The Normal Range of Central Corneal Light Reflex Ratio in Thai Children

Supaporn Tengtrisorn MD*

* Department of Ophthalmology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Objective: *To determine the range of central corneal light reflex ratio (CCLRR) in Thai children.*
Material and Method: *Sixty-three students identified as having a visual acuity of poorer than 20/40 screening by a research assistant underwent a complete assessment including a visual acuity test, orthoptic examination, refraction, and cover tests were enrolled in the present study. Corneal light reflex photographs were obtained using a compact camera. The subject was photographed head-on, the photos were taken at a distance of one (near) and six (distance) meters, and each image was measured twice using the Adobe Photoshop software program. The CCLRR was the ratio of the summated bilateral distances between the central corneal light reflex (CCLR) and nasal limbus to the summated bilateral corneal diameters. Normal range of CCLRR was estimated based on a hypothetical normal range defined by mean $\pm$ 1.58 standard deviations.*
Results: *The present study included 63 students with a best correct visual acuity of better than 20/40 and a mean age of 9.18 (SD 1.72) years, comprising 36 males (57.1%) and 27 females (42.9%). The alternate prism cover test (APCT) at near/at distance, a certified diagnosis, revealed 29 (46.05%)/54 (85.7%) orthophoria, 29 (46.05%)/6 (9.5%) exophoria, 4 (6.3%)/ 1 (1.6%) intermittent exotroria, 0 (0%)/2 (3.2%) exotropia, and 1 (1.5%)/0 (0%) esotropia. The mean of stereopsis was 59.05 $\pm$ 50.47 (range of 40 to 400) seconds of arc. The normal range of CCLRR at near/at distance was 0.446 to 0.484/0.421 to 0.482, while the indeterminate groups at near were 0.435 to 0.445, and 0.485 to 0.495, and at distance 0.403 to 0.420 and 0.483 to 0.500. The cases that had lower or higher ratios should be considered as suspected strabismus.*
Conclusion: *Normal range of CCLRR in Thai children is established.*

Keywords: *Central corneal light reflex, Screening, Children*

J Med Assoc Thai 2012; 95 (3): 418-22
Full text. e-Journal: *http://www.jmat.mat.or.th*

Visual development is very important for physical, linguistic, psychomotor, and psychosocial development. In developing countries, the number of health personnel is limited, especially in the field of ophthalmology. Many childhood eye problems such as amblyopia and strabismus persist into adulthood, even though eye screening is a cost effective public health program[1]. Eye screening programs are usually performed by health personnel[2], teachers, or research assistants who often work apart from families, so it would be better if family members could detect abnormal eye development early using a simple instrument.

Strabismus is one of the common presenting symptoms of eye diseases like amblyopia, cataract, retinoblastoma, and other visual impairment. The early detection by parents of serious eye disease comes from strabismus. The Hirschberg test, a strabismic test, uses central corneal light reflex (CCLR) related to papillary margin to detect strabismus, but it cannot identify a small, abnormal angle[3]. The normal point of CCLR in simple photographs may be a feasible method of testing and screening in children.

There are many benefits from digital cameras and photography, including corneal diameter measurement[4] and strabismus evaluation[5-9]. Ocular alignment in a photograph may affect testing and screening[10]. For the observer, exotropia is easier to detect than esotropia[9]. Today compact cameras are inexpensive and easy to use by families generally. The present study aims to determine the range of central corneal light reflex ratio (CCLRR) in Thai children.

Material and Method

The research was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla

Correspondence to:
Tengtrisorn S, Department of Ophthalmology, Faculty of Medicine, Prince of Songkla University, Songkhla 90110, Thailand.
Phone: 074-451-380, Fax: 074-429-619
E-mail: tsupapor@medicine.psu.ac.th

University, and followed the tenets of the Declaration of Helsinki.

This was a satellite study of the project "Visual acuity and visual behaviors among primary school children in Nakhon Hat Yai municipality, Songkla province"[11]. One thousand nine hundred children were randomly selected from eleven primary schools. The visual screenings were conducted between April 2006 and March 2007 by a non-medical assistant researcher.

Among the 1900 students screened, 122 were identified as having a visual acuity of poorer than 20/40 screening by research assistant and, of these, 63 underwent a complete assessment, including the visual acuity test, an orthoptic examination, and refraction and stereoacuity tests and were enrolled in this study. Their ocular alignment was confirmed using an alternate prism cover test (APCT) as a gold standard.

Corneal light reflex photographs were obtained using a compact camera; namely, a Fuji FinePix S602 Zoom with a 6X optical zoom lens. The subject was photographed head-on, the photos were taken at a distance of 1-(near) and 6-(distance) meters, and each photograph was measured twice by a non-medical assistant researcher using the Adobe Photoshop software program. The zoom digitally performed the photograph to 1,200%, and then put marker in the center of CCLR and horizontal limbus. Measurements were made of the CCLR to nasal limbus distances and corneal diameters, as demonstrated in Fig. 1. The CCLRR was calculated as the ratio of the summated bilateral distances between CCLR and nasal limbus to the summated bilateral corneal diameters.

The reference range for CCLRR was defined as the mean $\pm$ 1.58 SD. However, because of sampling variability these values, both the mean and the standard deviation, are subject to uncertainty. Therefore, within the overall range of possible values, two limits were calculated within which values could be reliably considered "normal", two more extreme limits beyond which values could be reliably considered "abnormal", with the zone between these two limits in each direction being designated "indeterminate" zones. The calculations of these limiting values were made following the principle for small samples presented by Leslie and Greenberg[12].

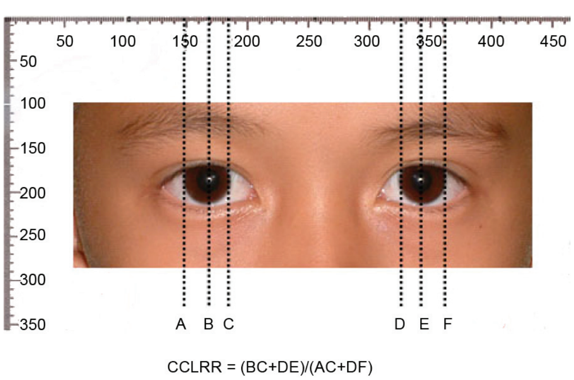

Fig. 1 Measurement of central corneal light reflex ratio (CCLRR)

Results

The present study included 63 students who had completed eye examination with a best corrected visual acuity of better than 20/40 with a mean age of 9.18 (SD 1.72) years, comprising 36 males (57.1%) and 27 females (42.9%). The APCT at near/at distance, a certified diagnosis, revealed 29 (46.0%)/54 (85.7%) orthophoria, 29 (46.0%)/6 (9.5%) exophoria, 4 (6.3%)/ 1 (1.6%) intermittent exotroria, 0 (0%)/2 (3.2%) exotropia, and 1 (1.6%)/0 (0%) esotropia. Stereopsis ranged from 40 to 400 seconds of arc (Table 1).

The distribution of strabismic position did not differ significantly between subjects of low stereopsis (< 40 sec) and those with higher stereopsis (> 40 to 400 sec) either in near or in distance measurements. Older children had a lightly lower proportion of orthotropia or exophoria than younger children, but the difference was not statistically significant (Table 1).

Table 2 shows the mean values ($\pm$ SD) of CCLRR at near and distance measurement for the different strabismic positions and Table 3 the estimated normal range of CCLRR based on the subset of subjects with orthotropia /expophoria. The normal range at near/at distance was estimated to be 0.446 to 0.484/ 0.421 to 0.482. The indeterminate ranges at near were 0.435 to 0.445 and 0.485 to 0.495 and ranges at distance were 0.403 to 0.420 and 0.483 to 0.500. Beyond these outer limits, the CCLRR should be considered to indicate suspected strabismus.

The relationship between classification based on CCLRR and strabismic position is shown in Table 4. Subjects with intermittent exotropia and esotropia tended to have CCLRR in the indeterminate or abnormal range.

Discussion

APCT at near and at distance, the percentage of strabismus among the students who were abnormally

Table 1. Association between strabismic position and age and stereopsis

Variable	APCT at near, No. (%)			APCT at distance, No. (%)		
	Ortho + X (n = 58)	X(T) (n = 4)	ET (n = 1)	Ortho + X (n = 60)	X(T) (n = 1)	XT (n = 2)
Age						
≤ 9 years	27 (96.4)	0	1 (3.6)	27 (96.4)	1 (3.6)	0
> 9 years	31 (88.6)	4 (11.4)	0	33 (94.3)	0	2 (5.7)
Stereopsis						
≤ 40 sec	36 (92.3)	2 (5.1)	1 (2.6)	38 (97.4)	1 (2.6)	0
> 40 to 400 sec	22 (91.7)	2 (8.3)	0	22 (91.7)	0	2 (8.3)

APCT = alternate prism cover test; Ortho = orthotropia; X = exophoria; X(T) = intermittent exotropia; XT = exotropia; ET = esotropia; CCLRR = central corneal light reflex ratio

Table 2. Comparison between measured CCLRR and APCT at near and at distance

Condition	APCT at near No. (%)	APCT at distance No. (%)	CCLRR at near mean ± SD (min, max)	CCLRR at distance mean ± SD (min, max)
Ortho + X	58 (92.1)	60 (95.2)	0.447 ± 0.010 (0.442, 0.485)	0.452 ± 0.017 (0.412, 0.488)
X(T)	4 (6.3)	1 (1.6)	0.453 ± 0.020 (0.437, 0.481)	0.412
XT	0	2 (3.2)	0	0.450 ± 0.070 (0.400, 0.500)
ET	1 (1.6)	0	0.428	0

Ortho = orthotropia; X = exophoria; X(T) = intermittent exotropia; XT = exotropia; ET = esotropia; CCLRR = central corneal light reflex ratio

Table 3. Boundary points of CCLRR for normal, indeterminate and abnormal ranges based on data from subjects with orthotropia /expophoria

Parameter	Near	Distance
Mean	0.465	0.451
Standard deviation	0.012	0.019
Normal	0.446-0.484	0.421-0.482
Indeterminate	0.435-0.445, 0.485-0.495	0.403-0.420, 0.483-0.500
Abnormal	<0.435, >0.495	<0.403, >0.500

Table 4. Relationship between classification based on CCLRR and strabismic position

CCLRR classification	APCT at near, No. (%)			APCT at distance, No. (%)		
	Ortho + X (n = 58)	X(T) (n = 4)	ET (n = 1)	Ortho + X (n = 60)	X(T) (n = 1)	XT (n = 2)
Normal	58 (96.7)	2 (3.3)	0	59 (100)	0	0
Indeterminate	0	2 (100)	0	1 (50.0)	1 (50.0)	0
Abnormal	0	0	1 (100)	0	0	2 (100)

APCT = alternate prism cover test; Ortho = orthotropia; X = exophoria; X(T) = intermittent exotropia; XT = exotropia; ET = esotropia; CCLRR = central corneal light reflex ratio screened by the Snellen chart as having a visual acuity of less than 20/40 was 15.0% and 9.3%, respectively. This prevalence differs considerably from the 1.4% reported in an earlier study in southern Thailand[13]. Similarly, in the report of Kattouf et al[14], among 4,298 healthy children ranging in age from birth to 6 years, the percentage of strabismus was 1.6%. These differences may arise from differences in multiple factors, including the study population (community, school, hospital-based), the type of visual acuity tests employed, the persons performing the screening (technician, trained school employees), etc.

An apparent relationship between strabismic position and degree of stereopsis is demonstrated in Table 1. Even if it had no statistical significance, it is crucial to determining sensory development. Nearly two-thirds (61.9%) of the studied population had fine stereopsis (≤ 40 sec of arc), while slightly more than one-third had medium stereopsis (> 40 to 400 sec of arc) without any one loss stereopsis. This applied to all the children who had good binocular sensory function. It should be noted that in the few studies about stereoacuity in children, the critical periods for binocular sensory function occurred during the first year of life, and stereopsis was better in older than in younger children[15,16].

The mean CCLRR at near was lower than that at distance in the subjects with orthotropia/expophoria possibly due to accommodation, the dissimilar figure is naturally different. Many studies have reported that the CCLR detected by the Hirschberg test varied from 12 to 20.89 prism diopters per millimeter, potentially due to the design of the study[6,7,16,17]. The CCLR variation may be exclusively exact, if the ocular alignment was actually in the central position of both corneas.

The present study has provided a preliminary estimate of the normal range of CCLRR at near and at distance among Thai children. Limitations of the present study comprise of the small sample size, poor standardization of the photographic technique, and variations in photographic positioning.

Further study should be geared toward digital computerized strabismus screening using relatively inexpensive equipment and user-friendly tools as described in the present study. Both medical and paramedical personnel are essential to early detection of strabismus. Early detection can help minimize visual dysfunction, allow for normal development of binocular vision and depth perception, and prevent psychosocial dysfunction.

Conclusion

The normal range of central corneal light reflex ratio in Thai children is presented. This could be used as the basis for developing a simple screening test for strabismus.

Acknowledgement

The authors wish to thank the Faculty of Medicine, Prince of Songkla University, for funded support; Dr. Alan Geater for suggestions in the use of statistics; Mr. Scott Kostiuk for editing assistance; and Assoc. Prof. Dr. Verapol Chandeying for his valuable advice and suggestions concerning the process of manuscript preparation.

Potential conflicts of interest

None.

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ค่าพิสัยปกติของอัตราส่วนของแสงสะท้อนกระจกตาในเด็กไทย

สุภาภรณ์ เต็งไตรสรณ์

***วัตถุประสงค์**: เพื่อหาค่าพิสัยปกติของอัตราส่วนของแสงสะท้อนกระจกตาในเด็กไทย*

***วัสดุและวิธีการ**: เด็กนักเรียน 63 คนได้รับการจำแนกมีสายตาต่ำกว่า 20/40 วัดโดยผู้ช่วยวิจัย ได้รับการประเมินครบถ้วน ได้แก่ การวัดสายตา การตรวจการมอง การทดสอบการหักเหและขอบเขต ส่วนการถ่ายภาพแสงสะท้อนกระจกตาใช้กล้องถ่ายรูปกะทัดรัด ถ่ายภาพหน้าตรงในระยะใกล้ 1 เมตร และระยะไกล 6 เมตร แต่ละภาพวัด 2 ครั้ง ด้วยโปรแกรม Photoshop อัตราส่วนของแสงสะท้อนกระจกตาเป็นอัตราส่วนของทั้งสองตาของผลรวมระยะทางจากจุดกลางแสงสะท้อนกระจกตาไปยังรอยต่อตาดำกับตาขาวด้านจมูก ค่าพิสัยปกติของอัตราส่วนของแสงสะท้อนกระจกตาประเมินค่าอิงกับค่าพิสัยปกติตามสมมุติฐานด้วยค่าเฉลี่ยบวก/ลบ 1.58 ของค่าเบี่ยงเบนมาตรฐาน*

***ผลการศึกษา**: เด็กนักเรียน 63 คนมีสายตาดีกว่า 20/40 อายุเฉลี่ย 9.18 (ค่าเบี่ยงเบนมาตรฐาน 1.72) ปี เป็นผู้ชาย 36 คน (ร้อยละ 57.1) ผู้หญิง 27 คน (ร้อยละ 42.91) ตรวจด้วยวิธี alternate prism cover test (APCT) ที่ระยะใกล้/ไกล พบตาตรง 29 คน (ร้อยละ 46.05)/54 คน (ร้อยละ 85.7) เขออกนอกซ่อนเร้น 29 คน (ร้อยละ 46.05)/6 คน (ร้อยละ 9.5) เขออกนอกบางครั้ง 4 คน (ร้อยละ 6.3)/1 คน (ร้อยละ 1.6) เขออกนอก 0 คน (ร้อยละ 0)/2 คน (ร้อยละ 3.2) เขเข้าใน 1 คน (ร้อยละ 1.5)/0 คน (ร้อยละ 0) ค่าเฉลี่ยการมองภาพ 3 มิติเป็น 59.05 $\pm$ 50.47 (พิสัย 40 to 400) seconds of arc ค่าพิสัยปกติของแสงสะท้อนกระจกตาในกลุ่มเด็กปกติระยะใกล้/ไกลเป็น 0.446 ถึง 0.484/0.421 ถึง 0.482 ขณะกลุ่มไม่แน่ชัดค่าพิสัยระยะใกล้เท่ากับ 0.435 ถึง 0.445 และ 0.485 ถึง 0.495 ส่วนระยะไกลเท่ากับ 0.403 ถึง 0.420 และ 0.483 ถึง 0.500 ผู้ที่มีอัตราส่วนต่ำหรือสูงกว่านี้ถือว่าสงสัยเป็นตาเข*

***สรุป**: ได้ค่าพิสัยปกติของอัตราส่วนของแสงสะท้อนกระจกตาในเด็กไทย*
