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Relationship between Optic Nerve Head Morphology, Retinal Nerve Fiber Layer Thickness and Refractive Errors in a Saudi Pediatric Population: A Cross-Sectional Study

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ABSTRACT

Background: Many biographical, ocular parameters and ocular pathologies like Glaucoma and Diabetic Retinopathy (DR) are known to affect the optic disc or macula, causing changes in the morphology of the Optic nerve head and variations in the retinal nerve fiber layer.

Objective: To compare the Optic Nerve Head (ONH) morphology and Retinal Nerve Fiber Layer (RNFL) thicknesses of eyes with different types of refractive error among Saudi children from Al Hasa region, Saudi Arabia.

Methods: This cross-sectional study was conducted among 117 Saudi children between 5 to 18 years of age visiting the Al-Moosa specialist hospital in Hofuf city. Children who presented with refractive errors were selected using Consecutive sampling method. An optometrist assessed the refractive status of each eye. A pediatric ophthalmologist examined anterior segment, measured intraocular ocular pressure, and assessed the posterior segment of the eye. The neuro-retinal rim area was 1.87 mm2 (± 0.93 mm2) and RNFL thickness was 130 μ (± 15.7 μ) in hypermetropic eyes. The neuroretinal rim area at disc and RNFL thickness were 1.74 mm2 (± 0.61 μ) and 90.71 μ (± 14.88 μ) in astigmatic (≥ 2D) eyes.

Results: We examined 234 eyes of 117 children, myopia 66 (28.21%), emmetropia 121 (51.71%), hypermetropia 21 (8.97%) and 26 (11.11%) astigmatism. Horizontal integrated rim area (mm2) was significantly higher in emmetropic eyes than in eyes with myopia (p=0.019). Other morphological parameters did not vary significantly among myopic and emmetropic eyes (p>0.05) respectively. The average RNFL thickness at optic disc was significantly higher in emmetropic eyes than in the myopic eyes (p<0.001). RNFL at inferior quadrants (p=0.090), superior quadrants (p=0.072), nasal quadrants (p=0.129) and temporal quadrants (p=0.460) does not differ significantly among myopic and emmetropic eyes. Similarly, high myopic had significantly higher RNFL thickness as compared to moderate myopia (p<0.001).

Conclusion: This study showed that refractive errors have a significant influence on the optic nerve and retinal parameters of Saudi children and therefore while interpreting the ONH parameters and RNFL thicknesses in children, status of refractive error must be considered.

Key words: Myopia, Hypermetropia, Optical coherent tomography, Optic nerve head, Retinal nerve fiber layer.

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INTRODUCTION

The Kingdom of Saudi Arabia (KSA) has a relatively high prevalence of refractive errors with the prevalence of refractive errors among children ranging from 13.7% to 35% in various studies [1,2]. The refractive state of the eye has a significant influence on many ocular parameters and may influence diagnosis of several ophthalmological conditions. Optical coherence tomography (OCT) is an important tool to determine posterior segment pathologies and neuroophthalmological conditions [3]. Refractive errors can affect the optic disc and retina and hence can create confusion while interpreting the results of OCT investigations for eyes with other optic nerve or retinal diseases. Hence, it is important to note OCT changes in different types and grades of refractive errors and compare them to the findings of emmetropic eyes.

The optic nerve head and retinal thickness at optic disc and macula are two important areas where changes occur in different eye diseases affecting retina [4-7]. Several studies have been documented in literature specifying normative values in children of different locations [8-10]. There are certain studies available in KSA which study the effect of various ocular morbidities on the optic nerve head (ONH) morphology and retinal nerve fiber layer (RNFL) thickness. Both these studies used OCT to assess the appearance of the ONH and assess the RNFL. There are published studies that have utilized OCT to assess the normal parameters in the Saudi population, but these studies comprise adult population [11-14]. Therefore, we planned to conduct a study with the aim of evaluating ONH and RNFL thickness in children with emmetropia and different refractive errors and to assess the normal values in the pediatric population.

METHODS

This cross-sectional study was conducted at a tertiary referral center in the Eastern province of KSA (Al-Moosa specialist hospital in Hofuf city). This study was approved by the Ethical and Research Committee (Al-Moosa Specialist Hospital). The duration of study was from June 2017 – December 2018. Inclusion criteria were Saudi children between 5 to 18 years of age visiting our institution for complaints of blurring of vision. Children having strabismus or amblyopia were also included in our study. A child with (a) ocular or systemic pathology, (b) history of any injury or trauma, (c) nutritional deficiency and (d) current or previous treatment for ocular or systemic condition was excluded from the study.

A pediatric ophthalmologist conducted the bulk of the work of the present study with the assistance of a pediatric optometrist and ophthalmic technician in testing the refractive error. Refractive status of each eye was determined by performing cycloplegic refraction. One drop of tropicamide 0.8% + phenylephrine 5% was instilled for this purpose. We used Straus Optical Coherence tomography (Carl Zeiss Meditec) to assess the ONH morphology and RNFL thickness at optic disc and the macula. ONH evaluation consisted of six radial scans. Each one was centered on the optic disc, spaced 300 microns apart and included 128 points. We used Fast Optic Disc acquisition protocol. The machine defined the edge of the optic disc as the end of the RPE-choriocapillaries and used smoothening with fit to circle and to fill the gaps between scans. A straight line connected the edges of the RPE-choriocapillaries, and a parallel line was constructed 150 microns in front. The findings below this line were defined as the cup of the optic disc and above this line were the neuro-retinal rim.

We noted OCT findings of horizontal disc size, disc area, cup area, rim area. C: D area ratio, vertical integrated rim area (VIRA) and horizontal integrated rim width (HIRA). The RNFL thickness was analyzed by using circular scans concentric to the optic disc. Scan size was of 3.4 mm concentric around discs.

Instead of single scan, three scans were analyzed to give better results. The instrument projects 820 nm near infrared light beam across the retina and obtains ocular scans (3.4mm) centered on the optic disc and measures RNFL thickness at 256 points. The RNFL is identified as a red colored high reflectivity zone adjacent to the optically zero reflective vitreous.

The mean peripapillary and the quadratic RNFL thickness were calculated automatically by the OCT software and these values were used for analysis.

The macular scans acquired measurements of the central 200 points around the foveola. We considered the scanning procedure acceptable if the centering of the beam on the optic disc was good and the signal strength was more than five.

The eyes were grouped according to their refractive status. For astigmatism of less than 2D, we calculated spherical equivalent and added to the spherical values.

Eye was defined as emmetropic if its refractive status were between -0.5D and +0.5D. Moderate myopia was defined as eye with -0.5D to -6.0D myopia. High myopia was defined as an eye with >-6.0D myopia. An eye with +0.5D to +3.0D refraction was considered as moderate hypermetropia. While an eye with more than +3.0D refraction was considered to have high hypermetropia.

The data was entered and analyzed using IBM SPSS 26.0. Continuous variables (HIRA, RNFL-OD, RNFL-I, RNFL-S, RNFL-N, RNFL-T and RNFL-macula) are expressed and Mean ± SD.

For comparisons purposes between ONH morphological parameters and RNFLT, the data was grouped into myopic and emmetropic eyes and moderate myopia and high myopia. The analysis was made using two-independent sample t test. Mean difference and Confidence Intervals are also reported for all analysis. A p-value of <0.05 was considered as statistically significant.

RESULTS

In this study, 234 eyes of 117 children were studied. Their age ranged from 5 to 18 years with the mean age of 10.8 ± 1.5 years. One hundred and twenty-one eyes of 61 children were emmetropic, 66 eyes of 33 children were myopic, 21 eyes had hypermetropia and 26 eyes had more than ± 2D astigmatism, results are presented in Figure 1.

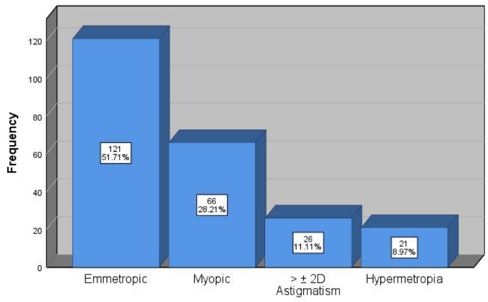

Figure 1: Prevalence of refractive error.

Results presented in Table 1 shows the comparison of ONH morphological parameters between myopic and emmetropic eyes. The mean horizontal integrated rim area (HIRA) in myopic eyes was 1.668 mm2 (± 0.374 mm2), while in emmetropic eyes, it was 1.78 mm2 (± 0.374 mm2). Emmetropic eyes had a significantly larger HIRA as compared to myopic eyes (mean difference=0.112, 95% CI=0.11-0.112, p=0.019).

Results presented in Table 2 shows the comparison of RNFL thickness between myopic and emmetropic eyes. The mean RNFL thickness at optic disc of emmetropic eyes was 93.55 μ (± 16.97 μ), while it was 85.32 μ (± 8.23 μ) in myopic eyes. Emmetropic eyes had a significantly larger RNFL-optic disc as compared to myopic eyes (mean difference=8.23, 95% CI=8.22-8.24, p<0.001). RNFL thickness at inferior quadrants (p=0.090), superior quadrants (p=0.072), nasal quadrants (p=0.129) and temporal quadrants (p=0.460) although had higher values but these does not differ significantly among myopic and emmetropic eyes.

Table 1: Comparison of optic nerve head morphology between myopic and emmetropic eyes.

Parameters	Mean ± SD (N=66)	Mean ± SD (N=121)	Mean Difference	95% CI	p-value
	Myopic Eyes	Emmetropic Eyes			
Horizontal Integrated Rim Area	1.668 ± 0.374	1.780 ± 0.271	0.112	0.11 – 0.112	0.019*

*Statistically significant at 5% level of significance; CI: Confidence Interval

Table 2: Comparison of retinal nerve fiber layer thickness between myopic and emmetropic eyes.

Parameters	Mean ± SD (N=66)	Mean ± SD (N=121)	Mean Difference	95% CI	p-value
	Myopic Eyes	Emmetropic Eyes			
Retinal Nerve Fiber Layer at optic disc	85.32 ± 8.23	93.55 ± 16.97	8.23	8.22 – 8.24	<0.001*
Retinal Nerve Fiber Layer at inferior quadrants	115.41 ± 11.87	118.22 ± 10.17	2.81	1.95 – 3.74	0.09
Retinal Nerve Fiber Layer at superior quadrants	125.27 ± 9.51	128.55 ± 12.94	3.28	3.01 – 3.55	0.072
Retinal Nerve Fiber Layer at nasal quadrants	70.75 ± 13.88	74.28 ± 15.81	3.53	2.80 – 4.28	0.129
Retinal Nerve Fiber Layer at temporal quadrants	60.67 ± 10.11	63.17 ± 11.77	3.53	2.80 – 4.28	0.46

*Statistically significant at 5% level of significance; CI: Confidence Interval

The ONH morphology and RNFL thickness in 23 eyes with moderate and 43 eyes with high myopia are presented in Table 3. The thickness of RNFL at optic disc in eyes with moderate myopia was 93.52 μ (± 8.21 μ) while it was 80.93 μ (± 14 μ) in eyes with high myopia. RNFL thickness was significantly higher in high myopic children (mean difference=12.59, 95% CI=10.78-15.97, p<0.001). However, the RNFL at macula does not differ significantly between moderate and high myopics hyperopic eyes suggested that in 21 eyes with (p=0.594). The ONH morphology and RNFL thickness of hypermetropia the neuro-retinal rim area was 1.87 mm2 (± 0.93 mm2). In this group, the RNFL thickness was 130 μ (± 15.7 μ) and macular thickness was 187.6 μ (± 22.7 μ). The mean RNFL thickness in 21 eyes with astigmatism was 90.71 μ (± 14.88 μ). The optic nerve rim area in this group was 1.74 mm2 (± 0.61 μ).

Table 3: Comparison of optic nerve head morphology and retinal nerve fiber layer thickness between moderate and high myopic eyes.

Parameters	Mean ± SD (N=23)	Mean ± SD (N=43)	Mean Difference	95% CI	p-value
	Moderate Myopia	High Myopia			
Retinal Nerve Fiber Layer at optic disc	93.52 ± 8.21	80.93 ± 14.0	12.59	10.78 – 15.97	<0.001*
Retinal Nerve Fiber Layer at macula	271.21 ± 18.33	273.97 ± 20.79	2.76	1.87 – 4.47	0.594

*Statistically significant at 5% level of significance; CI: Confidence Interval

DISCUSSION

The present study showed that the optic nerve head in myopic eyes had smaller neuro-retinal rim area in the horizontal meridian as compared to the emmetropic eyes. The differences in all other disc parameters were not statistically significant. However, retinal nerve fibre layer thickness was significantly less in all quadrants except temporal to the disc in the myopic eye compared to the emmetropic eye. The macular thickness was less in the myopic eyes compared to the emmetropic eyes. The average RNFL thickness at disc was more in mild myopia than in high myopic eyes. The ONH parameters did not vary significantly according to the severity of myopia. Our results are like studies among the pediatric population conducted elsewhere, however most of the other studies show significant differences in the parameters based on the severity of myopia [15-19]. With increase in axial length in high myopic eye, there is a shift of optic disc nasally, thinning of RNFL [20]. In our study, we found that eyes with high myopia had different RNFL thickness and ONH morphology compared to that found in children with myopia less than 6D. This contrasted with findings of a study conducted by Tong et al [21], the authors reported that the cup disc ratio did not correlate with severity of myopia.

Although our study comprised children aged 5 to 18 years, the children of younger age group were limited. Hence, we could not evaluate changing refractive error by age and its impact on ONH morphology and RNFL thickness. Agarwal et al had noted that the age and the gender had no significant association to the stereo-metric parameters of ONH [22]. A wide variation in the measurement of RNFL and ONH in normal eyes has been documented in the literature [9,23-30]. Difference in study population, ethnicity, age group and measurement methods could be responsible for this observed variation. This stresses the need to have normative values of ONH and RNFL measurement in different race and geographic areas. Straus OCT has been found to have better reproducibility in measuring macular and NFL thickness [31,32]. Thus, outcome of our study using this equipment are likely to be more reliable.

RNFL thickness is useful parameter to diagnose, quantify and follow up the disease progression in glaucomatous eyes [33]. Our study provided normative RNFL values for children of the Eastern province of Saudi Arabia. While screening for childhood glaucoma in this part of the country in which there is a comparatively high prevalence rate, the parameter of ONH and RNFL of our study could be used to compare further decline in the RNFL thickness [31,33]. The present study has few limitations. The numbers of astigmatic and hypermetropic eyes were few. Hence, interpreting the findings and suggesting their clinical significance was avoided. Further studies are recommended with a larger sample of astigmatic and hypermetropic types of refractive errors.

CONCLUSION

The normative values of Optical coherent tomography (OCT) based Optic Nerve Head (ONH) morphology and Retinal Nerve Fiber Layer (RNFL) thickness in children of eastern Saudi Arabia were noted in our study. Myopia had significant influence on RNFL thickness and therefore refractive status should always be noted prior to interpreting the OCT findings.

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