• Clinical Research •

Comparison of outcomes after early congenital cataract surgery in eyes with/without microcornea

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Abstract

• **AIM:** To find out intraoperative and postoperative outcomes of congenital cataract surgery in eyes with microcornea.

• **METHODS:** This retrospective consecutive case series study compared outcomes after congenital cataract surgery in eyes with/without microcornea. Infants (<1 year old) who underwent lensectomy surgery left aphakic were included. Microphthalmos was defined as an eye that has a horizontal corneal diameter less than or equal to 9.0 mm.

• **RESULTS:** There were 40 infants (54 eyes) in the microcornea group and 58 (87 eyes) in the control group. The two groups were age- and sex-matched. The microcornea group showed significantly smaller corneal diameter (P<0.001), steeper corneal keratometry (P=0.001), thinner lens thickness (P<0.001), and shorter axial length (AL, P<0.001). And microcornea increased the incidence of poor pupil dilation (P<0.01). The two groups showed no significant differences in postoperative intraocular pressure (IOP), best-corrected visual acuity, central corneal thickness (CCT), AL, and the incidence of strabismus and nystagmus at the last follow-up.

• **CONCLUSION:** Although microcornea have different features from normal ones, the one-year follow-up after surgery has shown that early surgical intervention for congenital cataracts in eyes with microcornea can result in favourable outcomes with an acceptable rate of postoperative complications. Regular follow-up and timely management of postoperative complications are crucial for successful outcomes.

• **KEYWORDS:** congenital cataract; microcornea; aphakic

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INTRODUCTION

Advancements in surgical instruments and techniques have increased the possibility of improving the visual acuity and quality of life of children with congenital cataracts through surgery. However, surgical treatment of congenital cataract presenting with microcornea remains challenging because of the small operation space and the difficulty of the operation, and is likely to cause glaucoma, visual axis opacity, retinal detachment, and other serious complications[1-5]. Although the efforts of surgeons have expanded the scope of surgery to include such cases, the relatively low incidence of this condition has meant that only a limited number of studies have evaluated cataract surgery in children with microcorneas[6-13]. The existing studies on this condition are essentially descriptive studies on complications, and the only studies with control groups had age-mismatched patients or included inconsistent surgical methods. Nevertheless, an understanding of the comprehensive anatomy and prevention and management of complications will empower surgeons to better prepare to avoid obstacles that could be encountered. Moreover, none of the previous studies compared the long-term prognosis between eyes with and without microcornea.

To better understand the clinical strategies for congenital cataract eyes with microcornea, we evaluated the surgical outcomes of patients who underwent early surgery within 1 year of age for congenital cataracts with or without a microcornea.

PARTICIPANTS AND METHODS

Ethical Approval This study was approved by the Wenzhou Medical University Institutional Review Board and adhered to the principles of the Declaration of Helsinki. This study is registered on www.clinicaltrial.gov (NCT03905044). Informed consents to participate in the study were obtained from participants'parents or legal guardian. For all manuscripts that include details, images, or videos relating to an individual

person, written informed consent for the publication of these details was obtained from their parents or legal guardian.

Participants This is a retrospective consecutive case series study. We included infants (<1 year old) who underwent lensectomy surgery left aphakic for congenital cataracts at the Paediatric Cataract Centre of the Eye Hospital of Wenzhou Medical University, Hangzhou, China, between 2016 and 2020. Detailed history, including prenatal and birth history, was obtained from the patient's parents. The inclusion criteria were as follows: 1) age at surgery <1 year old; 2) followed up for ≥3mo. The exclusion criteria were as follows: 1) eyes concurrent with glaucoma, uveitis, retinopathy of prematurity, traumatic cataract, aniridia, posterior persistent fetal vasculature causing stretching of the ciliary process, or tractional retinal detachment before surgery; 2) patients with systemic disorders such as Down's syndrome, Marfan syndrome; 3) history of previous ocular surgery. Patients with horizontal corneal diameter less than or equal to 9.0 mm were considered to have a microcornea and assigned to the microcornea group, and those with horizontal corneal diameter larger than 9.0 mm were assigned to the comparison group[7-9].

Eye Examinations All patients underwent eye examinations under sedation. In addition to preoperative examinations, patients were called for follow-up examinations on day 1, day 7, one month, and every three months. The anterior segment of the eye was evaluated with a handheld slit lamp, and cataract morphology was assessed again and recorded by reviewing the surgical videos. Posterior segment evaluation was performed using the Retcam digital imaging system and B scan. Horizontal corneal diameter was measured using a calliper from white to white before surgery. Central corneal thickness (CCT) was measured using a handheld ultrasonic pachymeter (Pachoen, Accutome, Inc.). Corneal keratometry (D) were measured using a handheld auto photokeratometer (HandyRef, NIDEK Co. Ltd., Japan). Axial length (AL), anterior chamber depth (ACD), and lens thickness were measured using a contact ultrasound A-scan (Axis Nano, Quantel Medical). The intraocular pressure (IOP) was measured using a handheld tonometer (Icare Finland Oy). Glaucoma was diagnosed if IOP was greater than 21 mm Hg with ≥1 of the following anatomical changes: 1) corneal enlargement; 2) asymmetrical progressive myopic shift coupled with enlargement of the corneal diameter and/or AL; 3) increased optic nerve cupping defined as an increase of ≥0.2 in the cup-to-disc ratio; 4) a surgical procedure was performed for IOP control. Aphakia was corrected postoperatively using spectacles. Postoperative visual acuity was assessed using Teller's acuity cards.

Surgical Procedures Before surgery, the pupil was dilated using a combination of tropicamide 0.5% and phenylephrine hydrochloride 0.5% phenylephrine hydrochloride. All patients underwent lensectomy and anterior vitrectomy *via* the limbal approach (two 1.0 mm incision at 2:30 and 9:30 o'clock) under general anaesthesia using a 23-gauge Venturi vacuum system (Centurion vision system, Alcon Laboratories, Inc.) by the same surgeon (Zhao YE). The incisions on both sides were closed with 10-0 nylon thread or absorbable thread. The diagnosis of a pre-existing posterior capsule defect (PCD) and posterior lenticonus was confirmed intraoperatively after uneventful aspiration of the lens cortex.

Visual Rehabilitation Retinoscopy was performed one week after operation and glasses were worn. After that, optometry was performed every three months and glasses were changed or rigid gas permeable contact lenses (RGP) was worn according to the degree. The type of lenses often depends on the parents' choice and the child's compatibility. Monocular patients patch the contralateral eye daily according to the age of the month, basically half of the waking time.

The occurrence of concurrent abnormalities and postoperative complications of patients in the two groups during the whole period of treatment was observed and the incidence was calculated.

Statistical Analysis A microcornea is a rare condition; therefore, statistical evaluations were performed individually for each eye of each participant. Generalized estimating equations (GEE) approach (SPSS 23, IBM, USA) was used to examine the univariate associations. This approach is appropriate for discrete longitudinal data because it allows for a within-subject repeated measures examination of change over time. Additionally, correction of variance estimates for correlated data within subjects greatly reduces the loss of information. Quantitative data were described using the median, minimum, and maximum values. Quantitative parameters between the two groups were compared using the Mann-Whitney *U* test. Categorical variables (sex and group) were compared using the Chi-square test. In all statistical tests, the level of significance was set at $P<0.05$, below which the results were considered statistically significant.

RESULTS

This study included 141 eyes of 98 patients. Preoperative clinical data, intraoperative characteristics, postoperative outcomes, and the incidence of complications were compared between the two groups. The demographic and preoperative characteristics of the two groups are shown in Table 1. The two groups were age- and sex-matched to allow consistent comparisons. CCT, ACD, and preoperative IOP were similar between the two groups (Table 1). The differences in the corneal diameter, lens thickness, and AL between the microcornea and control groups were statistically significant ($P<0.01$).

Cataract Types The distribution of cataract types is presented in Table 2. Cataracts in the microcornea group were more

Table 1 Demographics and baseline characteristics mean±SD (range)

Parameters	Microcornea	Comparison	*P*
n (patients/eyes)	40/54	58/87	
Male/eyes	26/28	33/54	0.856[a]
Female/eyes	14/26	25/33	
Eyes (right/left)	25/29	42/45	0.819[a]
Monocular surgery (patients)	26	29	
Age at surgery (mo)	3.6±1.7 (2, 7)	3.7±1.5 (1, 8)	0.525
Follow-up period (mo)	22.8±16.0 (1, 50)	28.4±14.1(1, 54)	0.294
Corneal diameter (mm)	8.7±0.4 (7.8, 9.0)	9.8±0.4 (9.2, 10.9)	<0.001[b]
Central corneal thickness (mm)	563.4±45.8 (413.0, 689.0)	562.8±41.0 (487.0, 705.0)	0.803
Corneal flat keratometry (D)	44.2±2.6 (39.0, 51.3)	42.5±2.2 (37.5, 48.3)	0.001[b]
Corneal steep keratometry (D)	46.4±2.7 (39.5, 53.0)	44.7±2.2 (39.3, 51.8)	0.001[b]
Anterior chamber depth (mm)	2.37±0.43 (1.60, 3.66)	2.53±0.52 (1.82, 4.03)	0.065
Lens thickness (mm)	2.90±0.72 (1.81, 5.25)	3.70±1.23 (1.76, 6.11)	<0.001[b]
Axial length (mm)	17.44±1.20 (15.22, 20.37)	18.50±1.29 (15.75, 24.98)	<0.001[b]
Intraocular pressure (mm Hg)	10.8±2.7 (6.1, 16.0)	11.1±2.5 (5.7, 16.0)	0.675

[a]Chi-square test; [b]Statistical significance.

frequently lamellar and nuclear cataracts, whereas the control group more frequently showed complete and lamellar cataracts. The frequency of complete cataracts was significantly lower in the microcornea group (P<0.001).

Concurrent Abnormalities and Postoperative Complications Table 3 shows the rate of concurrent abnormalities and postoperative complications in the two groups. The results suggest that microcornea increases the incidence of poor pupil dilation (P<0.01). Clinical outcomes analysed included IOP, best-corrected visual acuity, CCT, AL, and the incidence of strabismus and nystagmus at the last follow-up.

Surgical Outcomes The two groups showed no significant differences in the outcomes (Table 4).

Table 2 Cataract types in all study eyes *n* (%)

Cataract type	Microcornea	Control	*P*
Number	44	74	
Nuclear	13 (29.5)	15 (20.3)	0.630
Lamellar	19 (43.2)	21 (28.4)	0.202
Membranous	0	2 (2.7)	0.271
Complete	5 (12.2)	30 (34.5)	0.038[a]
Posterior polar	7 (17.1)	6 (8.1)	0.251

[a]Statistical significance.

Table 3 The incidence of concurrent abnormalities and postoperative complications *n* (%)

Complication	Microcornea	Control	*P*
Concurrent abnormalities			
Pre-existing posterior capsule defect	19 (35.2)	28 (32.1)	0.909
Persistent fetal vasculature	5 (9.3)	10 (11.5)	0.525
Strabismus	12 (22.2)	23 (26.4)	0.891
Nystagmus	13 (24.1)	22 (25.2)	0.699
Iris hypoplasia	6 (11.1)	10 (11.5)	0.890
Posterior lenticonus	0	2 (2.3)	0.261
Poor pupil dilation	15 (27.8)	6 (6.9)	0.008
Postoperative			
Secondary glaucoma	5 (9.3)	1 (1.1)	0.113
Visual axis opacification	2 (3.7)	8 (9.2)	0.213
Pupillary posterior synechiae	5 (9.3)	14 (16.1)	0.278

DISCUSSION

In our study, microcornea group has steeper corneal curvatures. Preoperative and postoperation CCT in eyes with microcorneas was not significantly different from that in the control group. Filous *et al*[13] has demonstrated a significantly higher CCT in eyes with microcorneas without any history of eye surgery and in healthy school-aged children (642.31±93.07 *vs* 553.58±33.12 μm). This discrepancy could potentially be due to the small sample size and the lack of age-matching (0.94±1.22 *vs* 2.7±3.0y). Age and cataract surgery have been identified as important factors that affect CCT. Simsek *et al*[14] found a negative correlation between the age at lensectomy and CCT. In addition, Lupinacci *et al*[15] reported a higher CCT in aphakic eyes than in unoperated eyes with congenital cataracts. Our findings are consistent with this trend. Bayoumi *et al*[16] demonstrated that children with aphakia and microcornea exhibit significantly elevated CCT compared to healthy controls. Specifically, the mean CCT in this patient group was 545.22±28.14 μm. Similarly, Elhusseiny *et al*[17] reported increased CCT in pediatric eyes following cataract extraction, irrespective of whether an intraocular lens (IOL) was implanted. This CCT increase is hypothesized to be secondary to direct surgical trauma, cytotoxic effects of irrigating solutions, or postoperative inflammation-induced endothelial dysfunction. Our findings are consistent with this trend.

Preoperatively, the microcornea group showed a significantly thinner lens and shorter AL than the control group. This

Table 4 Comparison of surgical outcomes between two groups at last follow-up

Parameters	Microcornea		Control		*P*
	n	Outcomes	*n*	Outcomes	
BCVA (logMAR), median (IQR)	30	0.30 (0.21)	50	0.40 (0.38)	0.072[a]
IOP (mm Hg), mean (SD)	52	15.5 (5.5)	78	14.2 (3.4)	0.239[b]
AL (mm), median (IQR)	52	20.20 (1.92)	87	20.82 (1.93)	0.129[a]
CCT (μm), mean (SD)	54	596.44 (55.41)	87	591.15 (47.85)	0.638[b]
Strabismus, *n* (%)	54	20 (37.0)	76	29 (34.5)	0.880[c]
Nystagmus, *n* (%)	54	28 (51.9)	76	35 (41.7)	0.254[c]

IQR: Interquartile range; SD: standard deviation; BCVA: Best-corrected visual acuity; IOP: Intraocular pressure; AL: Axial length; CCT: Central corneal thickness. [a]Mann-Whitney *U* test; [b]Independent *t* test; [c]Chi-square test.

study is the first to report the difference of two groups in lens thickness. Admittedly, PCD can lead to lens thinning, but the almost identical ratio of PCD between the two groups in this study suggests a developmental factor. As in early foetal period, after the lens vesicles separate from the epidermal ectoderm, the epidermal ectoderm fuses again into a layer of cuboidal epithelium, which later evolves into the corneal epithelium[18-19]. The developmental homology of the cornea and lens could also explain the inconsistency in cataract types in the microcornea group[20]. These findings suggest that microcornea may be related to abnormal development of the embryo. In terms of AL, we found an interesting phenomenon, the preoperative AL of microcornea team is significantly shorter, and the difference between the groups disappeared at the time of the last follow-up. In a series by Sun *et al*[21], the higher AL growth rate is found in complex microphthalmos compared with controls after first-stage operation for congenital cataract in infants <1 year of age. So, we speculate that patients with microcornea may show delayed development of the globe, which raises concerns about the dyssynchrony between the globe and the anterior segment in eyes with microcornea. The results of visual acuity and visual function were not significantly different between the two groups, suggesting that early surgical intervention can effectively improve the visual function in infants with congenital cataract and microcornea.

Poor pupil dilation was particularly frequent in the microcornea group, which may indicate that infants with microcornea were prone to dysplasia of dilator pupillae muscle. So, it was necessary to strengthen pupil dilation before the operation and to be careful during the operation.

Microcornea may be a risk factor for the development of glaucoma after cataract surgery[22-29], as reported by Trivedi *et al*[30]. Several hypotheses have been proposed to explain this finding, including potential associations with age and surgical methods[30-31]. Alternatively, in a study by Wong *et al*[32] both microcornea and persistent fetal vasculature were not found to be significant predictors of glaucoma. Since our study controlled for these variables, our results showed no difference in incidence of secondary glaucoma between the two groups. Further, Trivedi *et al*[30] did not find a significant difference in the corneal diameter between eyes that developed glaucoma and those that did not. All suggests that the microcornea may not be an independent risk factor for the development of postoperative glaucoma.

In our study, several limitations should be noted. First, the retrospective design may introduce selection and information biases, limiting the generalizability of the findings. Second, inconsistent follow-up durations among patients could affect the accuracy of postoperative complication rates. Additionally, the lack of preoperative anterior segment imaging, such as ultrasound biomicroscopy (UBM) or handheld anterior segment optical coherence tomography (AS-OCT), restricts a comprehensive evaluation of ocular structures and may result in overlooked preoperative characteristics and changes. In addition, corneal diameter does change with age, which has a certain impact on the grouping of small corneas, and corneal diameter should be included in the follow-up in the future.

Although microcornea have different features from normal ones, such as thinner lens, poor pupil dilation, and shorter AL, however, the one-year follow-up after surgery has shown that early surgical intervention for congenital cataracts in eyes with microcornea can result in favourable outcomes with an acceptable rate of postoperative complications. Regular follow-up and timely management of postoperative complications are crucial for successful outcomes.

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