Original Article

Nomogram of peripapillary retinal nerve fiber layer thickness in myopic eyes of north Indian population

Ziaul H Yasir, Jimmy Mittal, Alok K Singh

Purpose: To evaluate peripapillary-RNFL thickness in myopia by Cirrus OCT among north Indian population by spherical equivalent (SE), age, gender, and axial length (AL). **Methods:** This was a cross-sectional study held during 2019–2020. Patients aged 18–60 years underwent ophthalmic examination including retinoscopy, AL, and OCT RNFL thickness. Persons with previous ocular surgery or ocular ailment other than refractive error were excluded. The peripapillary-RNFL thickness was noted and compared by demographic determinants. **Results:** We examined 300 eyes of 300 persons (mean age: 30.75 ± 8.57 years; 144 males/156 females). Among them, 224 were myopes and 76 were emmetropes (EM). The mean SE was − 3.3 ± 0.4D (range: −11.0D to + 0.37D). The mean AL was 24.61 ± 1.92 mm (22.1–29.5). Overall temporal, nasal, superior, inferior, and mean peripapillary-RNFL thickness was 66.31 ± 7.58, 78.57 ± 16.00, 120.63 ± 11.69, 116.60 ± 15.80, and 95.50 ± 10.84 µm, respectively. Temporal, nasal, superior, inferior, and mean peripapillary-RNFL thickness was 73.97 ± 8.36, 94.84 ± 7.63, 127.96 ± 8.96, 136.89 ± 6.53, and 108.34 ± 6.28 µm, respectively, in EM eyes as compared to 63.71 ± 6.18, 73.05 ± 14.24, 118.21 ± 11.53, 109.71 ± 11.50, and 91.14 ± 8.31 µm, respectively, in myopic eyes ($P < 0.001$). Association of peripapillary-RNFL thickness with myopia and its different grades was $P < 0.001$. Association of mean peripapillary-RNFL thickness with age was $P > 0.005$ and gender was $P = 0.168$. Correlation between SE and RNFL thickness was positive and significant. Correlation between AL and RNFL thickness was negative but statistically significant. Association of AL with SE was $P < 0.001$. **Conclusion:** We provide normative peripapillary-RNFL thickness in the north Indian population in order to help in screening for myopia with comorbidity such as glaucoma based on RNFL thickness.

Key words: Axial length, myopia, OCT, retinal nerve fiber layer, spherical equivalent

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Optic nerve head (ONH) and retinal nerve fiber layer (RNFL) show a remarkable variation within normal people.[1] The impact of refractive error (RE) on ONH and RNFL thickness is well studied.[2] Myopia is a leading cause of visual disability throughout the world.[3] Myopia is considered not a simple refractive error but an eyesight-threatening disease.[4] Few studies have evaluated possible structural changes in the retina in individuals with moderate to high myopia without clinically overt retinal disease. The histopathological changes that accompany myopia are well documented.[5-7] Contrary to histological findings and clinical observations that retinal thinning or chorioretinal atrophy is more common in myopia,[8-10] myopia, particularly high myopia, results in marked pathologic changes, such as posterior staphyloma, scleral thinning, large tilted optic discs, Fuchs' spot, large cuptodisc ratios, thin lamina cribrosa, and localized retinal nerve fiber layer (RNFL) defects.[11]

Optical coherence tomography (OCT) was introduced by Huang. OCT is a noninvasive imaging technology that needs no direct contact with the eye. It is analogous to the B-scan of the ultrasonograph, where light beams are used instead of sound waves. Since its introduction, it is a widely used modality for assessing the fovea and peripapillary RNFL.[12]

The prevalence of myopia varies by country, age, and ethnic group.[13] In India, uncorrected refractive errors are the most common cause of visual impairment and the second major cause of avoidable blindness.[13] Recent literature shows that the overall prevalence of myopia in India is 17.6%.[14] Parameters measured by OCT in the myopic eye have been studied in the north Indian population.[13] However, OCT characteristics have not yet been systematically analyzed and compared among different grades of myopia in the north Indian population. This RNFL thinning in high myopes may be confused with open-angle glaucoma, a disease also prevalent in high myopes.[15] Thus, there is a need to have RNFL thickness nomogram of myopes for a given population group to avoid wrong interpretation.

We present a study to evaluate the RNFL thickness in all grades of myopia among north Indian subjects using Cirrus HD OCT and their relationship with RE, age, gender, and axial length (AL).

Department of Ophthalmology, Vivekananda Polyclinic and Institute of Medical Sciences, Lucknow, Uttar Pradesh, India

Correspondence to: Dr. Ziaul H Yasir, Department of Ophthalmology, Vivekananda Polyclinic and Institute of Medical Sciences, Chandganj Flyover, Nirala Nagar, Vivekanandpuram, Lucknow - 226 007, Uttar Pradesh, India. E-mail: yasir0075@yahoo.co.in

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Methods

This cross-sectional study was conducted at the Ophthalmology department of our hospital between August 2019 and May 2020 after approval of the Institutional Ethics Committee (IEC) and Scientific Research Committee (SRC). The study adhered to the tenets of the Declaration of Helsinki. The study population attending our clinics aged 18–60 years. We randomly selected persons who were coming for refraction. Informed written consent was taken. Inclusion criteria were persons of both genders willing to participate. Those with ocular disease, history of ocular trauma/ocular surgery, having opaque media causing poor signal strength on OCT were excluded. Moreover, demographic profiles were noted.

To calculate the sample size for the study, we assumed that the prevalence of myopia in an individual over 18 years old would be 17.6%.[14] To achieve a 95% confidence interval (CI), 5% error margin, and 1% design effect, 223 individuals were required.

Vision was measured using the Snellen chart at 6-m distance. The anterior segment assessment was carried out using a slit-lamp biomicroscope (Topcon Corp., Tokyo, Japan). The intraocular pressure was measured using a noncontact tonometer (Rechart7). A drop of 1% tropicamide in each eye 3 times at 15-min intervals was administered to dilate the pupil. Retinoscopy by streak retinoscope (Heine, Germany) and dilated fundus examination by indirect ophthalmoscopy were performed.

A Cirrus HD-OCT (Carl Zeiss Meditec, Inc. Germany) was used to measure the peripapillary RNFL thickness.[16] This was a spectral-domain OCT device with an acquisition rate of 27000 A-scans per second. The optic disc cube 200 × 200 scan protocol was used to image the optic disc and the RNFL over the 6 × 6 mm^2 peripapillary region (200 × 200 data points). The software's automated built-in algorithms were used to identify the center of the optic disc, and a circle measuring 3.46 mm in diameter was positioned automatically. A satisfactory scan was signal with a strength of ≥6. All peripapillary RNFL region subfields included temporal (T), inferior (I), nasal (N), and superior (S) [Fig. 1]. Eyes were classified based on their spherical equivalent (SE = sphere + cylinder/2). Myopia was SE −0.5 D or greater. The severity groups was as follows: low myopia (LM; SE ≥ −0.5 D to <−3.0 D), moderate myopia (MM; SE −3.0 D to −6.0 D), and high myopia (HM; SE > −6.0 D). Emmetropia (EM) was defined as SE from <+0.5 D to <−0.5 D.[17] People with axial length (AL) <26.5 mm were grouped as low AL and >26.5 mm as high AL.

The data were collected using a pretested data collection form. The collected data were revised, coded, and transferred to the spreadsheet of an Excel® (Microsoft Corp., Redmond, WA, USA). Statistical Package for the Social Sciences (SPSS-20 or above) (IBM Corp., Armonk, NY USA) was used to perform the statistical analysis. The qualitative data were presented as numbers and percentages while the quantitative data were presented as mean, standard deviations, and ranges. Analysis of variance (ANOVA) was performed. $P < 0.05$ was considered statistically significant.

Results

A total of 300 eyes of 300 people were enrolled. The eye with high SE was taken for study from each participant. A total of 76 (25.3%) eyes were EM, while 224 (74.7%) eyes were myopic. Demographic profiles are presented in Table 1. The gender ratio was 0.92, with slightly more eyes of males (n = 156). The mean age of the patients was 30.75 ± 8.57 years (range: 18–60 years). AL ranged from 22.1 to 29.55 mm with a mean of 24.61 ± 1.92 mm. SE ranged from +0.37 D to −11.0 D with a median of −2.75D. Intraocular pressure ranged from 12 to 20 mm Hg (mean: 15.93 ± 1.93 mm Hg).

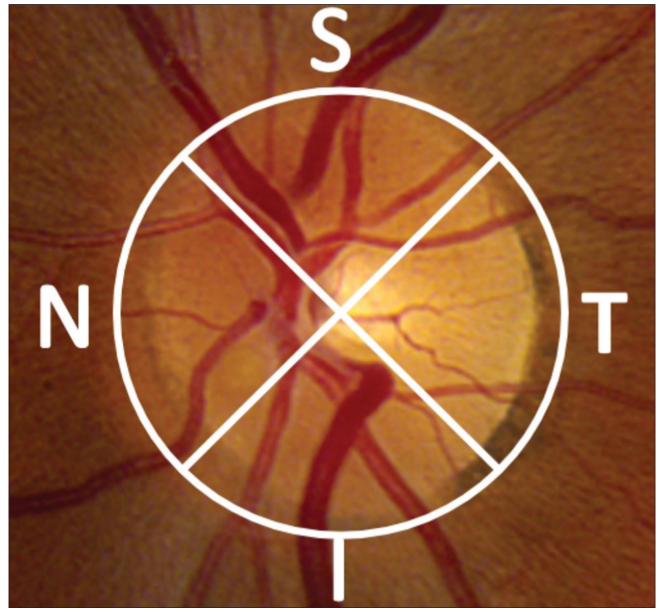

Figure 1: Peripapillary retinal nerve fiber layer thickness, superior (S), temporal (T), inferior (I), and nasal (N)

Association of peripapillary RNFL thickness with refractive status was statistically significant ($P \leq 0.001$). Peripapillary RNFL thickness of the study population (EM/LM/MM/HM) is shown in Table 2. The maximum thickness of RNFL was found in the S-RNFL quadrant followed by I-RNFL and N-RFNL. However, the least thickness was found for the T-RNFL quadrant. The average RNFL thickness was 95.50 ± 10.84 µm. EM eyes were found to have significantly thicker RNFL as compared to myopic eyes for all the segments as well as mean thickness ($P < 0.001$).

Association of peripapillary RNFL thickness with myopia and its different grades was statistically significant ($P < 0.001$). With increasing severity of myopia, there was a significant decline in mean peripapillary RNFL thickness values in all four quadrants as well as for average RNFL thickness. Analysis of RNFL thickness revealed that EM has the thickest quadrant inferiorly but myopia (LM/MM/HM) has thickest quadrant superiorly. The thinnest quadrant was temporal for EM and myopia (LM/MM) except HM where it was nasal.

Association of age with RNFL thickness showed no significant inter-age group differences in RNFL thickness for nasal, superior, inferior segments, and average ($P > 0.05$). A significant inter-age group difference was observed for the temporal segment only where the mean value was found to be lower in patients aged >40 years as compared to that in patients aged ≤40 years ($P = 0.006$) [Table 3].

Association of average peripapillary RNFL thickness with gender was not statistically significant ($P = 0.168$). On overall comparison, mean segmental and average RNFL thickness was found to be lower in females as compared to males; however, the difference between the two genders was statistically significant only for the inferior segment ($P = 0.024$) [Table 4].

Association of peripapillary RNFL thickness and AL was significantly higher in low AL eyes (<26.5 mm) as compared to high AL eyes (>26.5 mm) for all quadrants ($P < 0.001$) The average RNFL thickness for low AL as compared to high AL eyes was significantly higher ($P < 0.001$) [Table 5].

Discussion

Association of peripapillary RNFL thickness and refractive status was reported to be significant. Association of peripapillary RNFL thickness with myopia and its different grades was statistically significant and it decreased with an increase in the severity. Association of average peripapillary RNFL thickness with age and gender was not statistically significant. Association of axial length with peripapillary RNFL thickness and refractive status was statistically significant.

Association of peripapillary RNFL thickness with the refractive status of the study population (including 76 EM) showed maximum thickness in the S-RNFL quadrant followed by I-RNFL and N-RFNL. However, the least thickness was found for the T-RNFL quadrant. In the EM population, the mean RNFL thickness values were inferior > superior > nasal > temporal segment as compared to superior > inferior > nasal > temporal segment in the myopic group. Average peripapillary RNFL thickness was higher in the EM group as compared to that in the myopic group. For all the segments as well as for average RNFL thickness, a significant difference between EM and myopic groups was observed. The findings thus show that myopia is characterized by a thinning of peripapillary RNFL thinning in all the quadrants, which is also reflected by a significantly lower mean average value. However, the trend of thinning in all the quadrants cannot be said to be similar as in EM patients mean value was maximum in the inferior quadrant, whereas in the myopic group, the maximum value was observed for the superior segment. The mean difference between EM and myopic eyes was maximum for inferior segment followed by nasal, temporal, and superior segments, respectively. Thinning of peripapillary RNFL in myopic eyes as compared to EM eyes has been reported by several studies, but the pattern of segmental changes has been described variedly in different studies.[13,18-23] Similar to the present study, Malakar *et al*.[13] also found that in myopic eyes RNFL values were maximum for superior followed by inferior, temporal, and nasal quadrants, respectively, and reported the difference between EM and myopic group to be maximum for inferior followed by superior, nasal, and temporal, respectively, thus showing that the change in RNFL thickness is not equal in all the segments as also observed in the present study. Malakar *et al*.[13] in their study had only high myopia eyes in their myopic group. Fahmy *et al*.[18] reported mean RNFL thickness in EM as well as myopic eyes, maximum inferior followed by superior, nasal, and temporal segments, respectively, and found the values in each segment to be thinner in myopic as compared to EM eye. In contrast, Tai *et al*.[19] found mean RNFL thickness to be maximum in inferior followed by superior, temporal, and nasal quadrants in EM, LM, and MM eyes but found the mean value to be maximum in superior followed by inferior, temporal, and nasal quadrants in HM eyes. A similar

Table 1: Demographic profile of participants

n=300		*n*	Percentage
Gender	Male	156	52.0
	Female	144	48.0
Age	Mean		30.7
	SDV		8.6
UCVA	Median		0.6
	Inter quartile range (IQR)		0.2; 0.9
BCVA	Median		0.0
	IQR		0.0; 0.1
IOP	Mean		15.9
	SDV		1.9
Spherical (D)	Median		–2.25
	IQR		–5.25; –0.25
Cylinder (D)	Median		0.0
	IQR		–1.0; 0.0
Spherical equivalent (D)	Median		–2.75
	IQR		–5.88; –0.37

Table 2: Peripapillary RNFL thickness measured by OCT

	Temporal	Nasal	Superior	Inferior	Average
All	66.3±7.6	78.6±16.0	120.6±11.7	116.6±15.8	95.8±10.8
Male	66.3±7.7	77.7±15.9	120.1±12.3	114.6±16.6	94.7±11.3
Female	66.4±7.5	79.5±16.1	121.2±11.1	118.7±14.7	96.4±10.3
P	*P*=0.887	*P*=0.329	*P*=0.437	*P*=0.024	*P*=0.168
Emmetropia	74.0±8.4	94.8±7.6	127.8±9.0	136.9±6.5	108.3±6.3
Low Myopia	65.8±4.8	85.4±9.2	126.9±9.3	117.0±10.9	98.7±5.7
Moderate Myopia	63.1±5.6	76.4±10.1	120.4±8.7	110.9±10.0	92.7±4.9
High Myopia	62.3±4.4	57.6±4.2	107.5±6.6	101.4±7.7	82.2±3.5
ANOVA	*P*<0.001	*P*<0.001	*P*<0.001	*P*<0.001	*P*<0.001
Age					
11-20	67.0±6.4	74.9±13.5	119.9±13.3	110.4±14.5	93.1±10.4
21-30	66.5±7.6	78.6±16.2	120.7±11.7	117.7±16.0	95.8±10.9
31-40	67.7±8.4	80.9±16.9	121.0±11.6	117.3±16.4	96.7±11.5
41-50	63.4±4.1	80.1±14.1	121.2±11.8	116.4±14.4	95.3±9.6
51-60	60.8±7.1	71.1±15.5	118.3±9.6	115.4±14.8	91.4±9.3
ANOVA	*P*=0.006	*P*=0.156	*P*=0.932	*P*=0.211	*P*=0.311

Table 3: Association of age with retinal nerve fiber layer thickness

Age group	Temporal	Nasal	Superior	Inferior
Over all (*n*=300)				
≤20 (*n*=32)	67.00±6.40	74.94±13.46	119.88±13.31	110.44±14.53
21-30 (*n*=148)	66.45±7.59	78.55±16.20	120.69±11.65	117.71±15.95
31-40 (*n*=80)	67.70±8.40	80.88±16.89	121.04±11.62	117.30±16.37
41-50 (*n*=26)	63.38±4.09	80.12±14.09	121.19±11.76	116.38±14.44
51-60 (*n*=14)	60.79±7.07	71.07±15.50	118.29±9.55	115.36±14.78
ANOVA	F=3.704; P=0.006	F=1.672; P=0.156	F=0.212; P=0.932	F=1.472; P=0.211
Emmetropic (*n*=76)				
≤20 (*n*=2)	84.0±0.0	100.0±0.0	144.0±5.7	144.0±5.7
21-30 (*n*=42)	73.7±8.2	94.0±8.4	127.2±8.4	136.6±5.2
31-40 (*n*=24)	75.7±9.1	97.3 6.6	128.1±10.1	138.0±7.4
41-50 (*n*=6)	67.0±2.4	89.3±2.1	125.7±6.3	131.3±9.6
51-60 (*n*=2)	71.0±0.0	96.0±0.0	125.0±0.0	140.0±0.0
ANOVA	F=2.224; P=0.075	F=1.843; P=0.130	F=1.909; P=0.118	F=2.088; P=0.091
Myopic (*n*=224)				
≤20 (*n*=30)	65.9±4.7	73.3±12.1	118.3±12.1	108.2±11.9
21-30 (*n*=106)	63.6±5.0	72.5±14.4	118.1±11.8	110.2±12.1
31-40 (*n*=56)	64.3±5.2	73.9±15.0	118.0±11.0	108.4±9.8
41-50 (*n*=20)	62.3±3.9	77.4±15.0	119.9±12.8	111.9±12.6
51-60 (*n*=12)	59.1±6.1	66.9±12.3	117.2±9.9	111.3±11.4
ANOVA	F=4.524; P=0.002	F=1.108; P=0.354	F=0.131; P=0.971	F=0.582; P=0.676
Low Myopia (*n*=74)				
≤20 (*n*=8)	67.3±4.2	85.5±0.9	132.0±8.0	119.3±10.1
21-30 (*n*=30)	66.6±4.9	86.6±8.1	127.0±10.0	118.9±12.5
31-40 (*n*=17)	67.8±2.5	89.7±4.5	127.8±8.5	115.3±9.3
41-50 (*n*=13)	63.3±3.9	81.5±14.1	123.7±9.8	116.4±9.5
51-60 (*n*=6)	59.8±6.1	75.2±9.2	123.3±7.0	110.2±8.7
ANOVA	F=5.323; P=0.001	F=4.080; P=0.005	F=1.260; P=0.294	F=1.037; P=0.394
Moderate Myopia (*n*=75)				
≤20 (*n*=10)	65.4±3.2	79.0±6.3	119.4±5.0	107.4±12.0
21-30 (*n*=40)	62.6±5.5	76.1±10.0	121.0±9.9	111.2±10.4
31-40 (*n*=20)	63.9±6.5	76.1±10.7	118.3±7.9	109.8±6.5
41-50 (*n*=3)	62.3±2.9	82.7±12.7	129.0±1.7	118.3±4.0
51-60 (*n*=2)	55.5±7.8	64.0±17.0	121.5±2.1	124.0±18.4
ANOVA	F=1.561; P=0.194	F=1.241; P=0.302	F=1.115; P=0.357	F=1.733; P=0.152
High Myopia (*n*=75)				
≤20 (*n*=12)	65.3±6.2	60.3±5.9	108.2±8.6	101.5±7.2
21-30 (*n*=36)	62.2±3.4	56.6±3.3	107.4±5.3	101.9±7.3
31-40 (*n*=19)	61.6±3.8	57.3±3.9	108.9±7.7	100.9±8.1
41-50 (*n*=4)	59.0±3.5	60.0±4.6	100.5±0.6	92.5±0.6
51-60 (*n*=4)	59.8±6.6	56.0±4.4	105.8±3.9	106.5±9.8
ANOVA	F=2.647; P=0.040	F=2.358; P=0.062	F=1.516; P=0.207	F=1.948; P=0.112

observation was also made by Jeong *et al*.[20] for HM group. In contrast, Zha *et al*.[21] found RNFL thinning in myopic eyes as compared to EM eyes for all the segments as observed in the present study but did not find a change in the order of RNFL thickness in different segments. However, Sezgin *et al*.[22] in their study among myopic eyes of different grades found the mean RNFL thickness to be maximum in the inferior segment followed by superior, nasal, and temporal segments, as observed in EM patients in our study. On the other hand, Said *et al*.[23] in their study reported the sequence of RNFL thickness values in different quadrants among myopic eyes of different grades to be inferior > superior > temporal > nasal, respectively. These findings, in general, show that while mean values are higher in inferior and superior segments, they are lower in temporal and nasal segments, and the order of their thinning in myopic eyes could show a slight variability, probably with increasing severity grades of myopia.

Association of peripapillary RNFL thickness with myopia and its different grades was statistically significant. With

Table 4: Association of gender with retinal nerve fiber layer thickness (in µm)

Gender (*n*)	Temporal	Nasal	Superior	Inferior
Overall (*n*=300)				
Male (144)	66.38±7.50	79.51±16.14	121.17±11.06	118.74±14.66
Female (156)	66.25±7.68	77.71±15.87	120.12±12.26	114.62±16.59
Student *t* test value	*t*=0.142; *P*=0.887	*t*=0.978; *P*=0.329	*t*=0.778; *P*=0.437	*t*=2.273; *P*=0.024
Emmetropic (*n*=76)				
Male (44)	72.55±7.86	94.09±7.43	126.89±8.58	135.20±7.18
Female (32)	75.94±8.74	95.88±7.89	128.97±9.46	139.22±4.70
Student *t* test value	*t*=1.772; *P*=0.061	*t*=1.907; *P*=0.317	*t*=1.000; *P*=0.329	*t*=2.760; *P*=0.007
Myopic (*n*=224)				
Male (100)	63.66±5.48	73.10±14.70	118.66±11.13	111.50±10.70
Female (124)	63.75±4.95	73.02±13.91	117.84±11.88	108.27±11.96
Student *t* test value	*t*=0.129; *P*=0.907	*t*=0.044; *P*=0.965	*t*=0.529; *P*=0.597	*t*=2.102; *P*=0.037
Low Myopic (*n*=74)				
Male (34)	66.85±4.93	87.68±7.98	125.79±10.41	116.82±11.60
Female (40)	64.93±4.55	83.43±9.86	127.75±8.30	117.10±10.31
Student *t* test value	*t*=1.747; *P*=0.085	*t*=2.015; *P*=0.048	*t*=0.899; *P*=0.372	*t*=0.109; *P*=0.914
Moderate Myopic (*n*=75)				
Male (36)	61.81±6.06	73.17±9.99	119.47±9.74	111.69±9.23
Female (39)	64.28±5.00	79.38±9.36	121.26±7.69	110.18±10.64
Student *t* test value	*t*=1.936; *P*=0.057	*t*=2.783; *P*=0.007	*t*=0.884; *P*=0.380	*t*=0.656; *P*=0.514
High Myopic (*n*=75)				
Male (30)	62.27±3.49	56.50±3.34	109.60±6.27	105.23±7.82
Female (45)	62.24±4.96	58.24±4.64	106.07±6.42	98.78±6.44
Student *t* test value	*t*=0.021; *P*=0.983	*t*=1.773; *P*=0.080	*t*=2.357; *P*=0.021	*t*=3.902; *P*<0.001

Table 5: Association of Axial Length and peripapillary RNFL

Axial Length (*N*=300)	*n*	Mean±SD	95% CI	
			Lower	Upper
T-RNFL				
Low Axial Length (≤26.5 mm)	226	67.66±7.92	66.626	68.702
High Axial Length (>26.5 mm)	74	62.18±4.38	61.160	63.191
Student *t* test value		*t*=5.505; *P*<0.001		
N-RFNL				
Low Axial Length (≤26.5 mm)	226	85.48±11.84	83.926	87.030
High Axial Length (>26.5 mm)	74	57.49±4.23	56.506	58.467
Student *t* test value		*t*=19.813; *P*<0.001		
S-RNFL				
Low Axial Length (≤26.5 mm)	226	124.99±9.53	123.738	126.236
High Axial Length (>26.5 mm)	74	107.31±6.43	105.821	108.801
Student *t* test value		*t*=14.797; *P*<0.001		
I-RNFL				
Low Axial Length (≤26.5 mm)	226	121.59±14.52	119.690	123.496
High Axial Length (>26.5 mm)	74	101.35±7.72	99.564	103.139
Student *t* test value		*t*=11.513; *P*<0.001		
Avg. RNFL				
Low Axial Length (≤26.5 mm)	226	99.89±8.59	98.763	101.016
High Axial Length (>26.5 mm)	74	82.08±3.42	81.290	82.872
Student *t* test value		*t*=17.279; *P*<0.001		

increasing severity of myopia, there was a significant decline in peripapillary RNFL thickness values in all four quadrants as well as for average RNFL thickness. Mean (Average) RNFL thickness of LM> MM> HM. Among myopia (LM/MM/HM), the thickest quadrant was superiorly and the thinnest quadrant was temporal for myopia (LM/MM) except HM where it was nasal. However, Sezgin *et al*.[22] did not find a significant difference in mean RNFL thickness among different grades of myopia for the temporal segment, though for superior, nasal, and inferior segments, they also found a significant decrease with increasing grade of myopia, but for average thickness, they found the mean values in MM group to be higher as compared to LM group. Nevertheless, mean values in HM group were significantly lower as compared to both LM and MM groups. Said *et al*.[23] found significant differences in mean RNFL thickness among three grades of myopia for all the quadrants as well as for average thickness; however, in their study for the temporal segment, they also found the mean value as MM > LM > HM. A similar observation for the temporal segment was also made by Zha *et al*.,[21] Chaturvedi *et al*.,[24] and Porwal *et al*.[25] One of the reasons for this could be the fact that the temporal segment generally has relatively thinner RNFL and the magnitude of thinning in this segment is not directly proportional to the change in myopic grade. Leaving aside the exceptional segmental changes, declining RNFL thickness with increasing severity of myopia as observed in the present study has also been reported in several other studies.[19,20,25-27] HM shows temporal quadrant thicker than nasal quadrant in our study this can be explained by the redistribution of nerve fiber layer in HM that causes temporal retinal dragging and increased temporal thickness.[26,28]

Association of average peripapillary RNFL thickness with age was not statistically significant. We performed further assessment of the four quadrants of peripapillary RNFL and found that nasal, superior, and inferior quadrants were not statistically significant but temporal segment RNFL thickness of those aged >40 years was significantly lower as compared to that of patients aged ≤40 years. The pattern of relationship with age was not consistent throughout the entire study population. In EM eyes, a significant difference in peripapillary RNFL thickness among different age groups was observed for average thickness. For myopic eyes, significant differences among different age groups were observed for temporal segment thickness. Within the myopia group too, inter-age group differences in RNFL thickness were seen in temporal, nasal, and average measurements in LM and temporal segment measurements in HM groups. The trends showed thinning of RNFL with increasing age, though not consistently seen for all the comparisons. The effect of age on RNFL thickness among myopic patients has also been evaluated by some studies. Singh *et al*.[27] and Dhami *et al*.[29] reported no statistically significant correlation between the different age groups and RNFL thickness in the Indian population. Zha *et al*.,[21] contrary to observations of the present study, did not find a significant difference in RNFL thickness in different segments as well as the average thickness between those aged >12 years. In the present study, we did not include age <18; however, we found age differences in RNFL thickness pattern for some quadrants on some specific subgroup comparisons, which did not attain a generalized trend. We also did not find a significant linear correlation between age and RNFL thickness and found that segmental and average RNFL showed a weak and generally statistically nonsignificant correlation with age. Zha *et al*.[21] also reported a weak but statistically significant correlation between average RNFL and age. Jeong *et al*.[20] reported negative association of age with RNFL thinning for superior, temporal and inferior segment as well as for average. But for nasal segment there was a positive association, thus implying that the effect of age on RNFL thickness in a myopic population is inconsistent and is generally overshadowed by the myopic status.

Association of average peripapillary RNFL thickness with gender was not statistically significant, but we found several inconsistent results. On overall comparison (that included 76 EM eyes too), mean segmental and average RNFL thickness was found to be lower in females as compared to males; however, the difference between the two genders was significant statistically for the inferior segment only where males had a higher mean RNFL thickness than females. However, in the EM group, females had a higher mean peripapillary RNFL thickness as compared to males for all the segments as well as average thickness. The difference between the two genders was also found to be significant for the inferior segment and average thickness. On the other hand, in myopic eyes, the mean RNFL thickness of males was higher as compared to that of females for nasal, superior, inferior, and average assessments whereas females had a higher mean value as compared to males for the temporal segment. The difference between the two genders was found to be significant only for the inferior segment. On evaluation in different myopic grades, a significant difference between males and females was observed for the nasal segment in all LM and MM. LM value in males was significantly higher as compared to females, whereas MM mean value in females was significantly higher as compared to that of males. In the HM group, males had significantly higher superior, inferior, and average RNFL thickness as compared to that of females. Dhami *et al*.[29] reported that females had a statistically significant thicker RNFL in the temporal quadrants in comparison to males in the Indian population ($P < 0.05$). Zha *et al*.[21] did not find a significant difference in segmental RNFL thickness between males and females. For the global average, they reported a near significant ($P = 0.054$) value. Jeong *et al*.[20] reported a slower RNFL thinning rate in females as compared to males. However, in the present study, in general, we found the RNFL thickness of females to be lower as compared to that of males, which is in agreement with traditional gender-associated RNFL thinning relationships. In essence, though generally females tended to have thinner RNFL as compared to males, myopic status seemed to affect the direction of this relationship; as such, we can say that myopic status attained a dominant position in determining the direction of the conventional gender-RNFL thickness relationship.

Association of AL and RNFL thickness was significantly higher in low AL eyes as compared to high AL eyes for all quadrants. The segmental and average RNFL thickness values were significantly higher in low AL eyes as compared to high AL eyes. The mean RNFL thickness among low and high AL was maximum in the superior quadrant followed by the inferior quadrant. The mean RNFL thickness was least for low AL in the temporal quadrant but for high AL, it was the nasal quadrant. Porwal *et al*.,[25] Singh *et al*.,[27] and Dhami *et al*.[29] also reported statistically significant thinning of average RNFL with the increase of AL. Kamath *et al*.[26] and AttaAllah *et al*.[28] also found high AL (HM) with thicker temporal and thinner nasal comparatively. Reason could be explain by redistribution of temporal nerve fiber layer due to temporal dragging of retina as a consequence of globe enlargement and papillomacular fiber being tough for thinning.

Limitations

We need a population-based study on a bigger sample size. We have not considered correction for magnification factor for increased axial length.[26] We have not considered the difference between right eye and left eye. Some studies reported that RNFL thickness differs with axial length between right and left eye. This phenomenon has been explained by the asymmetry in the positioning of the superior retinal artery, vein, and nerve fiber bundle between eyes being located more slightly temporally in right eyes compared to left eyes.[30] Thickness measurements are not interchangeable among different OCT devices (Cirrus SD-OCT {Fourier-domain} and Stratus OCT {Time domain}) because of the poor-to-moderate inter-device measurement agreement. FD instruments yield more reproducible macular but not RNFL thickness measurements.[31]

Conclusion

Peripapillary RNFL thickness is affected by myopia and its severity. A gradual decline in RNFL thickness of all four quadrants as well as average thickness is observed with increasing severity of myopia. Association of peripapillary RNFL thickness with SE and AL is statistically significant. Age and gender seem to have an inconsistent relationship with peripapillary RNFL thickness within the limitations of study population. The findings of study show a structural-functional relationship consequent to myopia. The present study tended to provide normative peripapillary RNFL thickness in a north Indian population in order to help in screening for glaucoma on the basis of RNFL thickness. Further studies are recommended to substantiate this database.

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Conflicts of interest

There are no conflicts of interest.

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