OPTIC NERVE HEAD AND RETINAL NERVE FIBER LAYER ANALYSIS IN EMMETROPIC MALAY CHILDREN

BY

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ABSTRAK

Latarbelakang

Parameter kepala saraf optik dan ketebalan lapisan serat saraf retina bagi kanak-kanak normal telah banyak diterangkan dalam laporan-laporan yang telah diterbitkan terdahulu. Namun demikian, tiada satu pun ukuran ini diterangkan di kalangan populasi kanak-kanak Melayu menggunakan mesin 'Cirrus spectral domain optical coherence tomography' (SD-OCT). Tujuan kajian ini adalah untuk menentukan nilai normatif bagi parameter kepala saraf optik dan ketebalan lapisan serat saraf retina bagi kanak-kanak Melayu yang emetrop. Perkaitan di antara setiap parameter ini juga dinilai.

Objektif

Untuk menentukan purata parameter kepala saraf optic dan ketebalan lapisan serat saraf retina di kalangan kanak-kanak Melayu yang emetrop serta untuk menentukan perkaitan di antara parameter kepala saraf optic dan ketebalan lapisan serat saraf retina.

Metodologi

Sembilan puluh lima kanak-kanak Melayu yang normal yang berumur antara 7 hingga 17 tahun telah diambil di dalam kajian berbentuk hirisan lintang ini. Kajian ini telah dijalankan di Hospital Universiti Sains Malaysia, Malaysia dari bulan Januari 2014 hingga Disember 2015. Semua kanak-kanak telah menjalani pemeriksaan mata yang lengkap termasuk refraksi dan pengukuran panjang bebola mata. Pengukuran parameter kepala saraf optik dan lapisan serat saraf retina telah

dilakukan menggunakan mesin ‘Cirrus SD-OCT’. Hanya satu mata dipilih secara rawak untuk dianalisa. Perkaitan di antara parameter serta pengaruh umur, jantina, kepanjangan bola mata dan tahap refraksi pada setiap ukuran dinilai.secara statistik.

Keputusan

Sembilan puluh lima kanak-kanak telah menyertai kajian ini dengan 65 orang perempuan (68.4%) dan 30 orang lelaki (31.6%). Purata umur adalah 10.6 (2.82) tahun, purata tekanan mata adalah 14.8 (2.81) mmHg, purata tahap refraksi adalah -0.12 (0.28) diopters dan purata kepanjangan bola mata adalah 23.03 (0.76) mm. Purata kawasan cakera, kawasan rim dan isipadu cawan adalah masing-masing 2.32 (0.40) mm^2, 1.53 (0.33) mm^2 dan 0.204 (0.16) mm^3. Purata nisbah antara kawasan cawan dan kawasan cakera dan nisbah antara kawasan cawan dan kawasan cakera secara menegak adalah 0.55 (0.13) dan 0.50 (0.14). Purata keseluruhan lapisan serat saraf retina bagi semua pesakit adalah 102.08 (11.08) µm. Keseluruhan lapisan serat saraf retina, bahagian atas dan bahagian bawah menunjukkan perkaitan positif yang ketara dengan kawasan cakera optik. Perkaitan yang ketara juga diperhatikan antara kawasan rim dan keseluruhan lapisan serat saraf, bahagian atas, bahagian bawah dan bahagian nasal. Bahagian bawah lapisan serat saraf retina mempunyai perkaitan yang negatif dengan purata nisbah antara kawasan cawan dan kawasan cakera. Jantina juga mempunyai kesan yang ketara terhadap kawasan cakera. Namun, tiada kesan ketara oleh umur, kepanjangan bola mata dan tahap refraksi terhadap pengukuran.

Kesimpulan

Kajian ini menyediakan data normatif bagi kepala saraf optik dan ketebalan lapisan serat saraf retina dalam kanak-kanak Melayu yang emetrop. Lelaki Melayu emetrop mempunyai kawasan cakera optik yang ketara lebih besar. Peningkatan ketebalan lapisan serat saraf retina menyebabkan peningkatan yang ketara di kawasan cakera dan rim.

ABSTRACT

Background

Optic nerve head (ONH) parameters and retinal nerve fiber layer thickness (RNFLT) of normal children have been described in previous published reports. None of these measurements was described among Malay children population using Cirrus spectral domain optical coherence tomography (SD-OCT). The aim was to report normative values for ONH parameters and RNFLT in emmetropic Malay children. The possible correlations between these parameters were also evaluated.

Objectives

To determine the mean of ONH parameters and mean RNFL in emmetropic Malay children; and to determine correlation between the ONH parameters and RNFL thickness

Methods

Ninety-five Malay children with no ocular abnormality aged between 7 to 17 years were recruited into this cross sectional study. It was conducted in Hospital Universiti Sains Malaysia, Malaysia from January 2014 to December 2015. All children underwent a complete ocular examination including refraction and axial length measurement. ONH parameters and RNFLT measurement were performed using Cirrus SD-OCT machine. One eye of each subject was randomly selected for analysis. The correlations in between the parameters and influence of age, gender,

axial length and spherical equivalent (SE) on measurements were statistically evaluated.

Results

Ninety-five children were included in the study with 65 females (68.4%) and 30 males (31.6%). Mean age was 10.6 (2.82) years, mean IOP was 14.8 (2.81) mmHg, mean SE refraction was -0.12 (0.28) diopters and mean axial length was 23.03 (0.76) mm. Mean (SD) disc area, rim area and cup volume were 2.32 (0.40) mm^2, 1.53 (0.33) mm^2 and 0.204 (0.16) mm^3, respectively. The average cup to disc ratio (SD) and vertical CDR were 0.55 (0.13) and 0.50 (0.14). Mean (SD) RNFLT for all patients was 102.08 (11.08) µm. The average, superior and inferior RNFLT showed a significant positive correlation with the optic disc area. A significant correlation was also observed between the rim area and average, superior, inferior and nasal RNFLT. The inferior RNFLT was negatively correlated with average CDR. There was also significant effect of gender on disc area. There were no significant effects of age, axial length and SE on the measurements.

Conclusion

This study provides normative data of ONH parameters and RNFLT in emmetropic Malay children. Emmetropic Malay male had a significantly larger optic disc area. Increase in RNFLT is associated with significant increase in disc and rim areas.

CHAPTER 1:

INTRODUCTION

Measurement of optic nerve head (ONH) parameters and retinal nerve fiber layer thickness (RNFLT) have been described in previous studies using various techniques, namely optical coherence tomography (OCT), scanning laser polarimetry, Heidelberg Retinal Tomograph (HRT) I, II or III. OCT is a relatively new technology that allows non-invasive cross sectional imaging of ocular structures with high resolution. Since its introduction, there have been several version of software and hardware of OCT.

Earlier studies used time-domain OCT as a gold standard in their research (Leung *et al*., 2010; Pawar *et al*., 2014; Samarawickrama *et al*., 2009). However recently, usage of higher definition spectral-domain OCT (SD-OCT) has become more widespread. The newer generations of OCT proved to be superior to HRT in term of less measurement error and less variability in determining the RNFL thickness of both eyes in repeated measurements (Shpak *et al.,* 2012; Larsson *et al.,* 2011). The ability of Cirrus SD-OCT to discriminate between normal eyes with mild glaucoma is well reported (Mwanza *et al.,* 2011). Higher sensitivity and specificity is also demonstrated by Cirrus SD-OCT as compared to older generations of time-domain OCT (Sung *et al.,* 2012).

Numerous studies have been conducted in the past to establish a normative value for ONH parameters and RNFLT particularly in healthy adult population by using OCT (Mwanza *et al.,* 2011; Knight *et al.,* 2012; Mansoori *et al.,* 2011). Current database for RNFL measured by Cirrus SD-OCT only provides comparative normative value for healthy adults from 18 to 84 years old. Normative data outside this age range particularly in paediatric population is still lacking.

Preliminary studies have reported the normative values of ONH and RNFLT among childhood population using earlier version of time-domain OCT (Leung *et al.*, 2010; Pawar *et al.*, 2014; Samarawickrama *et al.*, 2009). Normative data for children using Cirrus SD-OCT is less reported, especially with regards to ONH parameters. The majority of these studies are confined to East Asian, Spanish and Middle Eastern population (Elia *et al.*, 2012; Al-Haddad *et al.*, 2013; Tariq *et al.*, 2012). To the best of our knowledge, there is only one study that described these parameters in South East Asian children using HRT machine (Tong *et al.*, 2007). None of the data reported the normative values of ONH parameters and RNFLT in Malay population.

Previous studies reported the correlation between RNFLT and ONH parameters using OCT (Tariq *et al.*, 2012; Mansoori *et al.*, 2010; Savini *et al.*, 2005; Jun *et al.*, 2008). Several authors described a significant increase in RNFLT with an increase in disc areas (Tariq *et al.*, 2012; Savini *et al.*, 2005; Jun *et al.*, 2008). Hence, the correlation between these parameters is essential for better evaluation of ONH parameters and RNFLT. On the other hand, several studies have also examined the relationship between ONH parameters and RNFL thickness with age, gender, axial length, race and refraction (Samarawickrama *et al.*, 2010; Tariq *et al.*, 2012; Hsu *et al.*, 2012; Pang *et al.*, 2009; Huyn *et al.*, 2006; Agarwal *et al.*, 2003; Tsai *et al.*, 1995).

ONH parameters and RNFLT vary considerably between ethnicities (Samarawickrama *et al.*, 2010; Samarawickrama *et al.*, 2012; Tariq *et al.*, 2012). East Asian children had thicker RNFL and larger mean cup to disc ratio as compared to European Caucasian children (Samarawickrama *et al.*, 2010; Tariq *et al.*, 2012). In

2012, Samarawickrama and colleagues reported that African Americans may have on average the largest optic discs followed by Indian, Chinese and Europeans. Hsu *et al.* (2012) reported that aging effect on neuroretinal rim loss and RNFL thickness is non-uniform in a study involving 133 healthy subjects in Taiwan. Pang *et al.* (2009) and Tariq *et al.* (2012) have found significant effect of gender on ONH parameters and RNFL.

In 2006, Huyn *et al.* have found significant increase in optic disc area and decreased in rim area with axial length. Budenz and colleague in 2007 reported thinner mean RNFL thickness by approximately 2.2 micrometer for every 1 mm increase in axial length. This negative correlation is subsequently supported by El Dairi *et al.* in 2009 and Knight *et al.* in 2012. Salchow *et al.* (2006) reported that refraction had significant effect on RNFL thickness. Several studies on children also demonstrate a similar finding in ONH parameters in relation to refractive errors (Agarwal *et al.*, 2003; Tsai *et al.*, 1995). Another study conducted in Asian Malay aged between 40 to 80 years old in Singapore have found that refractive error status is significantly related to ONH parameters and RNFL area measured by HRT II, whereby higher value reported in myopic and smaller value in hyperopic eye (Wu *et al.*, 2011).

The purpose of this study was to report normative values for ONH parameters and RNFLT in emmetropic Malay children and to evaluate correlations between these parameters. The effect of age, gender, axial length and refraction on these parameters was also evaluated as an additional insight for future studies.

CHAPTER 2:

OBJECTIVES OF THE STUDY

2.1 General Objective

To evaluate ONH parameters and RNFL thickness in emmetropic Malay children by using Cirrus spectral-domain OCT (SD-OCT)

2.2 Specific Objectives

i. To determine mean of ONH parameters in emmetropic Malay children

ii. To determine mean RNFL in emmetropic Malay children

iii. To determine correlation between the ONH parameters and RNFL thickness

CHAPTER 3:

MANUSCRIPT

3.1 Optic Nerve Head and Retinal Nerve Fiber Layer Analysis in Emmetropic Malay Children

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3.2 Abstract

Background

Optic nerve head (ONH) parameters and retinal nerve fiber layer thickness (RNFLT) of normal children have been described in previous published reports. None of these measurements was described among Malay children population using Cirrus spectral domain optical coherence tomography (SD-OCT). The aim was to report normative values for ONH parameters and RNFLT in emmetropic Malay children. The possible correlations between these parameters were also evaluated.

Methods

Ninety-five Malay children with no ocular abnormality aged between 7 to 17 years were recruited into this cross sectional study. It was conducted in Hospital Universiti Sains Malaysia, Malaysia from January 2014 to December 2015. All children underwent a complete ocular examination including refraction and axial length measurement. ONH parameters and RNFLT measurement were performed using Cirrus SD-OCT machine. One eye of each subject was randomly selected for analysis. The correlations in between the parameters and influence of age, gender, axial length and spherical equivalent (SE) on measurements were statistically evaluated.

Results

Ninety-five children were included in the study with 65 females (68.4%) and 30 males (31.6%). Mean age was 10.6 (2.82) years, mean IOP was 14.8 (2.81) mmHg, mean SE refraction was -0.12 (0.28) diopters and mean axial length was 23.03 (0.76) mm. Mean (SD) disc area, rim area and cup volume were 2.32 (0.40) mm^2, 1.53 (0.33) mm^2 and 0.204 (0.16) mm^3, respectively. The average cup to disc ratio (SD) and vertical CDR were 0.55 (0.13) and 0.50 (0.14). Mean (SD) RNFLT for all patients was 102.08 (11.08) µm. The average, superior and inferior RNFLT showed a significant positive correlation with the optic disc area. A significant correlation was also observed between the rim area and average, superior, inferior and nasal RNFLT. The inferior RNFLT was negatively correlated with average CDR. There was also significant effect of gender on disc area. There were no significant effects of age, axial length and SE on the measurements.

Conclusion

This study provides normative data of ONH parameters and RNFLT in emmetropic Malay children. Emmetropic Malay male had a significantly larger optic disc area. Increase in RNFLT is associated with significant increase in disc and rim areas.

Keywords

Optic nerve head, retinal nerve fiber layer, emmetropic, optical coherence tomography, spherical equivalent

3.3 Introduction

Numerous studies have been conducted in the past to establish a normative value for optic nerve head (ONH) parameters and retinal nerve fiber layer thickness (RNFLT) among childhood population worldwide using various types of modalities [1-11]. Nevertheless, the majority of these studies are confined to East Asian and Middle Eastern population [2, 4, 5, 7, 10]. Only one study in South East Asian region has examined these data by using HRT machine which involved mainly Singaporean Chinese children [11].

Malay ethnic comprises a significant proportion of population in South East Asia, with approximately 300 to 400 million of population [12]. However, none of the data reported the normative values of ONH parameters and RNFLT in Malay population except for one study in adult population which was described in Singapore [13]. Hence, the normative data for healthy Malay children is still lacking and need further attention.

Normative data for children using Cirrus SD-OCT is less reported; especially with regards to ONH parameters. Previous studies reported the correlation between RNFLT and ONH parameters using OCT [4, 23, 24, 25]. This is essential for better evaluation of ONH parameters and RNFLT as several authors described a significant increase in RNFLT with an increase in disc areas [4, 23, 24]. The purpose of this study was to report normative values for ONH parameters and RNFLT in emmetropic Malay children and to evaluate correlations between these parameters using Cirrus SD-OCT. The effect of age, gender, axial length and refraction on these

parameters was also evaluated as an additional insight for future studies. To the best of our knowledge, this is the first study describing on normative values and correlation of ONH parameters and RNFLT with Cirrus SD-OCT in South East Asian children.

3.4 Materials and Methods

This was a hospital-based study involving 95 emmetropic Malay children aged between 7 to 17 years attending Eye Clinic, Hospital Universiti Sains Malaysia from January 2014 to December 2015. The study protocol was approved by Research and Ethic Committee, School of Medical Sciences, Hospital Universiti Sains Malaysia and all procedures performed in accordance with Declaration of Helsinki.

Written informed consent was obtained from all parents or guardian before enrolment of subjects. The non-probability sampling was applied. Malay children aged between 7 to 17 with no ocular abnormalities, best corrected visual acuity (BCVA) better than 6/12, intraocular pressure (IOP) equal or less than 21 mmHg with SE between ±0.5 DS (emmetropia) and astigmatism less than -1.00 DC were included. The exclusion criteria were subjects with history of optic nerve anomalies or retinal diseases, history of glaucoma (primary, secondary, family history), history of intraocular surgery, prematurity, ocular trauma, history of neurological disease, syndromic child, child with strabismus or amblyopia.

All children underwent complete ocular examinations including distant visual acuity with Snellen chart, ocular motility, slitlamp examination. IOP was measured for both eyes using Goldman applanation tonometer or air puff tonometer (Reichert, NY, USA) followed by axial length measurement by IOL Master (Carl Zeiss Meditec, Jena, Germany). Both eyes were instilled with topical cyclopentolate 1% for 3 times, 5 minutes apart before refractive assessment. Cycloplegic refraction was done using

Auto Refractor (Reichert, NY, USA) and dilated fundus examinations were performed.

Quantitative assessment of ONH parameters and RNFL measurement was obtained by using Cirrus SD-OCT (Carl Zeiss Meditec, USA). It has a 5-µm axial resolution and scans at 27,000 A-scans per second. Measurement was obtained using Optic Disc Cube 200 x 200 protocol. A Cirrus software algorithm automatically placed a diameter calculation circle of 3.46 mm around the centre of the optic disc. Internal fixation target was used in all cases. The scan was centered on the optic disc and was verified by direct observation of fundus structures on a video screen by single trained co-investigator.

Criteria for satisfactory image quality includes images with optimal centration of optic disc, absent of blinking or eye movement artefacts and a signal strength ≥ 7. If the image was of inadequate quality, or was poorly focused, it was repeated until acceptable images were obtained. If the image is still unsatisfactory even after 5 attempts, the procedure is abandoned and repeated at different time. One eye of each subject was randomly selected for analysis.

The detailed demographic data, clinical findings, and the measurements of ONH parameters and RNFL thickness were documented in a separate data collection sheet. Data entry and analysis was done using SPSS Version 22. Mean and standard deviation (SD) were reported for normally distributed data, while median and interquartile range were described for skewed data. Correlation between ONH parameters and RNFL thickness was done using Pearson correlation coefficient.

Independent *t* test was done to compare measurements among different gender. Univariate and multivariate regression analysis were conducted to assess the possible effect of age, gender, axial length and spherical equivalent on the measurements. P value less than 0.05 was considered to indicate statistical significance.

3.5 Results

A total of 95 subjects who fulfilled the inclusion criteria were finally enrolled in the study. The demographic data and clinical characteristics of study subjects are listed in Table 1. Mean (SD) age of study subjects was 10.6 (2.82) years. There were 30 boys (31.6%) and 65 girls (68.4%). 71 subjects (74.7%) had visual acuity of 6/6 and the remaining 24 children (25.3%) had visual acuity of 6/7.5. Mean IOP was 14.8 (2.81) mmHg with range of 10 to 20 mmHg, mean SE refraction was -0.12 (0.28) diopters, ranging between -0.50 to +0.50 diopters and average axial length was 23.03 (0.76) mm with range of 21.37 to 24.90 mm.

Patients were subdivided into 2 subgroups based on age: 7 up to 10 years (n=50) and 11 up to 17 years (n=45) for better presentation of the data. The distribution of ONH parameters and RNFLT measurements according to age groups are reported in Table 2. Mean (SD) disc area, rim area and cup volume for all patients were 2.32 (0.40) mm^2 , 1.53 (0.33) mm^2 and 0.204 (0.16) mm^3, respectively. The average cup to disc ratio (SD) and vertical CDR were 0.55 (0.13) and 0.50 (0.14). Mean (SD) RNFLT for all patients was 102.08 (11.08) µm; with the thickest being the inferior RNFL followed by superior, temporal then nasal RNFL being the thinnest.

Table 3 shows correlation between ONH parameters and RNFLT measurements. The average, superior and inferior RNFLT showed a significant positive correlation with the optic disc area (r=0.363, p=0.000), (r=0.304, p=0.003), (r=0.299, p=0.003). A significant correlation was also observed between the rim area and average, superior, inferior and nasal RNFLT (r=0.445, p=0.000), (r=0.306, p=0.003), (r=0.409,

p=0.000), (r=0.305, p=0.003). The inferior RNFLT was negatively correlated with average CDR (r=-0.238, p=0.020).

We observed significant effect of gender on disc area (b= 0.281, p=0.001) (Table 4). No significant correlations were observed between all other variables on ONH and RNFLT measurements.

3.6 Discussion

We present normal reference values for ONH parameters and RNFLT using Cirrus SD-OCT in normal Malay children aged 7 to 17 years. Earlier studies used time-domain OCT as a gold standard in their research [8-10]. However recently, usage of higher definition SD-OCT has become more widespread. Comparison of studies on ONH parameters and RNFL measurements by using OCT in normal children with almost similar age groups were shown in Table 5 [1-10]. To our knowledge, this is the first study in South East Asian countries which highlights the normative values for ONH parameters and RNFLT, correlations between these parameters and factors affecting it in Malay children using Cirrus SD-OCT.

We observed a mean disc area of 2.32 (0.40) mm^2 and mean rim area of 1.53 (0.33) $mm^{2,}$. Our observation is consistent with Elia *et al.* who reported the mean disc area of 2.05 (0.39) mm^2 and mean rim area of 1.59 (0.33) mm^2 in Spain children [1]. Similarly, the mean average RNFLT in our Malay children is parallel with data from Taiwan, Turkish, Indian and East Asian children living in Australia [5, 7, 9, 10]. However, the measurements was done using Spectralis OCT and earlier version of time-domain OCT. It is interesting to note that Tariq *et al.* and Samarawickrama *et al.* who examined a large sample of Australian children aged between 6 to 19 years old, reported that East Asian children had thicker RNFL, larger disc area, smaller rim area and larger CDR as compared to whites [4, 14]. On the other hand, retinal thickness of less than 100 µm was observed in children living in Lebanon, Spain and Australia [1-4].

Our study exhibited slightly different distribution of RNFL, with inferior being the thickest followed by superior, temporal and nasal being the thinnest. This finding is consistent with reports by Turk *et al.* and Tsai *et al.* in 2012, who did a study on Turkish and Chinese children in Taiwan with different version of OCT, Spectralis and RTVue-100 [5, 7]. Few published reports done in USA and Australia also demonstrated exception to the normal ISNT rule [15-17].

This study demonstrate a significant relationship between gender and optic disc area (b= 0.281, p=0.001), with male gender revealed larger disc area as compared to female. Tariq *et al.* also noted similar effect of gender on optic disc parameters [4]. Interestingly, in 2009, Pang *et al.* have found significant differences between genders in cup-to-disc area ratio and linear cup-to-disc area ratio on normal ONH parameters. In this study, these two parameters were greater in boys than in girls of African American children [18]. This finding is supported by He *at al.* who had examined Chinese children aged 7 to 15 years, which showed that disc area and cup area were smaller in girls compared to boys [19]. There were no significant effect of age, axial length and SE on other ONH parameters were observed.

We reported no significant relationship between gender and RNFLT. This finding is comparable with previous published reports, which have found no significant effect of gender on RNFLT [1, 3, 9, 17]. We also found no correlation between age and RNFLT. This finding is in agreement with other published studies [1, 2, 5, 8, 9, 14, 18, 21]. In contrast, Hsu *et al.* reported that age correlated negatively with rim parameters, average RNFL and superior RNFL in 133 patients in Taiwan aged

between 10 to 77 years. However, the author concluded that the aging effect on neuroretinal rim and RNFL is non-uniform and age is not a constant confounder when using OCT [20].

Few studies have examined the relationship between ONH parameters and RNFLT with axial length [3, 5, 21, 22]. We observed no significant effect of axial length on ONH parameters and RNFLT. This finding is parallel with Barrio-barrio *et al.* and Turk *et al.* who reported a similar finding [3, 5]. On the other hand, Huyn *et al.* have reported significant increase in optic disc area and decreased in rim area with axial length in a large study involving 6-year-old children residing in Australia [21]. In 2007, Budenz and colleague reported thinner mean RNFL thickness by approximately 2.2 micrometer for every 1 mm increase in axial length in 328 of normal adult subjects in USA [22]. This negative correlations is subsequently supported by El Dairi *et al.* in 2009 and Tariq *et al et al.* in 2012 [4, 15]. Earlier studies have used the time-domain OCT with different age group, and this may have attributed for this different findings to ours. RNFL thinning with longer axial length may be also attributed by magnification effect [4].

The effect of refraction on OCT measurements has been debated in literatures. We did not find any significant correlation between spherical equivalent refraction and these measurements. This is expected because we only included emmetrope children within range of ± 0.5 DS in our study. This finding is also comparable to those studies done by Turk *et al.*, Tong *et al.* and Pang *et al.* who examined children aged between 6 to 17 years with SE ranging from – 8.0 to + 6.0 diopter [5, 11, 18]. They observed no correlation between refraction and RNFL thickness and no significant

difference in ONH parameters among children with low myopia and higher myopia in Turkish, African American and Singaporean Chinese children.

We documented a significant correlation between RNFLT with disc and rim area. The inferior RNFLT was negatively correlated with average CDR (r=-0.238, p=0.020). This finding is consistent with Tariq *et al.* who have found a significant correlation between disc area, rim area and CDR with average RNFL [4]. The author reported that larger disc and rim area is associated with thicker RNFL whereas larger CDR is associated with thinner RNFL.

Previous studies in healthy patients using time-domain OCT (Stratus OCT) have also shown positive correlation between RNFL thickness with size of optic disc [23, 24]. This finding might be due to increase in optic nerve fiber count with increasing ONH size or a smaller distance between the fixed circular scan and the true ONH margin. A Korean study by Jun *et al.* involving children aged between 4 to 15 years documented a decrease in RNFLT with smaller disc area [23]. Another study by Savini *et al.* conducted in older group of patients in Italy aged between 15 to 54 years demonstrates a similar finding. Mansoori *et al.*, however reported a contradictory findings in Indian adults [25]. The reason behind their lack of association may be due to their small sample size (n=65) with wider range of age group and differences in disc margin delineation between OCT instrument.

The strengths of our study are that it provides a new data regarding ONH and RNFL analysis in South East Asian children using the new generation of Cirrus SD-OCT. The usage of Cirrus SD-OCT provides less variability in repeated measurements with

higher sensitivity and specificity in comparison with HRT. Additionally, this study also covered a wide range of age group from 7 to 17 years and all children underwent comprehensive eye examination by single trained researcher and optometrist. Detailed correlations between all the parameters are also reported in this study. Main limitation in our study is that we only confined to one ethnic group. Multiracial comparison on ONH and RNFL measurements is needed in future studies.

In conclusion, this study provides normative data of ONH parameters and RNFLT in emmetropic Malay children measured by using Cirrus SD-OCT. Emmetropic Malay male had a larger optic disc area as compared to female. Increase in RNFLT is associated with significant increase in disc and rim area. This data will facilitate assessment of ONH and RNFLT particularly in children with suspected or diagnosed with glaucoma and optic neuropathies.

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