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.

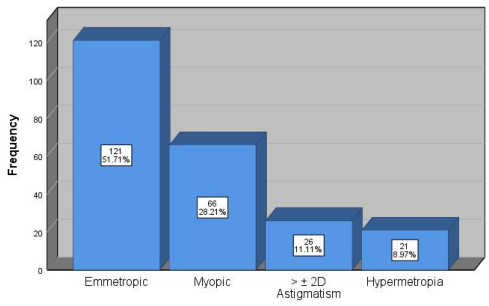

Figure 1: Prevalence of refractive error.

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 (p=0.594). The ONH morphology and RNFL thickness of hyperopic eyes suggested that in 21 eyes with 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.

REFERENCES

1. Wadaani F, Amin TT, Ali A, et al. Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. Glob J Health Sci 2013; 5:125–134.
2. Alrahili N, Jadidy ES, Alahmadi BS, et al. Prevalence of uncorrected refractive errors among children aged 3-10 years in western Saudi Arabia. Saudi Med J 2017; 38:804–810.
3. Costello F. Optical coherence tomography in neuro-ophthalmology. Neurologic Clin 2017; 35:153-63.
4. Park JH, Yoo C, Jung JH, et al. The association between prelaminar tissue thickness and peripapillary choroidal thickness in untreated normal-tension glaucoma patients. Medicine (Baltimore) 2019; 98:e14044.
5. Kapupara K, Huang TL, Wen YT, et al. Optic nerve head width and retinal nerve fiber layer changes are good indexes for validating the successful induction of experimental anterior ischemic optic neuropathy. Exp Eye Res 2018; S0014-4835(18)30274-4.
6. Jankowska-Lech I, Wasyluk J, Palasik W, et al. Peripapillary retinal nerve fiber layer thickness measured by optical coherence tomography in different clinical subtypes of multiple sclerosis. Mult Scler Relat Disord 2018; 27:260-268.
7. Krzyżanowska-Berkowska P, Czajor K, Helemejko I, et al. Relationship between the rate of change in lamina cribrosa depth and the rate of retinal nerve fiber layer thinning following glaucoma surgery. PLoS One 2018; 13:e0206040.
8. Gama R, Santos JC, Costa RS, et al. Optical coherence tomography analysis of the inner retinal layers in children. Can J Ophthalmol 2018; 53:614-620.

9. Salchow DJ, Oleynikov YS, Chiang MF, et al. Retinal nerve fiber layer thickness in normal children measured with optical coherence tomography. Ophthalmology 2006; 113:786-91.
10. Bae SH, Kang SH, Feng CS, et al. Influence of myopia on size of optic nerve head and retinal nerve fiber layer thickness measured by spectral domain optical coherence tomography. Korean J Ophthalmol 2016; 30:335-343.
11. Fahmy RM, Bhat RS, Al-Mutairi M, et al. Correlation between glycemic control and peripapillary retinal nerve fiber layer thickness in Saudi type II diabetics. Clin Ophthalmol 2018; 12:419-425.
12. Alasbali T, Lofty NM, Al-Gehaban S, et al. Macular ganglion cell-inner plexiform layer and retinal nerve fiber layer thickness in eyes with primary open-angle glaucoma compared with healthy saudi eyes: A cross-sectional study. Asia Pac J Ophthalmol 2016; 5:196-201.
13. El-Agamy A, Oteaf F, Berika M. Anterior lamina cribrosa surface depth in healthy Saudi females. Clin Ophthalmol 2017; 11:1045-1050.
14. Al-Zamil WM, Al-Zwaidi FM, Yassin SA. Macular thickness in healthy Saudi adults. A spectral-domain optical coherence tomography study. Saudi Med J 2017; 38:63-69.
15. Wang CY, Zheng YF, Liu B, et al. Retinal nerve fiber layer thickness in children: The gobi desert children eye study. Invest Ophthalmol Vis Sci 2018; 59:5285-5291.
16. Eslami Y, Vahedian Z, Moghimi S, et al. Peripapillary retinal nerve fiber layer thickness in normal iranian children measured with optical coherence tomography. J Ophthalmic Vis Res 2018; 13:453-457.
17. Tsai DC, Huang N, Hwu JJ, et al. Estimating retinal nerve fiber layer thickness in normal schoolchildren with spectral-domain optical coherence tomography. J Ophthalmol 2012; 56:362-70.
18. Nakazawa M, Kurotaki J, Ruike H. Long term findings in peripapillary crescent formation in eyes with mild or moderate myopia. Acta Ophthalmol 2008; 86:626-9.
19. Tong L, Saw SM, Chua WH, et al. Optic disk and retinal characteristics in myopic children. Am J Ophthalmol 2004; 138:160-2.
20. Sekhar GC, Prasad K, Dandona R, et al. Planimetric optic disc parameters in normal eyes: a population-based study in South India. Indian J Ophthalmol 2001; 49:19-23.
21. Park KA, Choi DD, Oh SY. Macular choroidal thickness and peripapillary retinal nerve fiber layer thickness in normal adults and patients with optic atrophy due to acute idiopathic demyelinating optic neuritis. PLoS One 2018; 13:e0198340.
22. Chen CY, Huang EJ, Kuo CN, et al. The relationship between age, axial length and retinal nerve fiber layer thickness in the normal elderly population in Taiwan: The Chiayi eye study in Taiwan. PLoS One 2018; 13:e0194116.
23. Mansoori T, Balakrishna N. Effect of aging on retinal nerve fiber layer thickness in normal Asian Indian eyes: A longitudinal study. Ophthalmic Epidemiol 2017; 24:24-28.
24. Miura N, Omodaka K, Kimura K, et al. Evaluation of retinal nerve fiber layer defect using wide-field en-face swept-source OCT images by applying the inner limiting membrane flattening. PLoS One 2017; 12:e0185573.
25. Jang JW, Lee MW, Cho KJ. Comparative analysis of mean retinal thickness measured using SD-OCT in normal young or old age and glaucomatous eyes. Int Ophthalmol 2018; 38:2417-2426.
26. Marsh BC, Cantor LB, WuDunn D, et al. Optic nerve head (ONH) topographic analysis by stratus OCT in normal subjects: Correlation to disc size, age, and ethnicity. J Glaucoma 2010; 19:310-318.
27. Girkin CA, Fazio MA, Yang H, et al. Variation in the three-dimensional histomorphometry of the normal human optic nerve head with age and race: Lamina cribrosa and peripapillary scleral thickness and position. Invest Ophthalmol Vis Sci 2017; 58:3759-3769.
28. Wang XY, Huynh SC, Burlutsky G, et al. Reproducibility of and effect of magnification on optical coherence tomography measurements in children. Am J Ophthalmol 2007; 143:484-488.
29. Bourne RR, Medeiros FA, Bowd C, et al. Comparability of retinal nerve fiber layer thickness measurements of optical coherence tomography instruments. Invest Ophthalmol Vis Sci 2005; 46:1280-1285.
30. Lešťák J, Pitrová Š, Žáková M. The difference between ganglion cell complex and nerve fiber layer in the same altitudinal halves of the retina in hypertension and normal-tension glaucomas. Cesk Slov Oftalmol 2018; 73:218-221.
31. Denniss J, Turpin A, McKendrick AM. Relating optical coherence tomography to visual fields in glaucoma: structure-function mapping, limitations and future applications. Clin Exp Optom 2018.
32. Malik R, Khandekar R, Boodhna T, et al. Eradicating primary congenital glaucoma from Saudi Arabia: The case for a national screening program. Saudi J Ophthalmol 2017; 31:247-249.
33. Al Obeidan SA, Dewedar A, Osman EA, et al. The profile of glaucoma in a tertiary ophthalmic university center in Riyadh, Saudi Arabia. Saudi J Ophthalmol 2011; 25:373-379.