Int J Clin Exp Med 2019;12(6):7772-7777
www.ijcem.com /ISSN:1940-5901/IJCEM0091758

Original Article

Correlation of diopter level with axis oculi and corneal curvature in adolescents with ametropic eyes

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Received January 24, 2019; Accepted March 11, 2019; Epub June 15, 2019; Published June 30, 2019

Abstract: Objective: The current study aimed to analyze the correlation of diopter levels with corneal curvature and axial length (AL) in adolescents with ametropic eyes. Methods: One hundred and seventy-six adolescents with ametropic eyes were enrolled in the experimental group, while 174 healthy subjects undergoing physical check-ups, during the same period, were enrolled into the control group. The study phase was from May 2017 to May 2018. AL, corneal curvature radius (CR) in vertical and horizontal directions, and diopter levels were measured and statistically analyzed. Results: There were statistically significant differences in AL, CR in vertical and horizontal directions, and diopter level between experimental and control groups ($P < 0.05$). There was a linear correlation of the AL and AL/CR with diopter level, with statistically significant differences ($P < 0.05$). Conclusion: Diopter level in adolescents with ametropic eyes are correlated with the AL/CR and AL. The latter is the primary cause of myopia.

Keywords: Adolescent, diopter, ametropia, corneal curvature, axial length, correlation

Introduction

Ametropia refers to the fact that, when eyes are not accommodated, parallel rays affected by refraction are not imaged in the retina but imaged in the front and rear of the retina. Ametropia includes hyperopia, astigmatism, and myopia [1, 2]. A clinical study showed that incidence of amblyopia and strabismus ranges from 1.0% to 1.5% [3]. At present, clinical causes of ametropia remain unclear. It is generally believed to be closely related to genetic factors. In addition, unreasonable medications are an important cause [4, 5].

With a special constitution and during growth and developmental stages, children may have excessive eye fatigue that leads to ametropia. This may be due to long reading times, dark lighting, and incorrect writing posture. High myopia causes retinal detachment and hyperopia easily results in blepharitis, hordeolum, and chronic conjunctivitis. These have serious adverse effects on patient health [6, 7]. In a study by Li Juan et al., diopter levels were positively correlated with axial length (AL) and corneal curvature [8]. Based on the above research, 176 adolescents with ametropic eyes in the Ophthalmology Department of Zhabei Central Hospital, from May 2017 to May 2018, were included in the current study. This study also included 174 healthy subjects undergoing physical check-ups, during the same period.

Materials and methods

Baseline data

Prior to this study, approved by the Ethics Committee of Zhabei Central Hospital, 176 adolescents with ametropic eyes in the Ophthalmology Department of Zhabei Central Hospital were enrolled as the experimental group. Additionally, 174 healthy subjects undergoing physical check-ups, during the same period, were enrolled as the control group. The study phase was from May 2017 to May 2018. The experimental group included 72 females and 104 males. The youngest was 13 years old and the oldest was 18 years old, with an average age of (15.5 ± 1.1) years old. There were 144 eyes in females and 208 eyes in males. There were 72 adolescents with a family history of genetic diseases and 104 adolescents without a history of this disease. There were 128 adolescents with a history of familial high myo-

Table 1. Comparison of baseline data (n, %)

Group	Experimental group (n = 176)	Control group (n = 174)	t	P
Gender			0.720	0.396
Male	104 (59.09)	95 (54.60)		
Female	72 (40.91)	79 (45.40)		
Average age (year)	15.5 ± 1.1	15.7 ± 1.1	1.663	0.097
Family history of genetic diseases			28.157	< 0.001
Yes	72 (40.91)	20 (11.49)		
No	104 (59.09)	154 (88.51)		
History of familial high myopia			108.777	< 0.001
Yes	128 (72.73)	30 (17.24)		
No	48 (27.27)	144 (82.76)		

pia and 48 adolescents without a history of this disease. In the control group, there were 79 females and 95 males. The youngest was 14 years old and the oldest was 17 years old, with an average age of (15.7 ± 1.1) years old. There were 20 adolescents with a family history of genetic diseases and 154 adolescents without a history of this disease. There were 30 adolescents with a history of familial high myopia and 144 adolescents without a history of this disease. Baseline data were comparable between the two groups.

Inclusion criteria: (1) Mentally normal and conscious; (2) Older than 13 years old and younger than 18 years old; and (3) Volunteered to participate in this study.

Exclusion criteria: (1) Abnormal intraocular pressure; (2) Irregular astigmatism, corneal scars, and a history of eye injury; (3) Incomplete clinical data; (4) Allergic to the drugs used in this study; (5) Complicated with congenital diseases; and (6) With amblyopia.

Methods

All enrolled subjects underwent routine eye examinations, including slit lamp (model: YZ5E; manufacturer: Qisheng (Shanghai) Medical Devices Co., Ltd.) examinations, Pentacam (model: SS-1000; manufacturer: Hanfei Medical Devices Co., Ltd., Shanghai) examinations, eye tests, fundus tester (model: APS-A; manufacturer: Kanghua Ruiming Technology Co., Ltd., Chongqing) examinations, and non-contact tonometer (model: Pulsair intelli; manufacturer: Chongqing Sun Kingdom Medical Equipment Co., Ltd.) examinations. Subjects were given compound tropicamide eye drops (manufacturer: Santen Pharmaceutical Co., Ltd.; specification: 5 mL) and underwent rapid dilated-pupil retinal retinoscopy procedures. IOL Master (Zeiss, Germany; model: IOL Master) was used to measure corneal curvature radius (CR) in vertical and horizontal directions, as well as AL. The latter was measured 5 times, while the former was measured 3 times, obtaining average values. Calculation of the corneal curvature: $K = (K1 + K2)/2$ (K1 and K2 represented the sum of the diopter in the two axes upward) and the average value was AL/CR [9-11].

Statistical methods

SPSS 24.0 software was used to process data. Measurement data are expressed as mean ± standard deviation ($\bar{x}$ ± sd). Independent sample t-tests or linear regression were used to calculate errors. The t-value of linear regression coefficient was -2, 10, and the absolute value was greater than 2. $P < 0.05$ indicates statistical differences. Count data are expressed as the number of cases/percentage (n/%) and χ^2 tests were used. $P < 0.05$ indicates statistically significant differences.

Results

Comparison of baseline data

There were no statistically significant differences between experimental and control groups in terms of age, gender, and number of eyes ($P > 0.05$). However, statistically significant differences existed in terms of family history of genetic diseases ($P < 0.05$). See **Table 1**. See **Table 2** for basic conditions of the disease in the experimental group.

Table 2. Basic conditions in the experimental group (n, %)

	Basic history of diseases		Degree of ametropia			Affected eyes (both eyes)
	No	Yes	Myopia	Hyperopia	Astigmatism	
Case	152 (86.36)	24 (13.64)	58 (32.95)	66 (37.50)	52 (29.55)	176 (100.00)

Table 3. Comparison of AL/CR, AL, CR, and diopter level

Group	Experimental group (n = 176)	Control group (n = 174)	t	P
Number of eyes	348	339		
AL/CR	2.98 ± 0.11	3.01 ± 0.14	2.230	0.026
CR (mm)				
Vertical radius	7.07 ± 0.35	7.19 ± 0.33	3.299	0.011
Horizontal radius	6.86 ± 0.28	6.95 ± 0.29	2.954	0.003
AL (mm)	22.02 ± 2.62	23.96 ± 2.97	3.141	0.002

Note: AL, axial length; CR, corneal curvature radius.

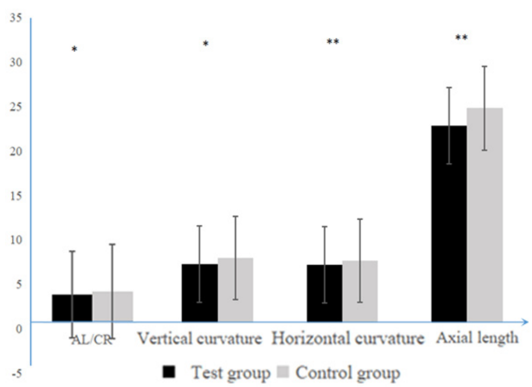

Figure 1. Comparison of AL/CR, AL, CR, and diopter level. AL, axial length; CR, corneal curvature radius. $^{*}P < 0.05$, $^{**}P < 0.01$.

Comparison of AL/CR, AL, CR, and diopter level

There were statistically significant differences between experimental and control groups in terms of AL, AL/CR, CR in vertical and horizontal directions, and diopter level (all P < 0.05). See **Table 3** and **Figure 1**.

Correlation of biological measurement factors with diopter levels in eyes

AL/CR and AL were negatively correlated with diopter levels, with statistically significant differences (all P < 0.05). There was no linear correlation of CR in vertical and horizontal directions with diopter level in the two groups. See **Table 4**.

Correlation of CR with AL

CR in vertical and horizontal directions was positively correlated with AL in the two groups, with statistically significant differences (all P < 0.05). See **Table 5**.

Correlation between CR in vertical and horizontal directions

There was a positive correlation between CR in vertical and horizontal directions in the two groups, with statistically significant differences (P < 0.05). See **Table 6**.

Discussion

Ametropia, including myopia, hyperopia, and astigmatism, is highly complex. It is known as "presbyopia", while the physiological adjustment problem caused by age is regarded as specific ametropia. The human body generally has 2 eyes. There are certain differences in ametropia between the two eyes, also known as anisometropia, increasing the complexity of ametropia. Diopter levels of human eyeballs are easily affected by factors in nature. The most typical are the corneal system, anterior chamber depth, axis oculi, and lens system. The equilibrium state of these systems is directly or indirectly related to the refractive state of the eyes [12, 13]. There is a clinical study showing that, in myopia, development of AL is negatively correlated with corneal curvature. During the development of the eyeball to emmetropization, the AL gradually becomes larger and the cornea is compensated for flattening. This causes corneal curvature to be gradually lower [14]. Ametropia has three major complications. First, high myopia has a higher probability of retinal detachment. Second, hyperopia causes blepharitis, hordeolum, and chronic conjunctivitis. Third, astigmatism is complicated with nausea and vomiting. A clinical study has shown that there is a complementary trend during the development of the refractive components of the eyeball [15]. During

Table 4. Correlation of biological measurement factors with diopter level in eyes

	Experimental group (diopter)		Control group (diopter)	
	r	P	r	P
AL/CR	-0.512	< 0.001	-0.514	< 0.001
CR				
Vertical radius	-0.168	0.286	0.159	0.311
Horizontal radius	-0.216	0.149	0.156	0.301
AL	-0.306	0.041	-0.625	< 0.001

Note: AL, axial length; CR, corneal curvature radius.

Table 5. Correlation of CR with AL

	Experimental group (AL)		Control group (AL)	
	r	P	r	P
CR (vertical)	0.568	< 0.001	0.574	< 0.001
CR (horizontal)	0.657	< 0.001	0.549	< 0.001

Note: AL, axial length; CR, corneal curvature radius.

Table 6. Correlation between CR in vertical and horizontal directions

	Experimental group (CR (horizontal))		Control group (CR (horizontal))	
	r	P	r	P
CR (horizontal)	0.931	< 0.001	0.962	< 0.001

Note: CR, corneal curvature radius.

the development of the human eyeball, the AL continues to increase, generally increasing to 8mm. The eyeball will, if not affected by other factors, have a high myopia of approximately -20.0D in the process [16, 17]. As AL increases, the crystalline lens and corneal planes gradually become flat. Diopter level are continuously reduced, ensuring the normal emmetropization of human eyeballs, and avoiding occurrence of high myopia [18, 19].

Development of the human eyeball is affected by many factors. If the balance between refractive factors is broken, the result is ametropia. During ametropia, AL is the primary influencing factor. Changes in the crystalline lens and cornea also have an influence [20-22]. Many studies at home and abroad have shown that the main factor affecting ametropia is AL [23]. In this study, the ametropia group had significantly lower CR and AL, according to comparisons of AL/CR, CR (vertical and horizontal), AL, and diopter level between the two groups. This suggests that, during emmetropization, corneal curvature has a compensatory effect. In other words, the cornea gradually flattens and the CR gradually increases, while corneal curvature gradually decreases. In addition, changes in CR in the vertical direction are consistent with those in the horizontal direction. This study also showed a linear correlation of AL/CR and AL with diopter level, indicating that, concerning influencing factors of the refractive state, AL is the main influencing factor. In contrast, corneal curvature has a relatively weak influence. There were differences in AL/CR between the two groups of patients. A linear correlation of AL/CR with diopter level was revealed, showing that AL/CR can be a sensitive indicator in monitoring myopia. Concerning influencing factors of the refractive state of the human eyeball, corneal curvature and AL are the main factors. AL is the most important and the most influential one. During emmetropization, growth of the AL is closely related to the compensation of corneal curvature. Therefore, if the cornea is insufficiently compensated for increases in AL, the balance between refractive components will be destroyed, resulting in myopia.

The present study suggests that AL has a great influence on the refractive state of patient eyes, while changes in corneal curvature have very little effect. Shortcomings of this current study include the small sample size and short study phase. These factors may have affected the generality and universality of results. Therefore, it is necessary to further expand sample sizes and extend study phases in future experiments. It is believed that, with the rapid development of medical technology and continuous research on the ametropia of human eyes, influencing factors of ametropia can be more scientifically and accurately interpreted.

In summary, AL/CR may be a sensitive indicator in monitoring myopia. In modern medical technology, it is difficult to use AL/CR to change the AL of patients. However, corneal curvature can be changed by means of orthokeratology lens and refractive surgery. These provide a new research direction for prevention and control of myopia.

Acknowledgements

This work was supported by the Excellent Talent Training Program of Shanghai Eye Disease

Prevention and Treatment Center: Measurement and intervention of intraocular pressure and ocular axis in school age myopic children (15GWZK0601-QJGG10).

Disclosure of conflict of interest

None.

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