· Clinical Research ·

Ocular biological characteristics and refractive errors in children with unilateral congenital ptosis

Yu-Ying Sun[1], Bing-Ying Lin[2], Zhen Mao[2], Xuan-Wei Liang[2], Cui-Yu Zhang[2], Dan-Ping Huang[2], Yao Ni[2], Zuo-Hong Li[2]

[1]Department of Ophthalmology, the Third Affiliated Hospital of GuangZhou University of Chinese Medicine, Guangzhou 510060, Guangdong Province, China
[2]State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510060, Guangdong Province, China
Co-first authors: Yu-Ying Sun and Bing-Ying Lin
Correspondence to: Zuo-Hong Li and Yao Ni. State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou 510060, Guangdong Province, China. lpplizuohong@163.com; niyao@gzzoc.com
Received: 2023-09-26 Accepted: 2024-11-28

Abstract
● **AIM:** To evaluate refraction and ocular biological characteristics in children with unilateral congenital ptosis.
● **METHODS:** In this cross-sectional study, 200 Chinese children (3-15y) with unilateral congenital ptosis were evaluated. Cycloplegic refraction and ocular biological measurements were taken from Oct. 2020 to Aug. 2022.
● **RESULTS:** In patients with congenital ptosis, the prevalence of with-the-rule astigmatism and oblique astigmatism was significantly high. The cornea was flatter in ptotic eyes [K1 (42.37±1.62 *vs* 42.78±1.51 D), K2 (43.8±1.86 *vs* 44.2±1.64 D), corneal power (Km; 43.09±1.68 *vs* 43.49±1.53 D), all P<0.001]. Axial length (AL) was longer in ptotic eyes (22.55 *vs* 22.51 mm, P=0.012). The white-to-white (WTW) was significantly smaller in ptotic eyes (11.49 *vs* 11.65 mm, P<0.001). The central corneal thickness (CCT) was greater in ptotic eyes (553.50 *vs* 545.00 μm, P<0.001). No significant differences were found in anterior chamber depth (AD), lens thickness (LT) and vitreous thickness (VT) between ptotic and fellow eyes (P>0.05). In addition, the incidence of amblyopia in ptosis eyes was 32.0%, which was significantly higher than that in the normal population.
● **CONCLUSION:** Ptotic eyes have longer AL, flatter, thicker and smaller corneas than fellow eyes. The congenital ptosis increases the risk of amblyopia. The results suggest that regular examinations of refractive status and ocular biological parameters such as AL, are essential for children with unilateral congenital ptosis.
● **KEYWORDS:** congenital ptosis; axis length; ocular biological characteristics
DOI:10.18240/ijo.2025.04.16

Citation: Sun YY, Lin BY, Mao Z, Liang XW, Zhang CY, Huang DP, Ni Y, Li ZH. Ocular biological characteristics and refractive errors in children with unilateral congenital ptosis. *Int J Ophthalmol* 2025;18(4):691-698

INTRODUCTION

Congenital ptosis, a prevalent developmental disorder of the eyelid, primarily arises from abnormalities in the oculomotor nerve nucleus or levator muscle, leading to partial or complete inability of the upper eyelid to elevate[1]. This disease is often evident at birth or during the first year of life[2]. Congenital ptosis significantly affects the aesthetic appearance, psychology well-being and visual function of children[3-4]. Currently, research primarily concentrates on the surgical advancements for treating ptosis. However, there is a scarcity of studies exploring the refractive status and ocular biological parameters with ptosis. Prior investigations into refractive status have indicated that congenital ptosis can elevate the risk of myopia, hyperopia, astigmatism, anisometropia and amblyopia[5-7], albeit with considerable variability in the incidence of these abnormalities. Some studies of ptosis patients have reported a tendency for myopia in the affected eye[8-9], while others have found no significant difference in refractive errors between the ptotic and fellow eyes[10]. Similarly, studies have documented that congenital ptosis influences ocular biological parameters[11-12], while the specific changes in these parameters in ptosis remain unclear.

In this study, the optical biometer, a non-contact biometric instrument, was used to accurately examine ocular biological parameters, including axial length (AL), central corneal thickness (CCT), lens thickness (LT), anterior chamber depth (AD) and keratometry values (K1, K2). The objective of this study was to evaluate the impact of congenital unilateral ptosis on refractive status and ocular biometric parameters in children.

PARTICIPANTS AND METHODS

Ethical Approval The Ethics Committee at Zhongshan Ophthalmic Center, Sun Yat-sen University, approved this study (Permit Number 2023KYPJ097). The study complied with the Declaration of Helsinki, and informed consent was obtained from patients or their guardians for the use of all data.

Research Objects A total of 200 patients diagnosed with unilateral congenital ptosis at Zhongshan Eye Centre of Sun Yat-sen University, spanning from October 2020 to August 2022 were included in this study. Patient ages ranged from 3 to 15y, with a mean of 6.44±3.20y, with a gender distribution of 126 males and 74 females. The exclusion criteria included the following: 1) encompassing individuals with other ophthalmic or systemic disorders (such as corneal opacity, congenital cataract, glaucoma, fundus disease, strabismus, high myopia, trauma, small palpebral fissure syndrome, oculomotor nerve palsy, levator palsy); 2) patients with a history of eyelid surgery or use of a hard contact lenses, which could potentially alter corneal shape and a family history of high myopia.

Diagnosis and Indexing of Ptosis According to the severity of the ptosis eyes, children with unilateral congenital ptosis were further divided into 3 groups by 2 ophthalmologists: mild group [margin reflex distance (MRD)-1≥2 mm], moderate group (0≤MRD-1<2 mm), and severe group (MRD-1<0). MRD-1 measurements were obtained by assessing the distance from the central margin of the upper eyelid to the pupillary light reflex at the primary gaze position[6].

Check Methods An experienced ophthalmologist conducted an ophthalmic slit-lamp examination (Topcon SL-2F) on both eyes, focusing on the anterior segment. Subsequently, an accomplished optometrist measured cycloplegic refraction after achieving ciliary muscle paralysis with 0.5% tropicamide eye solution (Santen Pharmaceutical Co., Japan). This solution was instilled three times at ten-minute intervals to ensure pupil dilation The spherical degree, cylindrical degree and axial direction of each eye were meticulously recorded and transformed into the spherical equivalent refraction (SER; spherical degree+0.5×cylinder degree), which was used to calculate the refraction. Myopia was defined as SER<-0.50 D, hyperopia as SER>+0.50 D and emmetropic as -0.5≤SER≤+0.5 D. Astigmatism was characterized by a cylindrical degree exceeding 0.5 D. A difference of 1.00 D or more in SER between the two eyes were recognized as anisometropia[12]. Astigmatism was further subclassified into with-the-rule (WTR; 0°≤axis≤30°, or 150°≤axis≤180°), against-the-rule (ATR; 60°≤axis≤120°), and oblique (OA; 30°<axis<60°, or 120°<axis<150°). Amblyopia was defined as a visual condition in which the best-corrected visual acuity (BCVA) of one or both eyes is below the normative level expected for the individual's age, stemming from various factors including uncorrected refractive anisometropia, refractive errors, and form deprivation during the pivotal stage of visual maturation. Alternatively, it may manifest as BCVA difference of two or more Snellen lines between the two eyes, with the eye exhibiting the lower acuity being classified as amblyopic[13].

The ocular biological parameters were measured utilizing an advanced ocular biometry system (Optical Biometer, SW-9000, Suoer, China). Additionally, the corneal curvature was measured three times consecutively, and the average of these measurements was recorded.

To validate the AL measurements, the individual readings were compared, and only those with a variation of no more than 0.02 mm were considered valid, adhering to established criteria[14]. Prior to participation, informed consent was obtained from all patients or their legal guardians, authorizing the use of their data for research purposes. To avoid pressure on the eye during the measurement process, the patient's droopy eyelid was carefully elevated, and the pupil was gently exposed using minimal finger pressure. Five consecutive measurements were averaged. The average of three consecutive measurements of corneal curvature was taken. AL was considered valid if the individual measurements varied by no more than 0.02 mm[14].

Statistical Analysis Statistical analysis was performed by using the statistical software SPSS 25.0 (SPSS Inc., IBM, USA). First, we measured the normality distribution and variance homogeneity of continuous variables. Then, the continuous variable data that conformed to a normal distribution were expressed as the mean±standard error, and *t*-test was used for comparisons. The other data that did not conform to a normal distribution were expressed as P50 (P25-P75), and the Wilcoxon rank sum test was used to compare ptotic eyes and fellow eyes. The Chi-square test was used to compare the ratios. *P*<0.05 was considered statistically significant.

RESULTS

General Information A total of 200 patients, aged between 3 and 15y, were diagnosed with unilateral congenital ptosis. The cohort comprised 126 males and 74 females. The severity of ptosis was categorized as mild in 17 patients (8.5%) with mild disease, moderate in 84 patients (42.0%), and severe in 99 patients (49.5%).

Refraction Table 1 showed that there were 175 (87.5%) eyes with refractive error in the ptotic eyes, including 27 (13.5%) with myopia and 148 (74%) with hyperopia; 169 (84.5%) eyes with refractive errors in the fellow eyes, including 26 (13.0%) with myopia and 143 (71.5%) with hyperopia, with no statistically significant difference in refractive error between the ptotic eyes and fellow eyes (*P*>0.05). Furthermore, Figure 1 also demonstrated that there was no significant difference in refractive errors among the ptosis subgroups (*P*>0.05).

Table 1 Incidence of refractive errors and amblyopia for ptosis eyes compared to fellow eyes *n* (%)

Parameters	Postotic eyes	Fellow eyes	χ^2	*P*
Myopia	27 (13.5)	26 (13.0)	0.022[b]	0.883
Mild ptosis	4 (2.0)			
Moderate ptosis	11 (5.5)			
Severe ptosis	12 (6.0)			
Emmetropia	25 (12.5)	31 (15.5)	0.748[b]	0.387
Mild ptosis	0			
Moderate ptosis	11 (5.5)			
Severe ptosis	14 (7.0)			
Hyperopia	148 (74.0)	143 (71.5)	0.315[b]	0.574
Mild ptosis	13 (6.5)			
Moderate ptosis	62 (31.0)			
Severe ptosis	73 (36.5)			
WTR	21 (10.5)	7 (3.5)	7.527[b]	0.006
Mild ptosis	2 (1.0)			
Moderate ptosis	7 (3.5)			
Severe ptosis	12 (6.0)			
ATR	96 (48.0)	104 (52.0)	0.640[b]	0.424
Mild ptosis	7 (3.5)			
Moderate ptosis	44 (22.0)			
Severe ptosis	45 (22.5)			
OA	12 (6.0)	3 (1.5)	5.610[b]	0.018
Mild ptosis	0			
Moderate ptosis	4 (26.7)			
Severe ptosis	8 (53.3)			
Astigmatism	129 (64.5)	114 (57.0)	2.359[b]	0.125
Mild ptosis	9 (4.5)			
Moderate ptosis	55 (27.5)			
Severe ptosis	65 (32.5)			
WTR	21 (10.5)	7 (3.5)	7.527[b]	0.006
ATR	96 (48.0)	104 (52.0)	0.640[b]	0.424
OA	12 (6.0)	3 (1.5)	5.610[b]	0.018
WTR *vs* ATR			7.167[b]	0.007
ATR *vs* OA			5.715[c]	0.017
None	71 (35.5)	86 (43.0)		
Amblyopia	64 (32.0)	5 (2.5)	60.966[b]	<0.001
Mild ptosis	1 (0.5)			
Moderate ptosis	24 (12.0)			
Severe ptosis	39 (19.5)[a]			
None	136 (68.0)	195 (97.5)		

[a]*P*<0.05 compared with the mild ptosis group; [b]Pearson Chi-square test; [c]Fisher exact test. WTR: With-the-rule; ATR: Against-the-rule; OA: Oblique astigmatism.

Table 2 presented that the SERs of ptotic eyes and fellow eyes were 1.25 (0.50-2.25) D and 1.50 (0.75-2.00) D, respectively, with no statistically significant difference between them (*P*=0.50). It also indicated that differences in refractive error of ptotic and fellow eyes were not significant.

Regarding the degree of spherical power (DS), ptotic eyes exhibited a mean value of 1.63 (0.75-2.50) DS, while fellow eyes had an average of 1.50 (0.75-2.00) DS. The astigmatic power (cylindrical power; DC) of ptotic eyes was -0.50 (-1.25 to -0.25) DC, and that of fellow eyes was -0.50 (-0.75 to -0.00) DC. Table 2 showed a significant difference in the spherical power and cylindrical power between ptotic and fellow eyes (*P*<0.05). Specifically, the spherical equivalent of the ptotic eyes was found to be 0.13 D higher compared to that of the fellow eyes.

Astigmatism From Table 1, the percentage of astigmatism observed in ptotic eyes did not significantly differ from that in fellow eyes (64.5% *vs* 57%, *P*=0.125). Among the 129 ptotic eyes exhibiting astigmatism, 9 (4.5%) had mild ptosis, 55 (27.5%) had moderate ptosis, and 65 (32.5%) had severe ptosis. There was no statistically significant difference in the percentage of astigmatism among the three subgroups of ptosis (*P*>0.05; Figure 1).

Furthermore, Table 3 revealed that the incidence rates of WTR OA in ptotic eyes were significantly higher than those in fellow eyes (*P*<0.05). Conversely, no significant difference was observed in the incidence of ATR between ptosis and fellow eyes [96 (48%) *vs* 104 (52%), *P*>0.05; Table 1)].

Notably, Figure 2 demonstrated that the incidence of ATR was higher than that of the other two types of astigmatism in ptotic eyes.

Amblyopia Among the 200 patients with ptosis, 64 (32.0%) had amblyopia, of which 1 (0.5%) with mild ptosis, 24 (12%) with moderate ptosis, and 39 (19.5%) with severe ptosis. In contrast, only 5 fellow eyes (2.5%) were found to have amblyopia. The incidence of amblyopia was significantly higher in ptotic eyes than in fellow eyes (32% *vs* 2.5%, *P*<0.001), suggesting that children with ptosis had a higher risk of amblyopia (Table 1). According to the severity of ptosis, ptotic eyes were categorized into mild, moderate and severe ptosis. The incidence of amblyopia in severe ptosis was significantly higher than that in mild-moderate ptosis (*P*<0.05), indicating a correlation between the severity of ptosis and the likelihood of developing amblyopia.

Ocular Biological Parameters Table 4 revealed a comparison of keratometry values between ptotic eyes and fellow eyes. The K1, K2 and Km of ptotic eyes were 42.37±1.62, 43.8±1.86, 43.09±1.68 D, and the K1, K2 and km of fellow eyes were 42.78±1.51, 44.2±1.64, and 43.49±1.53 D, respectively. Table 3 showed that K1, K2, and km were smaller in ptotic eyes (*P*<0.05). Additionally, Table 5 and Figure 3B provided further insights into the relationship between the severity of ptosis and keratometry values. Specifically, they show that the Km in moderate-severe ptosis was significantly smaller than that in mild ptosis (*P*<0.05). This finding suggests that as the severity of ptosis increases, there is a corresponding decrease in keratometry values.

Table 4 and Figure 3A indicated that the AL of ptotic eyes was longer than that of fellow eyes [22.55 (22.04-23.29) *vs* 22.51 (22.03-23.28) mm, *P*=0.012], suggesting that ptosis

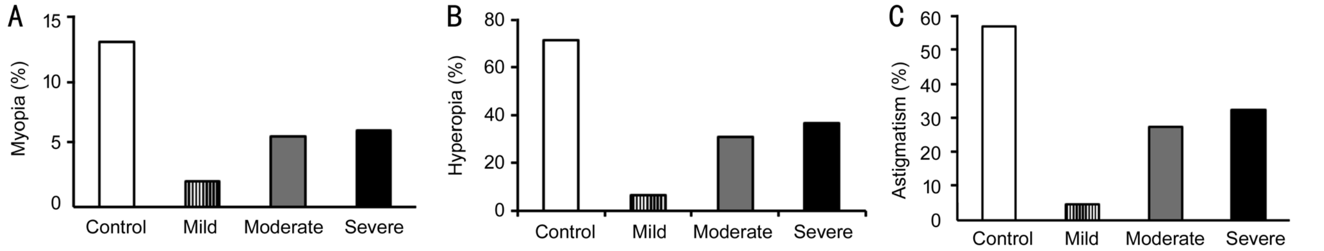

Figure 1 The ratio of myopia, hyperopia and astigmatism among the fellow eye group and ptotic eye subgroup No significant difference in incidence of refractive error were found among the fellow eye group and ptotic eye subgroup.

Table 2 Analysis of difference in refractive power between the ptotic and fellow eyes P50 (P25-P75), D

Parameters	Pototic eyes (*n*=200)	Fellow eyes (*n*=200)	*Z*	*P*
DS	1.63 (0.75-2.50)	1.50 (0.75-2.00)	-5.234	<0.001[b]
DC	-0.50 (-1.25 to -0.25)	-0.50 (-0.75 to -0.00)	-4.508	<0.001[b]
SER	1.25 (0.50-2.25)	1.50 (0.75-2.00)	-0.674	0.500[b]

DS: Diopter sphere, DC: Diopter cylinder, SER: Spherical equivalent refraction.

Table 3 Analysis of difference in WTR, ATR, and OA in the ptotic eyes

Parameters	*n* (%)	DC (mean±SD)
WTR	21 (10.5)	-1.06±0.50
ATR	96 (48.0)	-1.30±0.84
OA	12 (6.0)	-1.00±0.41
F		1.483
P		0.231

WTR: With-the-rule; ATR: Against-the-rule; OA: Oblique; DC: Diopter cylinder.

may be associated with changes in AL. However, there was no significant difference in AL among the mild to severe ptosis subgroups (*P*>0.05; Table 5). This suggests that the severity of ptosis does not have a significant impact on AL. Table 4 provided additional information on ocular parameters, comparing ptotic eyes to fellow eyes. The results show that the white-to-white (WTW) was significantly smaller and the CCT was greater in ptotic eyes than in fellow eyes. The WTW of ptotic eyes was 11.49 (11.13-11.84) mm, and fellow eyes was 11.65 (11.32-12.03) mm; the CCT of ptotic eyes was 553.50 (533.25-578.00) μm, and fellow eyes was 545.00 (525.25-568.75) μm, and the differences of WTW and CCT were statistically significant (*P*<0.05). The AD of ptotic eyes was 2.59 (2.26-2.84) mm, and fellow eyes was 2.60 (2.30-2.87) mm; the LT of ptotic eyes was 3.71 (3.42-4.03) mm, and fellow eyes was 3.72 (3.41-4.01) mm; the vitreous chamber depth (VT) of ptotic eyes was 15.77 (15.06-17.04) mm, and fellow eyes was 15.71 (15.01-16.77) mm. The differences in AD, LT and VT between the ptotic and fellow eyes were not significant (*P*>0.05). These findings suggest that ptosis may have specific effects on certain ocular parameters, such as AL, WTW, and CCT, but does not significantly impact AD, LT, and VT.

DISCUSSION

Our study demonstrated that the prevalence of amblyopia was higher in ptosis patients than in the normal population, which

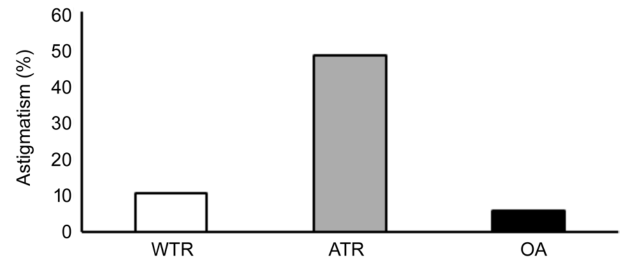

Figure 2 The ratio of astigmatism, including WTR, ATR and OA, among the ptotic eyes The differences in the form of astigmatism did not reach statistical significance in the ptotic eyes. WTR: With-the-rule; ATR: Against-the-rule; OA: Oblique.

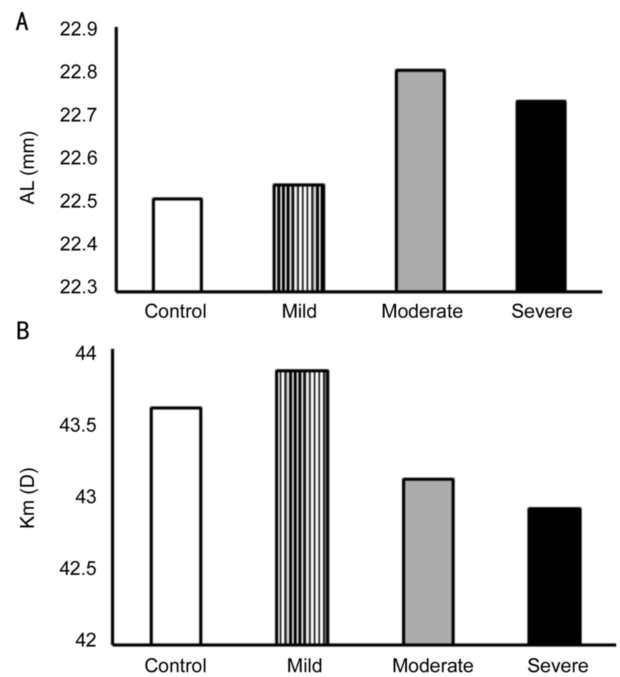

Figure 3 Comparison of parameters of AL and Km among the ptotic eye subgroups and the fellow eye group A: That there were no significant differences in AL among the ptotic eye subgroup; B: Km in moderate-severe ptosis were significantly smaller than that in mild ptosis. AL: Axial length; Km: Average corneal curvature.

Table 4 The measurement results of ocular biological parameters in the ptotic and fellow eyes

Parameters	Ptotic eyes	Fellow eyes	*t*/Z	*P*
K1, D	42.37±1.62	42.78±1.51	-9.943	<0.001[a]
K2, D	43.80±1.86	44.20±1.64	-6.582	<0.001[a]
Km, D	43.09±1.68	43.49±1.53	-9.626	<0.001[a]
AL, mm	22.55 (22.04-23.29)	22.51 (22.03-23.28)	-2.504	0.012[b]
AST, D	1.22 (0.77-1.89)	1.28 (0.89-1.90)	-0.468	0.640[b]
WTW, mm	11.49 (11.13-11.84)	11.65 (11.32-12.03)	-4.646	<0.001[b]
CCT, μm	553.50 (533.25-578.00)	545.00 (525.25-568.75)	-10.034	<0.001[b]
AD, mm	2.59 (2.26-2.84)	2.60 (2.30-2.87)	-1.702	0.089[b]
LT, mm	3.71 (3.42-4.03)	3.72 (3.41-4.01)	-0.053	0.958[b]
VT, mm	15.77 (15.06-17.04)	15.71 (15.01-16.77)	-1.898	0.058[b]

[a]Conform to the normal distribution, the paired *t*-test was used; [b]Did not conform the normal distribution, the Wilcoxon signed rank test was used. AL: Axial length; WTW: White-to-white; CCT: Central corneal thickness; AD: Anterior chamber depth; LT: Lens thickness; VT: Vitreous thickness; AST: Astigmatism.

Table 5 Differences in AL and Km among the ptotic eye subgroup

Parameters	*n* (%)	AL (mean±SD)	Km (mean±SD)
Mild ptosis	17 (8.5)	22.54±0.79	43.86±1.87
Moderate ptosis	84 (42.0)	22.80±1.12	43.12±1.78[a]
Severe ptosis	99 (49.5)	22.73±1.11	42.92±1.53[a]
F		0.422	2.342
P value		0.657	0.099

[a]Compared with the mild ptosis group, *P*<0.05. AL: Axial length; Km: Average corneal curvature.

was consistent with previous studies[5-6,15]. However, there was no difference in the refractive status. Interestingly, we found that K1, K2, Km and WTW were smaller in ptotic eyes, while CCT was greater in ptotic eyes when analysing the ocular parameters in ptotic and fellow eyes. In addition, we found that the AL was longer in ptotic eyes compared to fellow eyes.

Previous studies have shown that ptosis in childhood is related to abnormalities in visual function, including amblyopia, strabismus, and refractive error, induced by stimulus deprivation and corneal pressure caused by the upper eyelid[8,16]. Amblyopia was observed to have a higher prevalence in ptosis patients than in the general population[7,17-19]. Previous studies have reported the prevalence of amblyopia in patients with ptosis, ranging from 19% to 70%, which may be attributed to different diagnostic criteria for amblyopia[20-23]. According to the current study, the incidence of amblyopia was 32%, which was aggravated with the severity of ptosis, consistent with the report of Srinagesh *et al*[24] The lower incidence compared to some other studies may be due to the absence of strabismus (misalignment of the eyes) in the cases enrolled in the current study. Given these findings, we hypothesize that amblyopia in our study population is associated with both refractive errors and form deprivation resulting from ptosis obscuring the pupillary axis. These insights underscore the importance of early detection and intervention to mitigate the risk of amblyopia in individuals with congenital ptosis. According to previous research[21-25], the prevalence of amblyopia in the general population was approximately 3%, which is comparable to the 2.5% prevalence of amblyopia in fellow eyes in our study. Our findings further suggest that congenital ptosis plays a significant role in elevating the incidence of amblyopia. However, the the underlying causes of this heightened prevalence of amblyopia in patients with congenital ptosis remain controversial. Previous studies have identified strabismus, significant refractive errors, or anisometropia as primary factors contributing to the increased incidence of amblyopia in congenital ptosis, with potential associations to eyelid occlusion[26-27]. Although some experts contend that the occlusive effect of ptosis does not interfere with visual development, subsequent studies have revealed that 1.6%-12.3% of patients with congenital ptosis will develop amblyopia solely due to the deprivation of occlusive stimuli[26]. In contrast, Griepentrog *et al*'s[15] findings provided a 40-year prevalence of amblyopia in children and suggested that optic axis occlusion was the primary cause of amblyopia in congenital ptosis. In our study, all 63 cases with amblyopia had refractive error, including 53 astigmatism cases and 14 anisometropia instances in the ptosis eyes. Additionally, 39 out of the 63 eyes amblyopic patients had severe ptosis, 24 had moderate ptosis, and 1 had mild ptosis. Thus, we presumed that amblyopia was associated with refractive error and form deprivation due to ptosis obscuring the pupillary axis.

The pressure of the eyelid on the eye in ptosis individuals may increase the likelihood of astigmatism. According to the present study, astigmatism occurs in ptosis at a rate of 64.5%, significantly higher than that observed in healthy individuals. This finding is slightly elevated compared to the results reported by Hsia *et al*[22], which may be related to the fact that the subjects of our study were Asian. According to Kame *et al*[28], astigmatism is more prevalent in Asian populations because of their tighter eyelids and smaller lid fissures. Uğurbaş and Zilelioğlu[17] further observed that the cornea of congenital ptosis is more asymmetric and irregular, leading to an increase in the degree of astigmatism. In patients with congenital ptosis, due to weakness of the levator muscle, the eyelid cannot be lifted properly and is pressed against the corneal surface for an extended period of time, flattening the cornea and changing its curvature, ultimately resulting in astigmatism[29-30], which can vary depending on the severity of ptosis and the location of corneal compression. The prevalence of WTR and ATR was discovered by Stärk *et al*[31] to be approximately equal. However, Thapa[23] observed that two forms of astigmatism, OA and ATR, in ptosis. Our research revealed that ATR was relatively common in ptosis eyes. These results may be related to the fact that young children were enrolled in our study, whose corneas are not fully developed during childhood, and their response to upper eyelid compression is more sensitive.

Previous studies have indicated that ptosis can increase the prevalence of myopia and hyperopia, but we found no statistically significant difference in refractive error in ptosis eyes compared with fellow eyes, and the comparison revealed no significant difference in SER between the two groups. Nevertheless, we did detect significantly higher spherical and cylindrical refractive powers in ptosis eyes compared to their fellow eyes, hinting at an enhanced propensity for refractive errors in ptosis. These observations are consistent with previous research demonstrating that pediatric patients with ptosis are at a heightened risk of developing refractive errors[23]. The animal model demonstrated that young monkeys, cats, and other animals can develop axial myopia as a result of visual deprivation caused by eyelid suture, optical blurring, or chemical corneal opacity[32-33]. Nevertheless, it has also been suggested that the eye is not deprived of vision unless the ptosis is complete, *i.e.*, obstructing the pupil so that the patient cannot see even while tilting the head backwards[34].

AL increases as the eye matures, and it may be influenced by various factors. At present, there is still no consensus on the effect of ptosis on AL. Some studies have reported that patients with ptosis have a longer AL[8], while others have suggested that shorter AL in this patient population[34]. Conversely, some research has found no significant alterations in AL[35-36]. The present study found an increase in AL in the ptotic eyes of children with ptosis compared to the fellow eyes, while there was no difference among the subgroups of ptosis. We clarified that the form deprivation brought on by pupil occlusion is not the primary cause of the change in AL in ptosis. Nevertheless, the reason for this change needs to be further explored.

In addition, our study demonstrated that the percentage of myopia in ptosis eyes was significantly lower than that of hyperopia, which was considered to be age-related with a higher proportion of hyperopia at younger ages. The majority of participants in this study were predominantly preschoolers with a predominance of hyperopia. This is further confirmed by the fact that fellow eyes have a substantially lower percentage of myopia than hyperopia.

Consistent with the study results of Li *et al*[35] and Liu *et al*[11], our analysis revealed that CCT was significantly thicker in ptotic eyes than in fellow eyes. However, Gandhi *et al*[18] showed no significant changes in CCT in ptosis patients. To date, the mechanism of corneal thickening is uncertain. According to Liu *et al*[11], congenital ptosis is caused by mechanical stress, which results in persistent corneal hypoxia and corneal thickening. Interestingly, we also discovered that the WTW of ptosis eyes was significantly smaller than that of fellow eyes. However, the mechanism of ptosis causing a decreased WTW remains to be detected. Since Yinon and Koslowe[37] discovered that darkness causes smaller eyes, we speculate that ptosis due to pupillary occlusion may have an impact on corneal size. Meanwhile, our results found that K1, K2, and Km of ptotic eyes were significantly smaller than those of fellow eyes, indicating that the cornea of ptotic eyes was thicker, which was consistent with the study results of Liu *et al*[11]. We assumed that corneal flattening was related to mechanical compression and the pressure degree. Consequently, we hypothesize that corneal thickening and shrinking may also be caused by delayed ocular development due to ptosis. Further studies are needed to evaluate corneal biological changes in children with congenital ptosis.

Our study has several limitations that should be acknowledged. The number of unilateral congenital ptosis cases included in our study was relatively small, which may have an impact on the statistics. The young age of some patients, especially children around three years old, may have led to a less accurate diagnosis of amblyopia and consequently influenced the results of the statistics. In the future, we plan to expand the sample size to further study and explore the effect of congenital ptosis on visual development. We will consider incorporating a classification of amblyopia severity into our statistical analysis in our next steps. In addition, it should be noted that our study population was exclusively Chinese, and therefore, the findings may not be generalizable to other ethnic groups.

In conclusion, our study suggests that refractive status is not associated with unilateral congenital ptosis. However, the incidence of amblyopia in ptotic eyes was higher than that in fellow eyes, and it was related to the severity of ptosis, which indicates that congenital ptosis may increase the risk of amblyopia. Moreover, our study also found that congenital ptosis causes the cornea to become flatter, thicker, and smaller as well as lengthen the AL, suggesting that ptosis may delay corneal development. Therefore, patients with unilateral congenital ptosis should be examined regularly during sensitive periods of visual development to identify refractive error and amblyopia. Once these conditions have been identified, they should be treated with prescription eyeglasses, other therapies, or even early surgical intervention to reduce the influence of ptosis on visual development.

ACKNOWLEDGEMENTS

Data Availability: The raw data used to support the findings of this study could be obtained by getting in touch the corresponding author.

Foundations: Supported by the Fundamental Research Funds of the State Key Laboratory of Ophthalmology (No.30306020240020319); Municipal School (Hospital) Jointly Fund Project of Guang Zhou (No.SL2024A03J00492); Teaching Reform Projects in 2023 by the Steering Committee for the Construction of New Medical Departments in Guangdong Province; Guangdong Medical Research Foundation (No.A2021369); Natural Science Foundation of Guangdong Province, China (No.2023A1515011652).

Conflicts of Interest: Sun YY, None; **Lin BY,** None; **Mao Z,** None; **Liang XW,** None; **Zhang CY,** None; **Huang DP,** None; **Ni Y,** None; **Li ZH,** None.

REFERENCES

1 Bernardini FP, Cetinkaya A, Zambelli A. Treatment of unilateral congenital ptosis: putting the debate to rest. *Curr Opin Ophthalmol* 2013;24(5):484-487.

2 Pavone P, Cho SY, Praticò AD, *et al*. Ptosis in childhood: a clinical sign of several disorders: case series reports and literature review. *Medicine* (*Baltimore*) 2018;97(36):e12124.

3 Ueki S, Suzuki Y, Kiyokawa M, *et al*. Hyperopic anisometropia with a shorter axial length ipsilateral to the ptotic eye in children with congenital ptosis. *BMC Ophthalmol* 2021;21(1):358.

4 Bremond-Gignac D. Unilateral ptosis in children. *Rev Prat* 2020;70(9): 993-996.

5 Wu XS, Zhang JY, Ding X, *et al*. Amblyopia and refractive status in congenital ptosis: the effect and timing of surgical correction. *Ann Plast Surg* 2021;87(1):49-53.

6 Paik JS, Kim SA, Park SH, *et al*. Refractive error characteristics in patients with congenital blepharoptosis before and after ptosis repair surgery. *BMC Ophthalmol* 2016;16(1):177.

7 Wang YJ, Xu YF, Liu X, *et al*. Amblyopia, strabismus and refractive errors in congenital ptosis: a systematic review and meta-analysis. *Sci Rep* 2018;8(1):8320.

8 Huo LJ, Cui DM, Yang X, *et al*. A retrospective study: form-deprivation myopia in unilateral congenital ptosis. *Clin Exp Optom* 2012;95(4): 404-409.

9 Gusek-Schneider GC, Martus P. Stimulus deprivation myopia in human congenital ptosis: a study of 95 patients. *J Pediatr Ophthalmol Strabismus* 2001;38(6):340-348.

10 Bacharach J, Lee WW, Harrison AR, *et al*. A review of acquired blepharoptosis: prevalence, diagnosis, and current treatment options. *Eye* (*Lond*) 2021;35(9):2468-2481.

11 Liu YL, Chen TT, Huang JW, *et al*. Refractive error characteristics and influence on ocular parameters in patients with unilateral congenital ptosis. *BMC Ophthalmol* 2022;22(1):291.

12 Deng L, Gwiazda JE. Anisometropia in children from infancy to 15y. *Invest Ophthalmol Vis Sci* 2012;53(7):3782-3787.

13 Zeng XY, Wang JX, Qi XL, *et al*. Effects of congenital ptosis on the refractive development of eye and vision in children. *Int J Ophthalmol* 2020;13(11):1788-1793.

14 He XG, Zou HD, Lu LN, *et al*. Axial length/corneal radius ratio: association with refractive state and role on myopia detection combined with visual acuity in Chinese schoolchildren. *PLoS One* 2015;10(2):e0111766.

15 Griepentrog GJ, Diehl N, Mohney BG. Amblyopia in childhood eyelid ptosis. *Am J Ophthalmol* 2013;155(6):1125-1128.e1.

16 Oral Y, Ozgur OR, Akcay L, *et al*. Congenital ptosis and amblyopia. *J Pediatr Ophthalmol Strabismus* 2010;47(2):101-104.

17 Uğurbaş SH, Zilelioğlu G. Corneal topography in patients with congenital ptosis. *Eye* (*Lond*) 1999;13(Pt 4):550-554.

18 Gandhi A, Mehta A, Naik M. Does frontalis sling surgery for congenital ptosis change the corneal topography and refractive characteristics postoperatively? *Clin Ophthalmol* 2020;14:3667-3673.

19 Ueki S, Suzuki Y, Kiyokawa M, *et al*. Hyperopic anisometropia with a shorter axial length ipsilateral to the ptotic eye in children with congenital ptosis. *BMC Ophthalmol* 2021;21(1):358.

20 Gusek-Schneider GC, Martus P. Stimulus deprivation amblyopia in human congenital ptosis: a study of 100 patients. *Strabismus* 2000;8(4):261-270.

21 Kasaee A, Yazdani-Abyaneh A, Tabatabaie SZ, *et al*. Assessing amblyogenic factors in 100 patients with congenital ptosis. *Int J Ophthalmol* 2010;3(4):328-330.

22 Hsia NY, Wen LY, Chou CY, *et al*. Increased risk of refractive errors and amblyopia among children with ptosis: a nationwide population-based study. *J Clin Med* 2022;11(9):2334.

23 Thapa R. Refractive error, strabismus and amblyopia in congenital ptosis. *JNMA J Nepal Med Assoc* 2010;49(177):43-46.

24 Srinagesh V, Simon JW, Meyer DR, *et al*. The association of refractive error, strabismus, and amblyopia with congenital ptosis. *J AAPOS* 2011;15(6):541-544.

25 Chua B, Mitchell P. Consequences of amblyopia on education, occupation, and long term vision loss. *Br J Ophthalmol* 2004;88(9): 1119-1121.

26 Lin LK, Uzcategui N, Chang EL. Effect of surgical correction of congenital ptosis on amblyopia. *Ophthalmic Plast Reconstr Surg* 2008;24(6):434-436.

27 Dray JP, Leibovitch I. Congenital ptosis and amblyopia: a retrospective study of 130 cases. *J Pediatr Ophthalmol Strabismus* 2002;39(4):222-225.

28 Kame RT, Jue TS, Shigekuni DM. A longitudinal study of corneal

astigmatism changes in Asian eyes. *J Am Optom Assoc* 1993;64(3): 215-219.

29 Read SA, Collins MJ, Carney LG. The influence of eyelid morphology on normal corneal shape. *Invest Ophthalmol Vis Sci* 2007;48(1):112-119.

30 Assadi FA, Narayana S, Yadalla D, *et al*. Effect of congenital ptosis correction on corneal topography-a prospective study. *Indian J Ophthalmol* 2021;69(6):1527-1530.

31 Stärk N, Zubcov AA, Kast E, *et al*. Amblyopia, refractive errors and strabismus in congenital ptosis. *Ophthalmologe* 1996;93(4):345-350.

32 She ZH, Hung LF, Arumugam B, *et al*. The development of and recovery from form-deprivation myopia in infant rhesus monkeys reared under reduced ambient lighting. *Vis Res* 2021;183:106-117.

33 Raviola E, Wiesel TN. Effect of dark-rearing on experimental myopia in monkeys. *Invest Ophthalmol Vis Sci* 1978;17(6):485-488.

34 von Noorden GK, Lewis RA. Ocular axial length in unilateral congenital cataracts and blepharoptosis. *Invest Ophthalmol Vis Sci* 1987;28(4):750-752.

35 Li XY, Liu C, Mao Z, *et al*. Effect of congenital blepharoptosis on corneal biomechanical properties and changes after ptosis surgery. *Eye* (*Lond*) 2020;34(6):1055-1062.

36 Takahashi Y, Kang H, Kakizaki H. Axial globe length in congenital ptosis. *J Pediatr Ophthalmol Strabismus* 2015;52(3):177-182.

37 Yinon U, Koslowe KC. Eyelid closure effects on the refractive error of the eye in dark- and in light-reared kittens. *Am J Optom Physiol Opt* 1984;61(4):271-273.