statistically significant difference between the two surgical subgroups.

Current research on ocular growth after pediatric cataract surgery predominantly focuses on changes in AL, often overlooking the influence of corneal curvature variations on the development of the refractive system[24]. We also observed mild corneal curvature fluctuations: K_{flat} decreased significantly in Subgroup A1, and K_{steep} showed a decreasing trend in both surgical subgroups. The scleral tunnel incision preserved corneal stability, as evidenced by the absence of significant changes between preoperative and 1-month postoperative measurements. This finding suggests that postoperative corneal curvature evolution may be associated with physiological development, optical feedback, and other multifactorial influences[25]. This study found that although surgery and other factors can cause short-term fluctuations in both AL and corneal curvature, the AL/CR ratio in Group A demonstrated high stability between preoperative and 1-month postoperative measurements, confirming that the AL/CR ratio is a more reliable assessment parameter. During follow-up, the mean increase in the AL/CR ratio in Group B was 0.023, which falls within the normal physiological growth range for children of the same age[26]. The healthy contralateral eyes did not demonstrate any compensatory rise in the AL/CR ratio following the loss of accommodative function in their fellow surgical eyes. Both Subgroups A1 and A2 showed a notable increase in AL. A key finding, however, was the maintained stability of the AL/CR ratio within these subgroups. Collectively, these observations indicate that cataract surgery and IOL implantation, by altering the intraocular spatial structure, mechanical balance, and biochemical microenvironment, affect the natural developmental process of the refractive system, thereby delaying myopic shift.

The choroid is a vascular layer located between the retina and the sclera. It serves several critical physiological functions, paramount among which are the maintenance of metabolic homeostasis for the outer retinal layers and the regulation of ocular growth dynamics[27]. Consistent with the findings of Sen *et al*[28], this study also observed an increase in CT in operated eyes during the early postoperative period, with a coordinated trend of change across all subfields. This suggests that the choroid subfields in ocular growth regulation as a whole have particularly close associations between changes in the central and inner subfields. Unlike Group B, Group A did not exhibit significant choroidal thinning over time. Research by Li *et al*[29] showed an increase in CT following myopic excimer laser surgery, which was linked to a reduction in accommodative amplitude. In phakic eyes, contraction of the ciliary muscle not only mechanically influences the shape and biomechanical properties of the anterior sclera but can also induce a concomitant thinning of CT[30-31], aimed at maintaining retinal image quality. Prolonged near work leads to significant choroidal thinning. In pseudophakic eyes, the absence of accommodative activity cannot guide choroidal changes, which may be one of the protective factors slowing its thinning.

Selecting CSCT, the most sensitive CT subfield[32], for correlation analysis. The results revealed consistently strong negative correlations between AL, the AL/CR ratio, and CSCT at both 1mo postoperatively and the final visit within Group A. However, no meaningful correlation was found among the changes in these parameters over the follow-up period. In contrast, the variation observed in Group B followed the expected developmental pattern of a negative correlation[33]. This suggests that in the ocular maturation process following pediatric cataract surgery, CSCT does not simply vary in proportion to AL and the AL/CR ratio. A stable, structural negative correlation exists between them over the long term. Furthermore, the correlations between AL and CSCT were consistently more pronounced than those between the AL/CR ratio and CSCT, indicating a more direct relationship between AL and CSCT. The AL/CR ratio, as a composite parameter, may somewhat dilute the strength of its association with CSCT.

This study has several limitations. First, the non-randomized group assignment and unequal sample sizes between subgroups may introduce selection bias. Second, in Subgroup A2, different IOL platforms with distinct materials, haptic designs and optic edge profiles were used, which may have compromised cohort homogeneity and introduced confounding factors. Third, although this study was conducted at two centers, the overall sample size remains relatively small, and the follow-up duration is not adequate. This precludes any firm conclusions regarding long-term ocular development in children and limits the generalizability of the findings. Our study was designed to capture early postoperative changes; longer follow-up will be required to fully evaluate the effect of accommodative loss on myopia progression. Fourth, postoperative spectacle correction was not standardized between the two surgical subgroups. This may have confounded the comparison of ocular growth parameters and should be considered when interpreting the lack of significant differences between the subgroups. Future work will involve continued follow-up observation. Furthermore, multicenter, large-sample, randomized controlled trials with long-term follow-up are warranted to further elucidate the interactions among various factors, and to explore personalized refractive development prediction models based on the AL/CR ratio and choroidal biomarkers. In addition, future studies should standardize IOL type within each subgroup to improve homogeneity and credibility of this research. The ultimate goal is to achieve long-term, precise management of refractive status following pediatric cataract surgery.

In conclusion, this study provides preliminary observations on the refractive developmental trajectory following pediatric cataract surgery through dynamic monitoring of the AL/CR ratio and CT. In this short-term study of school-aged children after cataract surgery, we observed that operated eyes maintained a stable AL/CR ratio and CT during follow-up, whereas contralateral healthy eyes showed expected physiological myopic progression. No significant differences were found between the two surgical subgroups in any measured parameters. Cross-sectionally, operated eyes consistently exhibited significant negative correlations between AL/CR ratio and CT at postoperative 1mo and at the final follow-up. However, longitudinal change analysis revealed that the coordinated relationship between the ΔAL/CR ratio and ΔCT observed in healthy eyes was absent in operated eyes, suggesting that cataract surgery and IOL implantation may disrupt the physiological coupling between ocular elongation and choroidal changes. The loss of accommodative function may be a potential contributing factor, but this presumption requires further investigation. Given the small sample size and short follow-up duration, these findings are preliminary. Long-term, multicenter studies are necessary to confirm whether the observed stabilization of AL/CR ratio and CT in operated eyes can be translated into clinically meaningful retardation of myopic shift.

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