· Clinical Research ·

Optic disc changes in patients less than 3 years of age with congenital cataract

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Abstract

● **AIM:** To compare the cup-to-disc ratio (CDR) and optic disc morphology between eyes with congenital cataract and eyes without cataract in children under 3 years old.

● **METHODS:** This study included 63 patients with bilateral congenital cataract (mean age of 55.72±46.50wk, 44 were male), 33 patients with unilateral cataract (mean age of 56.63±33.23wk, 16 were male), and 31 age-matched healthy children (mean age of 55.80±29.29wk, 17 were male). Fundus photographs were taken with the RetCam 3 system. The horizontal-to-vertical disc diameter ratio (HVDR) was used as an index to describe the oval form of the optic disc.

● **RESULTS:** The horizontal cup-to-disc ratio (HCDR), vertical cup-to-disc ratio (VCDR) and HVDR of cataract eyes in unilateral groups were significantly smaller than those of the normal eyes ($P<0.05$). In the unilateral group, the HCDR, VCDR and HVDR of cataract eyes were significantly smaller than those in fellow eyes ($P<0.05$). The HVDR of eyes in the bilateral group was significantly smaller than those in the age-matched normal eyes ($P<0.001$). The form of optic disc of the cataract eyes in both the bilateral and unilateral groups was more vertical-oral than the normal eyes in the unilateral and the age-matched groups ($P<0.05$).

● **CONCLUSION:** Our results show that eyes with congenital cataract has a smaller HVDR and the form of the optic disc tended to be vertical-oval in young children.

● **KEYWORDS:** congenital cataract; cup-to-disc ratio; optic disc morphology; children

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INTRODUCTION

Cataract is a significant cause of visual disability in the pediatric population worldwide and can significantly affect the neurobiological development of a child[1]. The prevalence of congenital cataract has been reported to be between 1 and 15 per 10 000 children worldwide, whereas it ranges from 1 to 3 per 10 000 births in developing countries[2-3]. Congenital cataract, which may be caused by factors such as genetics, infections, and toxic substances, is a leading cause of visual deprivation, which can damage the developing visual system of a child[4-6]. In recent years, many patients with congenital cataract have been diagnosed and treated in the early stage. However, some patients did not reach normal visual function after surgery[7]. It was not confirmed whether there was an organic pathology change caused by congenital cataract.

The optic disc is the anatomic location where the optic nerve exits the eye and blood vessels enter the retina[8]. The optic nerve plays a critical role in the visual system, acting as the essential link that conveys visual data from the retina directly to the brain. The maintenance of its structural and functional integrity is vital for ensuring optimal visual acuity and field[9]. The cup-to-disc ratio (CDR) was used to assess the development of glaucomatous optic disc neuropathy[10] and other diseases of the brain[11]. Optic disc morphology was found to be associated with myopia and long optic axis and was affected by low birth weight (BW) and low gestational age (GA). The change in CDR and the horizontal-to-vertical disc diameter ratio (HVDR) may cause abnormal visual problems such as amblyopia, myopia, and astigmatism[12-13]. The visual system of children with congenital cataracts is often affected. However, current research has only observed the optic disc morphology in children with cataracts combined with glaucoma or postoperative secondary glaucoma[14-15].

To our knowledge, there has been no studies evaluating the CDR and optic disc morphology in congenital cataracts without complications. Similarly, it is unknown whether there are differences in CDR and optic disc morphology between the affected eye with unilateral congenital cataract and the healthy contralateral eye. Therefore, assessing the optic disc morphology in congenital cataracts may help us better understand the pathological changes of the disease and its potential associations.

The purpose of this study was to assess the fundus photographs of patients with congenital cataract and normal children with the RetCam3 system, evaluate optic disc morphology and the CDR of patients with congenital cataract, and determine the correlation between CDR, morphology, and population characteristics.

PARTICIPANTS AND METHODS

Ethical Approval The research adhered to the tenets of the Declaration of Helsinki. Local ethical approval was obtained from the Ethics Committee of Affiliated Eye Hospital of Wenzhou Medical University (Ethics Number:Y2017-014). Informed consent was obtained from the legal guardians of all children involved.

Participants and Methods The study utilized a cross-sectional study design. Fundus photographs were taken for all children diagnosed with congenital cataract in Affiliated Eye Hospital of Wenzhou Medical University using RetCam 3 from August 2016 to December 2021. Children with lens opacities revealed by morphological assessment were diagnosed with congenital cataract. Exclusion criteria included preterm infants and those with glaucoma, retinal diseases, microphthalmia, traumatic cataract, lens subluxation, metabolic disorders, uveitis, previous intraocular surgery, steroid use, or other ocular diseases. The control group consisted of infants who visited our hospital for routine neonatal fundus screening, had no fundus diseases, and were free of genetic disorders or family history of such conditions. Images from five distinct orientations: superior, inferior, nasal, temporal, and the posterior pole were systematically captured by RetCam 3. The quantification of the CDR was conducted utilizing images of the posterior pole. The photographs were taken before surgery or 1mo after cataract extraction by the same operator. Date of birth, GA, BW, and the history of disease were recorded. Pupils were dilated with tropicamide phenylephrine eye drops (Santen Pharmaceutical Co., Ltd., China) for 30min before screening. Proparacaine hydrochloride 0.5% (Alcaine, Alcon Laboratories, Inc., USA) was instilled for topical anesthesia before examination. Before the measurement, images were collected and clear photographs were chosen. Images that could not be evaluated for the optic disc due to poor quality were excluded. The quantification of the CDR was conducted utilizing images of the posterior pole. Horizontal and vertical optic disc diameters and optic cup diameters were measured blindly by one observer using a straight-line measurement tool of ImageJ software (National Institutes of Health, Bethesda, MD, USA). Based on the shape of the optic disc, if it is vertically oval, the horizontal diameter of the optic disc is measured as the line connecting the leftmost and rightmost points of the disc, and the vertical diameter is the line connecting the topmost and bottommost points of the disc. If the optic disc is obliquely oval, the horizontal diameter is the major axis of the ellipse, and the vertical diameter is the minor axis of the ellipse. The horizontal diameter of the optic cup is measured as the line connecting the leftmost and rightmost points of the cup, and the vertical diameter is the line connecting the topmost and bottommost points of the cup. Horizontal CDR (HCDR), vertical CDR (VCDR), and HVDR were calculated. Patients were divided into the bilateral group, unilateral group, and normal group. The right eyes of patients with bilateral cataracts were included. The unilateral group included the cataract eyes group and the fellow eyes group. The normal group consisted of normal children (Figure 1).

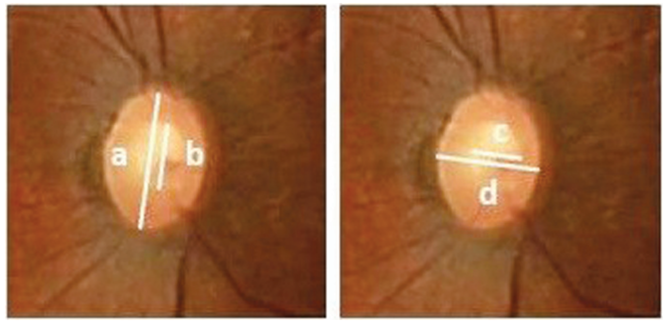

Figure 1 Measurement of optic disc diameter and optic cup diameter a: Vertical diameters of optic disc; b: Vertical diameters of optic cup; c: Horizontal diameters of optic cup; d: Horizontal diameters of optic disc.

Statistical Analysis Statistical analyses were applied to compare HCDR, VCDR, and HVDR among the bilateral group, cataract eyes group, fellow eyes group, and normal group using independent samples *t* test and one-way analysis of variance. The relevance of HCDR, VCDR, and HVDR to gender, BW, GA, and age during examination were analyzed using Pearson correlation. The stratification of HVDR into the bilateral group, cataract eyes group, fellow eyes group, and normal group was analyzed using the Chi-square test. Statistical analyses were performed using SPSS 17 software (SPSS Statistics; IBM Corp, New York, NY, USA). For all analyses, *P* values of <0.05 were considered statistically significant.

RESULTS

The study included 63 eyes of 63 patients with bilateral cataract, 61 eyes of 33 patients with unilateral cataract, and 31 eyes of 31 normal children. In the unilateral group, 32

Table 1 Demographics of the bilateral group, unilateral group, and normal group

Demographics	Bilateral group	Unilateral group	Normal group	*P*
Age (wk)	55.72±46.50 (4.43-186.50)	56.63±33.23 (6.00-142.86)	55.80±29.29 (8.13-163.70)	0.980
Sex (M:F)	44:21	16:16	17:14	0.248
GA (wk)	38.29±2.57	38.85±1.94	38.06±2.38	0.488
BW (g)	3088.77±751.91	3320.63±592.45	2998.55±594.89	0.134

M: Male; F: Female; GA: Gestational age; BW: Birth weight.

Table 2 Comparisons of optic disc parameters between the unilateral group and the normal group

Parameters	Cataract eyes in unilateral group (*n*=32)	Fellow eyes in unilateral group (*n*=29)	Normal group (*n*=31)	*P*	Post comparison between groups		
					Cataract *vs* fellow	Fellow *vs* normal	Cataract *vs* normal
HCDR	0.225±0.075	0.277±0.101	0.280±0.078	0.020	0.027	0.890	0.006
VCDR	0.241±0.094	0.315±0.107	0.307±0.100	0.007	0.005	0.757	0.009
HVDR	0.727±0.087	0.802±0.070	0.837±0.067	<0.001	*P*<0.001	0.056	*P*<0.001

HCDR: Horizontal cup-to-disc ratio; VCDR: Vertical cup-to-disc ratio; HVDR: Ratio of horizontal to vertical disc diameters.

Table 3 Comparisons of optic disc parameters between cataract eyes and normal eyes

Parameters	Cataract eyes in groups		Normal group (*n*=31)	*P*	Post comparison between groups		
	Bilateral group (*n*=63)	Unilateral group (*n*=32)			Cataract groups	Bilateral *vs* normal	Unilateral *vs* normal
HCDR	0.244±0.093	0.225±0.075	0.280±0.078	0.037	0.319	0.069	0.006
VCDR	0.257±0.091	0.241±0.094	0.307±0.100	0.015	0.414	0.080	0.009
HVDR	0.727±0.106	0.727±0.087	0.837±0.067	<0.001	0.880	<0.001	<0.001

HCDR: Horizontal cup-to-disc ratio; VCDR: Vertical cup-to-disc ratio; HVDR: The ratio of horizontal and vertical disc diameters.

eyes suffered cataracts and 29 eyes were fellow eyes. In the unilateral cataract group, the cataract-affected eye of one patient was excluded from the study due to insufficient image clarity of the fundus both preoperatively and postoperatively, while the contralateral healthy eye met the inclusion criteria and was included in the study. Additionally, due to poor cooperation during imaging, the fundus image clarity was insufficient, resulting in the exclusion of the contralateral healthy eyes of four patients. Eventually, among the bilateral cataract patients, 16 cataract eyes had qualifying fundus photography both preoperatively and postoperatively, while 47 cataract eyes had clear fundus photography postoperatively. In the unilateral cataract patients, 8 cataract eyes had qualifying fundus photography both preoperatively and postoperatively, and 24 cataract eyes had clear fundus photography postoperatively.

The morphologies of congenital cataracts in this study included nuclear cataract, total cataract, posterior polar cataracts, anterior polar cataracts, coral-like cataracts, crown-like cataracts, pulverulent cataracts, and lamellar cataracts. Among bilateral cataracts, nuclear cataract was the most common (25.4%, 16/63), while total cataract was predominant in unilateral cataracts (30.3%, 10/33).

The mean age, GA, BW, and gender of the bilateral group, unilateral group, and normal group were summarized in Table 1. There was no significant difference among the bilateral group, unilateral group, or normal group in terms of age, gender, GA, and BW (*P*>0.05).

The mean HCDR, VCDR, and HVDR in the bilateral, unilateral, and normal group were summarized in Tables 2 and 3. In the unilateral group, HCDR, VCDR, and HVDR of cataract eyes were significantly smaller than those of fellow eyes and normal group respectively. There was no difference between fellow eyes in the unilateral group and the eyes of the normal group in terms of HCDR, VCDR, and HVDR (*P*>0.05). No difference in HCDR was found between the eyes in the bilateral group and cataract eyes in the unilateral group (*P*>0.05); neither VCDR nor HVDR were different between the eyes in the bilateral group and cataract eyes in unilateral the group (*P*>0.05). The HVDR of the eyes in the bilateral group was significantly smaller than those in the normal group (*P*<0.001).

The distributions of HVDR in the bilateral group, unilateral group, and normal group were summarized in Table 4. The optic disc form was more vertical-oral in cataract eyes, both in the bilateral and unilateral groups, compared to the normal eyes in the unilateral and normal groups (*P*<0.05).

Correlation analysis showed that HCDR, VCDR, and HVDR had no relevance to age, gender, GA, or BW (*P*>0.05).

DISCUSSION

From the 6th week of gestation, over one million nerve fibers originate from retinal ganglion cells and extend across the entire retinal surface. The Bergmeister's papilla, which is the initial point of optic disc development, begins to form in the

Table 4 Distribution of the bilateral group, unilateral group, and normal group by HVDR

HVDR	Bilateral group	Unilateral group		Normal group
		Cataract eyes	Fellow eyes	
>0.9	4 (6.35%)	1 (3.125%)	3 (10.34%)	5 (16.13%)
0.8-0.9	11 (17.46%)	5 (15.625%)	11 (37.93%)	16 (51.61%)
0.7-0.8	22 (34.92%)	14 (43.75%)	13 (44.83%)	10 (32.26%)
<0.7	26 (41.27%)	12 (37.50%)	2 (6.90%)	0
F	35.873			
P	<0.001			

HVDR: Ratio of horizontal to vertical disc diameters.

early stages of embryonic development (gestation week 8). The original glial tissue of the Bergmeister's papilla gradually absorbs and shrinks during the developmental process, forming the optic cup[16]. Studies showed that the optic disc changed from the fetal period to postnatal ages. Rimmer *et al*[17] found that by approximately 20wk' gestation, 50% of the growth of the optic disc and nerve occurred, with 75% by birth; 95% of the growth occurs before the age of 1y. Bouzerar *et al*[18] found that the optic discs of premature infants showed a vertical-oval form with a mean ratio of vertical to horizontal optic disc diameters of 1.25, and the form of the optic disc tended to normalize during the first week after birth. Kandasamy *et al*[19] examined full-term infants and found that the vertical diameter of the optic disc was significantly greater than the horizontal diameter. Feng *et al*[20] found a higher proportion of mature types (single-ring and double-ring) in full-term newborns compared to preterm infants. The double-ring type represented a normal stage of optic disc development. Patel *et al*[21] found that the average diameter of the disc and cup showed a respective 30% and 40% increase from birth to 13 years of age when measured in terms of distance.

With the RetCam system for fundus examination of infants, we found that congenital cataract eyes had smaller VCDR than normal eyes, and we also found that the optic discs were more vertical-oval in cataract eyes. CDR and HVDR in the study were not related to gender, age, GA, or BW.

In the embryo's early stages and during early ontogenesis, the optic disc and CDR are gradually formed, growing with age and gradually changing from an undeveloped mature state to a mature state[17-18,21]. During the development in the postnatal period, the visual system adjusts and changes the neural and synaptic structures according to the visual environment, which is the key period for visual development. In this period, the abnormal visual environment cannot be eliminated, potentially causing development of the visual system development and amblyopia. In our study, the patients and normal children included were in the key stage of visual development, and congenital cataract as an abnormal visual environment affected the development of the visual system. Early detection and early surgical treatment were performed to relieve the effect of congenital cataract on the retina by the projection of light into the retina. We found that the optic discs in the eyes of patients with congenital cataract had a more elliptical shape, and the CDR was smaller than that of the fellow eye and of the normal control group. We speculated that congenital cataracts might affect the development of the optic disc.

In our study, HVDR, HCDR, and VCDR were not affected by gender, age, GA, or BW. It was consistent with the findings of Bouzerar *et al*[18]. However, Hackl *et al*[12] reported that the form of the optic disc was affected by low BW and low GA. More vertical-oval optic discs appeared when the BW was lower. Kandasamy *et al*[19] suggested that the size of the optic disc in term infants was not affected by BW or gender.

Tay *et al*[22] found that greater ovality of the optic disk was correlated with greater myopia and longer axial length. They defined the optic disc ovality as the ratio of minimum to maximum disc diameter, which could assess the tilt ratio of the disc. They found that a higher degree of myopia (spherical equivalent) showed a correlation with a smaller tilt ratio and that a longer axial length was also associated with a smaller tilt ratio. Samarawickrama *et al*[23] found that adolescents with tilted optic discs tended to have a longer axial length and a more myopic spherical equivalent refraction. The sign of a tilted optic disc showed a strong association with an increasing likelihood of myopia. It was thought that form deprivation caused the reduction in the light received by the retina and finally affected the maturity of the visual signal pathway and the macula[23-24]. Growth signals were not encoded with the magnitude of defocus, and the signal pathway appeared to be modified by optic nerve section, at least for form-deprivation myopia[25-26]. We suggested decreased physiological stimulation may modify the signal pathway and eventually affect the morphology of the optic disc.

In our study, eyes with congenital cataract tended to have an optic disc with a more vertical-oval form; according to the above-mentioned studies, they might have a larger future possibility of having a high degree of myopia and long optic axis than normal eyes.

In conclusion, we suggest that the congenital cataract eyes had a smaller VCDR than the normal eyes, and the form of the optic disc tended to be vertical-oral. The mechanisms explaining the change in CDR and optic disc morphology need further investigation.

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