Original Article

Assessment of changes in optic disc parameters and peripapillary retinal nerve fiber layer thickness in myopic patients and its correlation with axial length and degree of myopia

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Purpose: The present study aimed to assess the changes in optic disc and peripapillary retinal nerve fiber layer (RNFL) parameters in myopic patients and its correlation with axial length (AL) and spherical equivalent (SE) using optical coherence tomography (OCT). **Methods:** This was a cross-sectional study carried out from August 2019 to September 2021 in the ophthalmology department of a tertiary care hospital in eastern India. Myopic patients in the age group of 20–40 years and SE between − 0.5 to − 10 Diopters (D) were included in the study. Patients were divided into two groups on the basis of degree of myopia and AL. Appropriate statistical analysis was done at the end of the study period. **Results:** The study included 307 eyes of 307 myopic patients. There were 181 females (58.96%) and 126 males (41.04%). The mean age of the patients enrolled for the study was 28.78 ± 5.76 years. Statistically significant difference ($P < 0.001$) was found between SE and AL in between the subgroups of A and B. With every 1 D increase in SE, the average peripapillary RNFL thickness decreased by 0.61 μ while with every 1 mm increase in AL, the average peripapillary RNFL thickness was found to reduce by 1.03 μ. **Conclusion:** Analysis of optic nerve head parameters and RNFL thickness by OCT for the diagnosis should be compared with a normative control group that has been matched for refractive error and AL instead of comparison with a normative database that has only been age matched.

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Myopia is an increasingly important public health problem across the entire world. It is the most common type of refractive error that especially affects schoolgoing children and young adults.[1,2] A study conducted to assess the global prevalence of myopia shows that there are approximately 1950 million cases of myopia worldwide, out of which 277 million cases are that of high myopia.[3] Prevalence of myopia in India varies between 4% and 10% in community-based settings and between 10% and 20% in school-based settings.[4] These numbers are predicted to increase exponentially in the near future. High myopes have an increased risk of developing ocular complications like pre-senile cataracts, glaucoma, retinal detachment, myopic choroidal neovascularization (CNV), posterior staphyloma, macular atrophy, and even blindness.[5,6] Pathological myopia due to excessive increase in axial length is associated with severe visual impairments. Risk factors associated with axial elongation in adults with high myopia include female sex, poor initial vision, presence of myopic maculopathy, and prior choroidal neovascular membrane.[7]

It has been widely reported that myopia affects the size and shape of the optic disc and the peripapillary retinal nerve fiber layer (RNFL) around it.[8–11] Myopia is considered to be a risk factor for open-angle glaucoma and may also be a confounding factor in its diagnosis. Disc changes in myopes like optic disc tilt and torsion along with peripapillary atrophy can make it difficult to distinguish glaucomatous optic neuropathy from myopic pathology.[12] Diagnosis of glaucoma in the presence of myopic optic nerve and retinal changes is a unique challenge. Thus, it becomes very important to understand the effects of myopia on peripapillary RNFL thickness. Increasing axial myopia is associated with reduced macular volume and thickness.[13] The influence of myopia on optic disc and peripapillary RNFL parameters has been studied extensively. However, conflicting results regarding the influence of myopia on peripapillary RNFL thickness have been reported in the literature. Studies involving large number of participants and comparing the influence of both spherical equivalent (SE) and axial length (AL) on optic disc and peripapillary RNFL parameters from eastern India are absent.

The purpose of the present study was to assess changes in optic disc parameters and peripapillary RNFL thickness in myopic patients and the correlation of peripapillary RNFL thickness with SE and AL using optical coherence

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tomography (OCT). We also aimed to determine whether longer AL or increasing myopia is associated with thinner peripapillary RNFL.

Methods

This was a cross-sectional, observational study carried out from August 2019 to September 2021 in the ophthalmology department of a tertiary care hospital in eastern India. The study adhered to the basic tenets of the Helsinki declaration. Institutional ethical committee clearance was received (letter no DRI/IMS.SH/SOA/2021/088 dated 21st June 2021). Written, informed consent was obtained from each participant before enrolment into the study.

Myopia is defined as a refractive error in which rays of light entering the eye parallel to the optic axis are brought to a focus in front of the retina with ocular accommodation at rest. All myopic patients in the age group of 20–40 years with SE between − 0.5 and − 10 diopters (D) and best-corrected visual acuity (BCVA) of 20/20, N6 were included in the study. Patients with family history of glaucoma or diagnosed as having glaucomatous optic neuropathy were excluded from the study. Patients having history of trauma to the eye or head or any intraocular surgeries, patients suffering from any neurological diseases like Parkinsonism, Alzheimer's, multiple sclerosis, and patients taking any medications which could influence the optic disc parameters were also excluded from the study. Raosoft™ sample size calculator was used to calculate the sample size. Using a confidence limit of 95%, a sample size of 300 was deemed adequate for the study. A total of 307 eyes were eventually included in the study.

Patient particulars and brief clinical history was obtained from each participant. BCVA was obtained using the Snellen chart. Assessment of refractive error was done by a single examiner. SE was calculated for each eye as the sum of the spherical power and half of the cylindrical power. Pupils were dilated using a combination of tropicamide (0.5%) and phenylephrine (10%) eye drops. Anterior segment examination was done in all cases using slit lamp. Patients with nuclear sclerosis which can cause a refractive shift to myopia were excluded from the study. A thorough dilated fundus examination was done using indirect ophthalmoscope and 20 D lens in each patient. The thickness of peripapillary RNFL was measured after proper alignment by a single operator using the Topcon 3D OCT-1 Maestro version 8.3 (Topcon Inc, Tokyo, Japan) and three scans were obtained. RNFL scan was done using 3D disc protocol with scan length of 6 × 6 mm and resolution of 512 × 128. Good quality scans were selected and used for analysis, which included scans with signal strength >8, without blinking artefacts or RNFL discontinuity and absence of RNFL algorithm segmentation failure. The 360 degrees average peripapillary RNFL thickness, average thickness in four quadrants (superior, inferior, temporal, and nasal), and average thickness in 12 o'clock positions were noted. Disc area, cup volume, rim area, average cup-to-disc ratio, and vertical cup-to-disc ratio were also recorded. An average of three readings was used for statistical analysis. Appascan Max (Appasamy associates, Chennai, India) was used to determine the AL in all patients using the A-scan ultrasound biometry technique.

All patients were divided into two groups, that is, group A and B on the basis of degree of myopia and AL, respectively. Group A was further subdivided into three groups: A1 (mild myopia <−3 D), A2 (moderate myopia −3 D to −6 D), and A3 (high myopia >−6 D). Group B was subdivided into two groups: B1 (AL ≤24 mm) and B2 (AL >24 mm). The primary objective of the study was to assess changes in optic disc parameters and peripapillary RNFL thickness in myopic patients and the correlation of peripapillary RNFL thickness with SE and AL using OCT. The secondary objective was to determine whether longer AL or increasing myopia is associated with thinner peripapillary RNFL.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences version 25. The right eye of each patient was chosen for statistical analysis. Categorical variables were expressed as percentage and continuous variables were expressed in terms of mean and SD. Difference in mean between three subgroups of group A was calculated using the analysis of variance (ANOVA) test. Difference in means of the two subgroups in group B was calculated using unpaired *t* test. Correlation analysis was performed with Pearson's correlation coefficient. *P* values <0.05 were considered statistically significant.

Results

This cross-sectional, comparative study included 307 eyes of 307 patients with myopia. Out of 307 patients, 181 (58.96%) were females and 126 (41.04%) were males. The mean age of the patients enrolled for the study was 28.78 ± 5.76 years (range 20–40 years). The mean SE was − 3.41 ± 2.43 D (range −0.5 to −10 D) with the mean AL being 24.02 ± 1.36 mm.

In group A, subgroups A1, A2, and A3 included 150, 112, and 45 eyes with mean age of patients being 29.02 ± 6.43, 28.91 ± 5.03, and 27.67 ± 5.03 years, respectively. Mean SE in groups A1, A2, and A3 was − 1.44 ± 0.78 D, −4.31 ± 1.03 D and −7.73 ± 1.33 D, respectively. Mean AL in group A1 was 23.30 ± 1.24 mm, in group A2 was 24.45 ± 1.05 mm, and in group A3 was 25.33 ± 0.97 mm. In group B, subgroups B1 and B2 included 148 and 159 eyes with mean age of the patients being 27.99 ± 6.37 and 28.52 ± 5.04 years, respectively. Mean SE in groups B1 and B2 was −1.98 ± 2.49 D and −4.74 ± 2.49 D, respectively. Mean AL in groups B1 and B2 was 22.91 ± 0.85 mm and 25.04 ± 0.84 mm, respectively.

Statistically significant difference ($P < 0.001$) was found between SE and AL in between the subgroups of A and B. No significant difference was found for age, IOP, and gender among the groups.

All optic nerve head parameters were found to decrease with increase in degree of myopia except the rim area that was found to increase with increasing SE. A correlation analysis of the SE with optic disc parameters showed statistically significant positive correlation with vertical disc diameter ($r = 0.155$, $P = 0.006$) and disc area ($r = 0.326$, $P = 0.0001$) and weak positive correlation between SE and other disc parameters [Table 1]. Analysis of 360° average RNFL showed peripapillary RNFL thickness to decrease with increase in degree of myopia [Table 2]. The thickest quadrant was the inferior followed by the superior, nasal, and temporal quadrants. Clock hour analysis showed peripapillary RNFL thickness to decrease with increase in degree of myopia in all clock hours except in 4, 8, and 10 o' clock positions. A significant

Table 1: Correlation analysis between optic disc parameters and degree of myopia

Disc parameters	Group A1	Group A2	Group A3	Correlation coefficient (*r*)	*P*
Vertical disc diameter (mm)	1.77±0.21	1.74±0.28	1.68±0.32	0.155	0.006
Disc area (mm²)	3.96±0.66	3.79±0.59	3.52±0.66	0.326	0.0001
Cup area (mm²)	4.77±1.29	4.38±1.06	3.79±1.32	0.096	0.093
Rim area (mm²)	1.38±0.38	1.46±0.35	1.55±0.19	0.039	0.495
Cup-to-disc ratio	1.78±0.59	1.77±0.55	1.61±0.36	0.026	0.649
Cup volume (mm³)	1.95±0.77	1.89±0.66	1.73±0.50	0.093	0.103

A1 <–3 D; A2: –3 to–6 D; A3 >–6 D

decrease was also noted in superior and inferior quadrants between myopic eyes <6 D and myopic eyes >6 D but not in nasal and temporal quadrants [Table 3]. Similarly, a decrease in peripapillary RNFL thickness was noted in 5, 6, 7 and 11, 12, 1 o'clock positions. Decrease was insignificant at 11 o'clock position when compared between groups A1 and A2.

A statistically significant, linear positive correlation was noted between the SE and RNFL thickness in average RNFL thickness (r = 0.135, P = 0.0176) and inferior quadrant thickness (r = 0.261, P = 0.0001) [Fig. 1a and b]. However, the superior, nasal, and temporal quadrants showed no significant correlation with the SE [Fig. 1c-e].

Comparison of average peripapillary RNFL thickness between groups B1 and B2 showed increasing AL to be associated with thinner RNFL thickness. A statistically significant difference was noted in the average (P = 0.0003), inferior (P = 0.005), and superior (P = 0.0009) peripapillary RNFL thickness [Table 4]. Statistically significant decrease in RNFL thickness was found in 1, 6, 7, 10, 11, and 12 o' clock position with increase in AL. A significant negative correlation was detected between AL and average peripapillary RNFL thickness (r = −0.126, P = 0.026) as well as with inferior (r = −0.122, P = 0.031) and superior (r = −0.184, P = 0.001) quadrant RNFL thickness [Fig. 2a-c]. Statistically insignificant correlation was detected between AL and nasal (r = 0.047, P = 0.41) and temporal (r = −0.07, P = 0.21) quadrant RNFL thickness [Fig. 2d and e].

In our study, we noted that with every 1 D increase in SE, the average peripapillary RNFL thickness decreased by 0.61 μ while with every 1 mm increase in AL, the average peripapillary RNFL thickness was found to reduce by 1.03 μ.

Table 2: Mean peripapillary RNFL thickness in the three groups of myopia

RNFL thickness (μm)	Group A1	Group A2	Group A3
Average	87.17±11.87	85.63±10.52	81.53±8.79
Quadrant wise			
Inferior	110.13±17.57	106.29±19.43	96.33±21.39
Superior	108.38±22.75	105.29±19.55	100.47±10.86
Nasal	64.41±14.59	63.78±14.87	63.07±13.02
Temporal	61.56±13.55	60.15±13.01	60.27±9.08

A1 <–3 D; A2: –3 to–6 D; A3 >–6 D; RNFL: Retinal nerve fiber layer

Table 3: Comparison of average and quadrant-wise peripapillary RNFL thickness between three myopia groups using ANOVA test

RNFL thickness (μm)	Myopia groups (A1, A2, A3)		Mean difference	*P*
Average	<3 D	3-6 D	1.54	0.1373
		>6 D	5.64	0.0002
	3-6 D	>6 D	4.09	0.0088
Inferior	<3 D	3-6 D	2.81	0.29384
		>6 D	34.69	0.00001
	3-6 D	>6 D	31.88	0.00016
Superior	<3 D	3-6 D	3.72	0.15764
		>6 D	18.86	0.00076
	3-6 D	>6 D	15.14	0.00711
Nasal	<3 D	3-6 D	2.89	0.36600
		>6 D	1.35	0.27716
	3-6 D	>6 D	4.24	0.38258
Temporal	<3 D	3-6 D	3.09	0.19764
		>6 D	1.29	0.22969
	3-6 D	>6 D	4.39	0.47539

RNFL: Retinal nerve fiber layer

Discussion

In our study, the average peripapillary RNFL thickness was noted to decrease with increase in degree of myopia. The decrease was found to be statistically significant between groups A1 and A3 (P = 0.002) and also when groups A2 and A3 (P = 0.008) were compared. These findings are consistent with those of previous studies conducted by Kang *et al.*, Wang *et al.*, Ozdek *et al.*, and Savini *et al.*,[14–17] who also reported a significant decrease (P < 0.05) in average peripapillary RNFL thickness with increasing degree of myopia. In our study, inferior quadrant RNFL thickness was found to be thickest followed by superior, nasal, and temporal quadrants. This is similar to the findings of Kamath *et al.*[18] and Said-Ahmed *et al.*[19] The decrease in quadrant-wise RNFL thickness with increasing myopia was significant in the superior and inferior quadrants when group A1 was compared with group A3 (P < 0.0001) and group A2 was compared with A3 (P < 0.001). Our results are similar to those noted by Kang *et al.*, Wang *et al.*, and Ozdek *et al.*, who reported a significant decrease in RNFL thickness only in the superior and inferior quadrants (P < 0.05) with an insignificant difference in the nasal and temporal quadrants.[14–16] However, Kamath *et al.*[18] reported a significant decrease (P < 0.05) in RNFL thickness in all quadrants with an insignificant decrease in the temporal quadrant. RNFL thickness was found to decrease with increase in degree of myopia in all clock-hour positions except in 4, 8, and10 o'clock positions. Kamath *et al.*[18] reported a significant

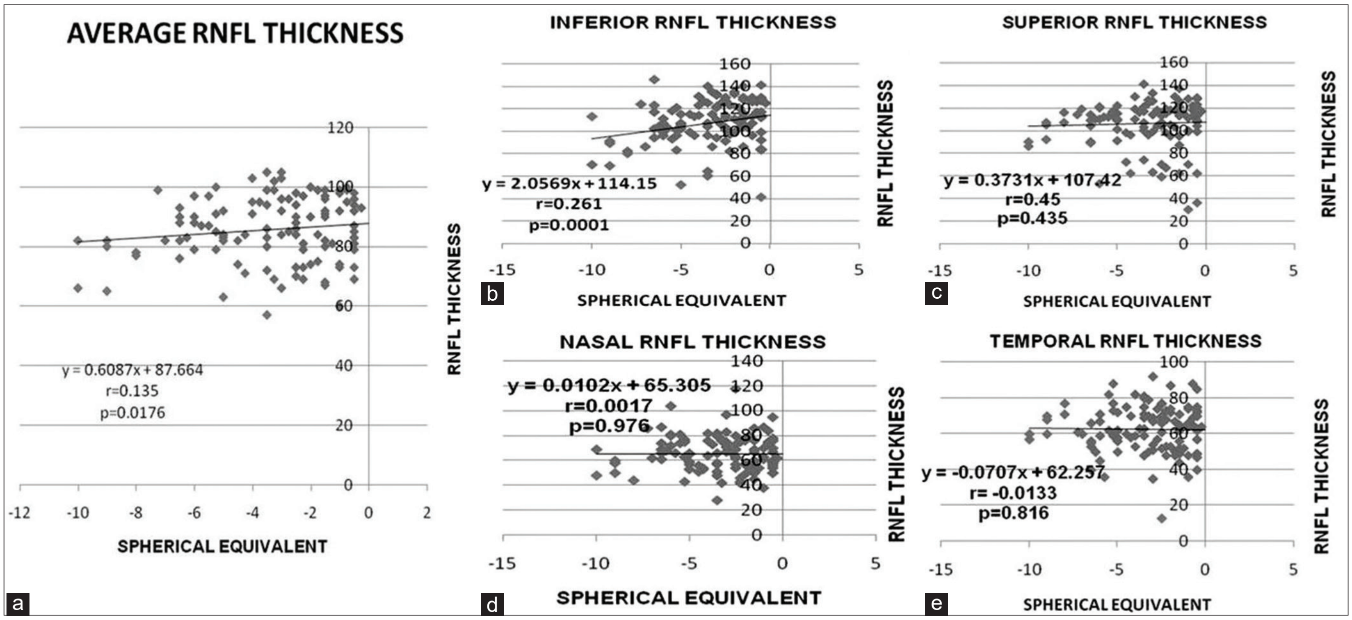

Figure 1: Correlation analysis of peripapillary retinal nerve fiber thickness with spherical equivalent; statistically significant positive correlation was noted between average (a) and inferior quadrant (b) RNFL thickness with spherical equivalent. No statistically significant correlation was noted between spherical equivalent and superior, nasal, and temporal (c-e) quadrant RNFL thickness

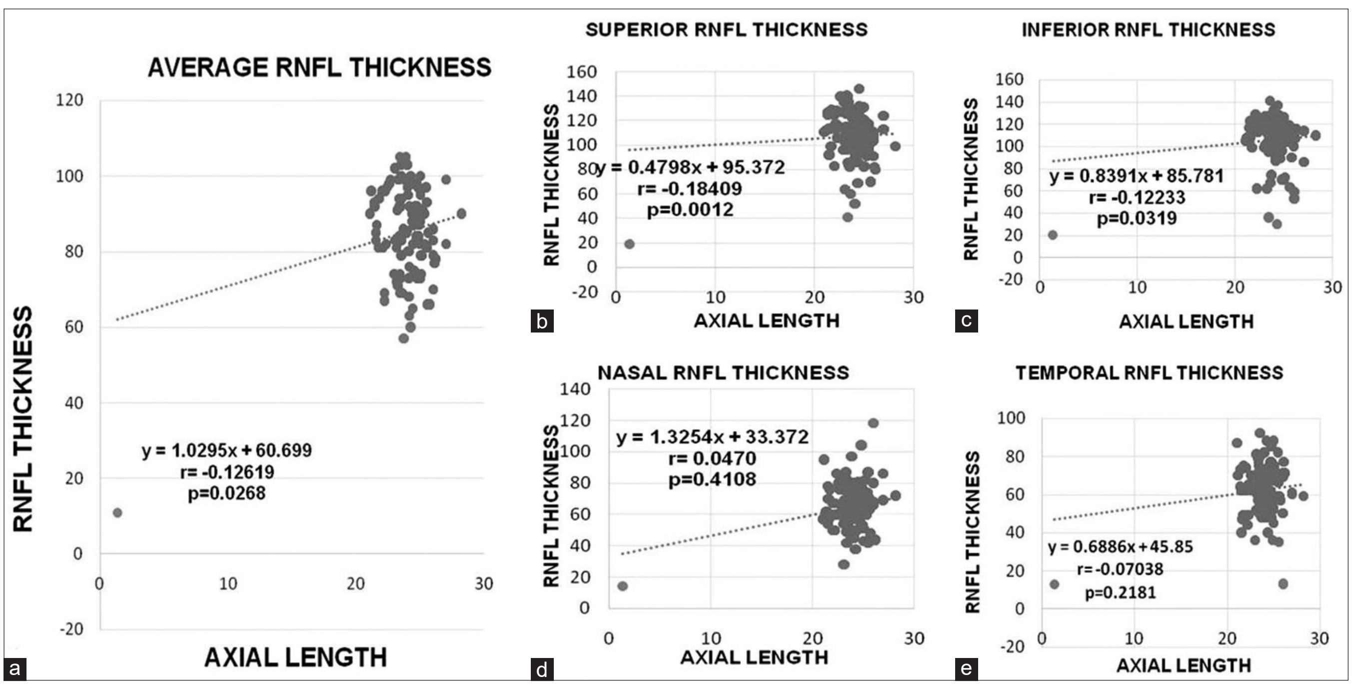

Figure 2: Correlation analysis of peripapillary retinal nerve fiber thickness with axial length; statistically significant negative correlation was noted between average, superior, and inferior quadrant (a-c) RNFL thickness with axial length. No statistically significant correlation was noted between axial length and nasal and temporal quadrant RNFL thickness (d and e)

reduction in RNFL thickness in high myopic eyes (>6 D) in all clock-hour positions except 4, 8, 9, and 10 o'clock positions. On correlation analysis between average and quadrant-wise RNFL thickness with degree of myopia, a weak positive correlation ($r = 0.135$, $P = 0.0176$) was found between average peripapillary RNFL thickness and degree of myopia. A fair positive correlation ($r = 0.261$, $P = 0.0001$) was noted between inferior quadrant RNFL thickness and degree of myopia. This finding is similar to the studies by Mohammad[20] and Rauscher *et al.*[21]

In our study, all optic nerve head parameters were found to decrease with increase in the degree of myopia except the rim area which was found to increase. This result is in agreement with the studies conducted by Tsutsumi *et al.*[22] and Sujatha *et al.*[23] which reported smaller disc areas and a decrease in

Table 4: Average and quadrant-wise peripapillary RNFL thickness in group B

RNFL thickness (μm)	Groups	Mean±SD	*P*
Average	B1	87.76±11.39	0.00033
	B2	83.57±10.10	
Quadrant wise			
Inferior	B1	110.56±20.20	0.00510
	B2	103.96±17.58	
Superior	B1	109.14±19.55	0.00092
	B2	103.37±20.59	
Nasal	B1	65.87±13.73	0.24131
	B2	64.71±15.24	
Temporal	B1	63.96±12.18	0.2652
	B2	61.14±13.37	

B1: Axial length ≤24 mm; B2: Axial length >24 mm; RNFL: Retinal nerve fiber layer

cup area, cup volume, and cup-to-disc ratio with increasing myopia. AttaAllah *et al*.,[24] Hsu *et al*.,[25] and Bhaila *et al*.[26] reported significantly larger rim volume in eyes with high myopia (>6 D) as compared to emmetropic eyes. In our study, the rim area was found to increase with increase in degree of myopia which was statistically significant ($P = 0.00004$) when compared between groups A1 and A2. Bueno-Gimeno *et al*.[27] reported no significant difference ($P > 0.05$) among three groups of myopia while considering the rim area. In our study, we noted cup volume, cup-to-disc ratio, and cup area to decrease with increase in myopia. Statistically significant difference was found between groups A1 and A3 ($P = 0.007$) and between groups A2 and A3 ($P = 0.013$) which is consistent with the studies conducted by Tsutsumi *et al*.[22] and Sujatha *et al*.[23]

Several studies have reported RNFL thickness to decrease with increase in AL.[28–31] Our study showed that there was a statistically significant decrease ($P < 0.05$) in average peripapillary RNFL thickness as the AL increased. A significant decrease was also noted in RNFL thickness of superior and inferior quadrants as the AL increased and insignificant in the nasal and temporal quadrants. Statistically significant decrease ($P < 0.05$) in RNFL thickness was found in 1, 6, 7, 10, and 12 o'clock positions (corresponding to inferior and superior quadrant) with increase in AL. Leung *et al*.[32] and Kamath *et al*.[18] reported decrease in RNFL thickness with increase in AL in all clock-hour positions except in 7, 8, 9, and 10 o'clock positions. Correlation analysis between average peripapillary RNFL thickness and AL revealed statistically significant negative correlation ($r = -0.126$, $P = 0.026$). A similar result was reported by Nagai-Kusuhara *et al*.[33] and Park *et al*.[34] in their studies where a significant negative correlation was found between average RNFL thickness and AL. In our study, significant negative correlation was also noted between RNFL thickness in superior ($r = -0.184$, $P = 0.0012$) and inferior quadrants ($r = -0.122$, $P = 0.031$) with increase in AL whereas correlation analysis between AL and RNFL thickness in nasal and temporal quadrants was found to be insignificant. Our findings are consistent with the study by Rauscher *et al*.[21] but differ from Said-Ahmed *et al*.[19] who noted strong negative correlation between AL and RNFL thickness in all quadrants except the temporal quadrant ($r = -0.4$, $P = 0.001$).

The decrease in RNFL thickness with AL (1.03 μ/mm) is lower in our population than in previously published articles for other populations (Rauscher *et al.* −2 μ/mm).[21] This may be due to the fact that we have taken relative younger (28.78 ± 5.76 years) and more number of patients as compared to other studies. Our study also noted that RNFL thickness correlated strongly with AL compared to SE. This result is consistent with the study conducted by Rauscher *et al*.[21] This could be due to variations in refractive power of the cornea and lens affecting the measured SE. It could also be an indication that RNFL thinning is affected more by the elongation of the globe, resulting in thinning of the globe wall. This may explain that globe elongation is an important determinant of thinner RNFL.

In eyes with high myopia, the scleral canal was found to take an oblique course which is more towards the nasal side of the orbit, resulting in an oblique insertion of the optic nerve.[35,36] This results in an elevation of the nasal half of the optic disc anteriorly with posterior depression of the temporal half which gets hidden in the scleral canal. Thus, as the degree of myopia increases, disc tilt increases, resulting in misinterpretation of optic disc diameter, rim border, and cup-to-disc ratio. Disc tilt may also be responsible for the spreading of nerve fibers in the temporal quadrant, making it the thinnest as is found in our study. Axial myopia results in an elongation and thinning of the globe and sclera as well as the retina. This spreads the nerve fibers over a comparatively larger area when compared to emmetropes and could be one of the reasons for the findings of thinner RNFL in myopic eyes. The measurement of thin RNFL in myopes could be a reason for the over-diagnosis of glaucoma in myopic patients.

Potential strengths of our study include larger sample size, a single operator performing the tests, and repetitive scanning on OCT (an average of three readings were taken). The inability to generalize the findings of our study to other ethnic groups, as patients from only eastern India were included, is one of the drawbacks of the present study. OCT model used in our study may have some fallacies when detecting Bruch's membrane opening and internal limiting membrane around the optic disc. We have only included myopes with SE < 10 D and have not compared them with hypermetropic and emmetropic patients.

Conclusion

Peripapillary RNFL thickness gets significantly thinner in patients with higher degree of myopia and longer AL. Optic nerve head parameters are also significantly influenced by the degree of myopia. Current OCT nomograms are only age-matched. RNFL thinning in myopic patients can easily be misdiagnosed as due to glaucomatous damage if we do not take into account the effect of SE and AL and adjusting for them in the current nomograms. Analysis of optic nerve head parameters and RNFL thickness by OCT for the diagnosis should be compared with a normative control group that has been matched for refractive error and AL instead of comparison with a normative database that has only been age-matched.

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Conflicts of interest

There are no conflicts of interest.

References

1. Agarwal D, Saxena R, Gupta V, Mani K, Dhiman R, Bhardawaj A, *et al*. Prevalence of myopia in Indian school children: Meta-analysis of last four decades. PLoS One 2020;15:e0240750.
2. Saxena R, Vashist P, Menon V. Is myopia a public health problem in India? Indian J Community Med 2013;38:83-5.
3. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, *et al*. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology 2016;123:1036-42.
4. Wadhwani M, Vashist P, Singh SS, Gupta V, Gupta N, Saxena R. Myopia prevalence in a population-based childhood visual impairment study in North India-CHVI-2. Indian J Ophthalmol 2022;70:939-43.
5. Saw SM, Gazzard G, Shih-Yen EC, Chua WH. Myopia and associated pathological complications. Ophthalmic Physiol Opt 2005;25:381-91.
6. Pan T, Su Y, Yuan ST, Lu HC, Hu ZZ, Liu QH. Optic disc and peripapillary changes by optic coherence tomography in high myopia. Int J Ophthalmol 2018;11:874-80.
7. Du R, Xie S, Igarashi-Yokoi T, Watanabe T, Uramoto K, Takahashi H, *et al*. Continued increase of axial length and its risk factors in adults with high myopia. JAMA Ophthalmol 2021;139:1096-103.
8. Tomlinson A, Phillips CI. Ratio of optic cup to optic disc. In relation to axial length of eyeball and refraction. Br J Ophthalmol 1969;53:765-8.
9. Jonas JB, Gusek GC, Naumann GO. Optic disk morphometry in high myopia. Graefes Arch Clin Exp Ophthalmol 1988;226:587-90.
10. Hyung SM, Kim DM, Hong C, Youn DH. Optic disc of the myopic eye: Relationship between refractive errors and morphometric characteristics. Korean J Ophthalmol 1992;6:32-5.
11. Samarawickrama C, Wang XY, Huynh SC, Burlutsky G, Stapleton F, Mitchell P. Effects of refraction and axial length on childhood optic disk parameters measured by optical coherence tomography. Am J Ophthalmol 2007;144:459-61.
12. Porwal S, Nithyanandam S, Joseph M, Vasnaik AK. Correlation of axial length and peripapillary retinal nerve fiber layer thickness measured by Cirrus HD optical coherence tomography in myopes. Indian J Ophthalmol 2020;68:1584-6.
13. Luo HD, Gazzard G, Fong A, Aung T, Hoh ST, Loon SC, *et al*. Myopia, axial length, and OCT characteristics of the macula in Singaporean children. Invest Ophthalmol Vis Sci 2006;47:2773-81.
14. Kang SH, Hong SW, Im SK, Lee SH, Ahn MD. Effect of myopia on the thickness of the retinal nerve fiber layer measured by Cirrus HD optical coherence tomography. Invest Ophthalmol Vis Sci 2010;51:4075-83.
15. Wang G, Qiu KL, Lu XH, Sun LX, Liao XJ, Chen HL, *et al*. The effect of myopia on retinal nerve fibre layer measurement: A comparative study of spectral-domain optical coherence tomography and scanning laser polarimetry. Br J Ophthalmol 2011;95:255-60.
16. Ozdek SC, Onol M, Gürelik G, Hasanreisoglu B. Scanning laser polarimetry in normal subjects and patients with myopia. Br J Ophthalmol 2000;84:264-7.
17. Savini G, Barboni P, Parisi V, Carbonelli M. The influence of axial length on retinal nerve fibre layer thickness and optic-disc size measurements by spectral-domain OCT. Br J Ophthalmol 2012;96:57-61.
18. Kamath AR, Lakshey D. Peripapillary retinal nerve fibre layer thickness profile in subjects with myopia measured using optical coherence tomography. J Clinical Ophthalmol Research 2014;2:131-6.
19. Said-Ahmed KEG, Inbrahem AMA, Salama AA. Association of retinal nerve fibre layer thickness and degree of myopia using spectral-domain optical coherence tomography. Menoufia Med J 2017;30:966-70.
20. Mohammad Salih PA. Evaluation of peripapillary retinal nerve fiber layer thickness in myopic eyes by spectral-domain optical coherence tomography. J Glaucoma 2012;21:41-4.
21. Rauscher FM, Sekhon N, Feuer WJ, Budenz DL. Myopia affects retinal nerve fiber layer measurements as determined by optical coherence tomography. J Glaucoma 2009;18:501-5.
22. Tsutsumi T, Tomidokoro A, Saito H, Hashizume A, Iwase A, Araie M. Confocal scanning laser ophthalmoscopy in high myopic eyes in a population-based setting. Invest Ophthalmol Vis Sci 2009;50:5281-7.
23. Sujatha R, Maqbool A. Analysis of optic disc and peripapillary area using optical coherence tomography in young adult indian myopic eyes at Ambedkar Medical College. J Evid Based Med Healthc 2016;3:777-85.
24. AttaAllah HR, Omar IAN, Abdelhalim AS. Evaluation of optic nerve head parameters and retinal nerve fiber layer thickness in axial myopia using SD OCT. Ophthalmol Ther 2017;6:335-41.
25. Hsu SY, Chang MS, Ko ML, Harnod T. Retinal nerve fibre layer thickness and optic nerve head size measured in high myopes by optical coherence tomography. Clin Exp Optom 2013;96:373-8.
26. Bhaila S, Joshi SN, Thapa M, Shrestha GS. Effect of high myopia on optic nerve head by confocal scanning laser ophthalmoscopy in Nepalese eyes. Korean J Ophthalmol 2019;33:181-8.
27. Bueno-Gimeno I, Espana-Gregori E, Gene-Sampedro A, Ondategui-Parra JC, Zapata-Rodriguez CJ. Variations of OCT measurements corrected for the magnification effect according to axial length and refractive error in children. J Innov Opt Health Sci 2018;11:1850001.
28. Leung MM, Huang RY, Lam AK. Retinal nerve fiber layer thickness in normal Hong Kong Chinese children measured with optical coherence tomography. J Glaucoma 2010;19:95-9.
29. Huynh SC, Wang XY, Rochtchina E, Mitchell P. Peripapillary retinal nerve fiber layer thickness in a population of 6-year-old children: Findings by optical coherence tomography. Ophthalmology 2006;113:1583-92.
30. Hougaard JL, Ostenfeld C, Heijl A, Bengtsson B. Modelling the normal retinal nerve fibre layer thickness as measured by Stratus optical coherence tomography. Graefes Arch Clin Exp Ophthalmol 2006;244:1607-14.
31. Vernon SA, Rotchford AP, Negi A, Ryatt S, Tattersal C. Peripapillary retinal nerve fibre layer thickness in highly myopic Caucasians as measured by Stratus optical coherence tomography. Br J Ophthalmol 2008;92:1076-80.
32. Leung CK, Mohamed S, Leung KS, Cheung CY, Chan SL, Cheng DK, *et al*. Retinal nerve fiber layer measurements in myopia: An optical coherence tomography study. Invest Ophthalmol Vis Sci 2006;47:5171-6.
33. Nagai-Kusuhara A, Nakamura M, Fujioka M, Tatsumi Y, Negi A. Association of retinal nerve fibre layer thickness measured by confocal scanning laser ophthalmoscopy and optical coherence tomography with disc size and axial length. Br J Ophthalmol 2008;92:186–90.
34. Park SH, Park KH, Kim JM, Choi CY. Relation between axial length and ocular parameters. Ophthalmologica 2010;224:188-93.
35. Yanoff M, Fine BS. Ocular Patholgy. 3rd ed. Philadelphia: JB Lippincott; 1989. p. 84.
36. Chihara E, Sawada A. Atypical nerve fiber layer defects in high myopes with high-tension glaucoma. Arch Ophthalmol 1990;108:228-32.