

Relationship between peripapillary choroidal thickness and retinal nerve fiber layer in young people with myopia

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Abstract

Aim: To study the characteristics and relationship between peripapillary retinal nerve fiber layer (RNFL) and choroidal thickness in young people with myopia.

Methods: We retrospectively analyzed 92 cases (52 myopia, 40 emmetropia) regarding age, sex, refractive power, axial length (AL), and intraocular pressure. Peripapillary RNFL and choroidal thicknesses were measured by optical coherence tomography (OCT) in six sectors. Differences in thicknesses between the two groups were compared by single-factor analysis.

Results: RNFL was thickest in the inferotemporal sector ($157.3 \pm 19.66 \mu\text{m}$) and thinnest in the nasal sector ($58.78 \pm 18.41 \mu\text{m}$). Peripapillary choroid was thickest in the superonasal sector ($176.37 \pm 33.92 \mu\text{m}$) and thinnest in the inferotemporal sector ($131.79 \pm 25.22 \mu\text{m}$). The RNFL was thinner in the myopia group ($99.04 \pm 8.23 \mu\text{m}$) vs the emmetropia group ($103.25 \pm 8.32 \mu\text{m}$); significantly different in the superotemporal and inferonasal sectors. Peripapillary choroid thickness in the myopia group ($148.65 \pm 26.64 \mu\text{m}$) was lower vs the emmetropia group ($160.88 \pm 29.06 \mu\text{m}$); significantly different in the nasal, inferonasal, and inferotemporal sectors. RNFL thickness was negatively correlated with choroidal thickness in the nasal sector ($r = -0.288$).

Conclusion: Peripapillary RNFL and choroidal thicknesses showed regional distributions. RNFL was negatively correlated with PCT in the nasal sector, possibly related to eye axis growth and choroidal compensation.

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Keywords

Retinal nerve fiber layer, optical coherence tomography, peripapillary choroidal thickness, myopia, emmetropia, young people

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Introduction

The prevalence of myopia is increasing annually. The latest meta-analysis results showed that by 2050, half of the global population will suffer from myopia, and the prevalence of high myopia is as high as 10%.¹ High myopia can cause irreversible changes in the retina, choroid, and sclera that are easily confused with other optic nerve diseases. It is of great significance to explore the characteristics of the myopic retina and choroid.^{2,3}

The optic nerve head is an important structure in the posterior fundus, where nerve fibers converge into the optic nerve. During the progression of myopia, a series of changes occur in the peripapillary blood vessels and nerve structures, such as the inclination angle of the optic disc, the formation of arc-shaped plaques near the optic disc, and increased optic disc area ratio.⁴ Myopia is an independent risk factor for the onset of primary open-angle glaucoma, and changes in the retinal nerve fiber layer (RNFL) is the basis for the diagnosis and treatment of optic nerve diseases and glaucoma. Branches from the short posterior ciliary artery enter the choroid layer next to the optic disc to provide the blood supply for the optic disc.⁵ However, a relationship between the peripheral choroid and RNFL has not been reported. It is of great significance to monitor changes in choroidal thickness in patients with myopia.⁶⁻⁸ The study of choroidal thickness first focused on the measurement of the macular area.^{6,8} In the current study, the latest-generation optical coherence tomography (OCT) was used to accurately

measure the thickness of the peripapillary RNFL and choroid in patients with myopia. The purpose of this study was to investigate changes in the peripapillary RNFL and choroid, and to provide evidence for follow-up of myopia and prevention of complications.

Materials and methods

Ethical approval

This retrospective study complied with the tenets of the Declaration of Helsinki. This study was approved by the ethics committee of the First Affiliated Hospital of Shandong First Medical University (approval number: S028). The patients participating in this study provided written informed consent. The reporting of this study conforms to the STROBE statement.⁹

Study population

This study was a retrospective analysis of the data of patients with myopia who attended the Department of Ophthalmology of the First Affiliated Hospital of Shandong First Medical University from January to December 2019. The inclusion criteria were patients with refractive errors and best corrected visual acuity (BCVA) better than 0.1 logMAR. We excluded the following patients: those with myopic macular degeneration (category 2 to category 4);¹⁰ eye diseases other than refractive errors; intraocular pressure >18 mmHg; patients accompanied by the following changes in the optic disc: hemorrhage, narrowing of

the disc rim, cup-to-disc ratio difference >0.2 between the two eyes, and optic nerve atrophy; previous history of ocular trauma or surgery; and systemic diseases.

Data collection

Both groups routinely underwent the following examinations: BCVA, spherical equivalent (SE), slit-lamp microscopy, intraocular pressure measurement (Goldman applanation tonometer), and indirect ophthalmoscope examination. The IOL Master (Carl Zeiss Meditec, Inc., Jena, Germany) was used to measure the axial length (AL). The retina and choroid were scanned in the EDI mode of the spectral domain OCT (Spectralis; Heidelberg Engineering, Heidelberg, Germany), and all patients' OCT examinations were performed by the same experienced ophthalmologist. The measurement of various other parameters was performed by another expert who was unaware of the patient groupings.

Measurement of optic disk parameters

Using the Fast RNFL Thickness 3.4 fast scanning program in OCT, a circular scan with a diameter of 3.46 mm was performed with the optic disc as the center. The recording instrument automatically divides and calculates the RNFL thickness value for six positions (sectors) around the optic disc (temporal, superotemporal, nasal, superonasal, inferonasal, and inferotemporal). We manually moved the RNFL boundary to the boundary under the retinal nerve epithelium, and moved the inner limiting membrane boundary to the choroid-scleral junction. After manually changing the position of the dividing line, the instrument automatically calculated the peripapillary choroidal thickness (PCT) value for the same six sectors around the optic disc.

Statistical analysis

Statistical analysis was performed using SPSS 25.0 statistical software (IBM Corp., Armonk, NY, USA). Measurement data were expressed as mean \pm standard deviation. Single-factor analysis of variance was used for between-group comparisons, and Pearson's correlation analysis was used for correlation analysis. The chi square test was used to compare proportions of variables, and multiple linear regression was used to evaluate the effect of age, sex, AL, and SE on the measurement data. The difference was statistically significant at $P < 0.05$.

Results

Ninety-two patients (92 eyes) were enrolled in this study, 52 cases (52 eyes) in the myopia group (SE: <-0.5 D) and 40 cases (40 eyes) in the emmetropia group (SE: -0.5 D to 0.5 D). The patients' ages ranged from 18 to 35 years. The average SE value was -2.74 ± 2.35 D (range: -6.00 D to $+0.25$ D), and the average AL was 24.88 ± 0.93 mm (range: 23.00 – 27.29 mm). The average PCT for all patients was 153.96 ± 28.23 μ m, and the average RNFL thickness was 100.87 ± 8.48 μ m. The inferotemporal sector was the thickest (157.3 μ m), followed by the superotemporal sector (144.8 μ m), superonasal sector (110.18 μ m), inferonasal sector (106.53 μ m), temporal sector (85.26 μ m), and nasal sector (58.78 μ m). There was no significant difference in the average age, intraocular pressure, and sex distribution between the groups (Table 1).

Table 2 shows the peripapillary RNFL and choroidal thicknesses at different locations in both groups. RNFL thickness differed in different sectors; the RNFL was thickest in the inferotemporal sector (157.3 ± 19.66 μ m) and thinnest in the nasal sector (58.78 ± 18.41 μ m) ($P < 0.001$). PCT also differed in different sectors, as

Table 1. Baseline data of the two diagnostic groups (mean±standard error).

Measurement	Myopia group (n = 52)	Emmetropic group (n = 40)	P-value
Spherical equivalent (diopters (D))	-4.71 ± 0.89	-0.19 ± 0.19	<0.001 ¹
Axial length (mm)	25.24 ± 0.62	24.12 ± 0.49	<0.001 ²
Sex (M/F)	16/24	24/28	0.55 ²
Age (years)	24.15 ± 2.59	24.03 ± 1.95	0.28
Intraocular pressure (mmHg)	16.1 ± 1.53	15.67 ± 1.31	0.52

¹One-factor analysis of variance; ²chi square test. M = male, F = female.

Table 2. Peripapillary thickness (µm) at different locations in the two groups.

RFNL and Choroidal sector	Average thickness	Myopia group (n = 40)	Emmetropic group (n = 52)					
				P ₀	P ₁	P ₂	P ₃	P ₄
RNFL-T	85.28 ± 15.42	86.65 ± 19.16	83.50 ± 8.34	0.33	0.26	0.22	0.55	0.03
RNFL-TS	144.8 ± 22.02	138.12 ± 19.56	153.50 ± 22.23	<0.001	<0.001	<0.001	0.10	0.01
RNFL-N	58.78 ± 18.41	59.00 ± 21.20	58.50 ± 14.28	0.89	0.92	0.93	0.34	0.05
RNFL-NS	110.18 ± 25.43	106.58 ± 25.31	114.88 ± 25.14	0.12	0.14	0.12	0.55	0.94
RNFL-TI	157.3 ± 19.66	154.56 ± 20.27	160.88 ± 18.49	0.13	0.17	0.18	0.40	0.01
RNFL-NI	106.53 ± 23.78	102.04 ± 28.28	112.38 ± 14.55	0.04	0.03	0.03	0.90	0.53
RNFL-G	100.87 ± 8.49	99.04 ± 8.23	103.25 ± 8.32	0.02	0.03	0.02	0.84	0.08
Choroid-T	132.21 ± 37.57	131.15 ± 27.91	133.63 ± 47.66	0.76	0.66	0.64	0.24	0.87
Choroid-TS	159.63 ± 36.72	161.85 ± 35.09	156.75 ± 38.99	0.51	0.56	0.58	0.06	0.65
Choroid-N	174.84 ± 38.64	165.00 ± 39.47	187.63 ± 33.90	0.01	0.01	0.01	0.03	0.01
Choroid-NS	176.37 ± 33.92	170.98 ± 36.20	183.38 ± 29.69	0.08	0.08	0.08	0.67	0.01
Choroid-TI	131.79 ± 25.22	126.92 ± 25.64	138.13 ± 23.50	0.03	0.03	0.02	0.63	0.47
Choroid-NI	149.67 ± 32.42	137.79 ± 29.93	165.13 ± 29.10	<0.001	<0.001	<0.001	0.02	0.14
Choroid-G	153.96 ± 28.23	148.65 ± 26.64	160.88 ± 29.06	0.04	0.04	0.04	0.63	0.16

Data are presented as mean ± standard deviation in µm.

P₀ one-factor analysis of variance.

P₁ multiple linear regression including age as a covariate.

P₂ multiple linear regression including age and sex as covariates.

P₃ multiple linear regression including age, sex, and axial length as covariates.

P₄ multiple linear regression including age, sex, axial length, and spherical equivalent as covariates.

RNFL = retinal nerve fiber layer, T = temporal sector, TS = superotemporal sector, N = nasal sector, NS = superonasal sector, NI = inferonasal sector, TI = inferotemporal sector, G = the average choroidal thickness from the above six sectors.

follows: thickest in the superonasal sector (176.37 ± 33.92 µm), followed by the nasal sector (174.84 ± 38.64 µm), superotemporal sector (159.63 ± 36.72 µm), inferonasal sector (149.67 ± 32.42 µm), and temporal sector (159.63 ± 36.72 µm) and thinnest in the inferotemporal sector (131.79 ±

25.22 µm) (P<0.001). The RNFL was thinner in the myopia group (99.04 ± 8.23 µm) than in the emmetropia group (103.25 ± 8.32 µm). Comparing the myopia group with the emmetropia group, the difference was statistically significant in the superotemporal and inferonasal sectors (P<0.05)

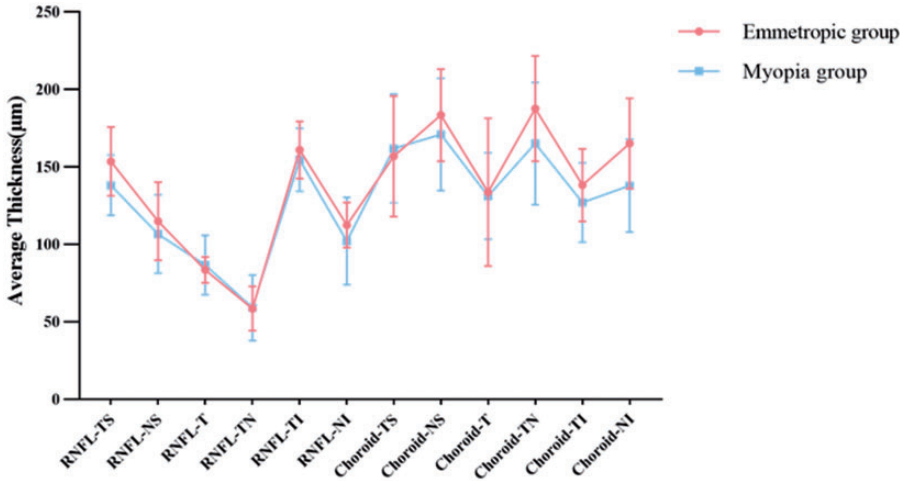


Figure 1. Nerve fiber layer thickness and choroid thickness in different sectors. TS = superotemporal sector, NS = superonasal sector, T = temporal sector, N = nasal sector, TI = inferotemporal sector, NI = inferonasal sector.

Table 3. Correlations between peripapillary choroidal thickness and retinal nerve fiber layer thickness

Location	r	P-value
T	-0.05	0.61
TS	-0.11	0.92
N	-0.288	0.005
NS	-0.125	0.23
NI	-0.07	0.47
TI	-0.03	0.78

T = temporal sector, TS = superotemporal sector, N = nasal sector, NS = superonasal sector, NI = inferonasal sector, TI = inferotemporal sector.

without correcting for confounding factors. We found no significant difference between the groups regarding RNFL thickness when we considered age as a confounding factor; age and AL, together, as confounding factors; and age, AL, and SE, together, as confounding factors. PCT in the myopia group ($148.65 \pm 26.64 \mu\text{m}$) was thinner than that in the emmetropia group ($160.88 \pm 29.06 \mu\text{m}$). Comparing the myopia group with the emmetropia group, the difference was

statistically significant in the nasal, inferonasal, and inferotemporal sectors ($P < 0.05$) without correcting for confounding factors. The trend was similar after correcting for confounding factors (Figure 1).

RNFL thickness was negatively correlated with PCT in the nasal sector ($r = -0.288$; $P < 0.005$) (Table 3).

Discussion

The choroid is rich in vascular tissue and provides blood and nutrients to the outer retina and optic disc.¹¹ The blood supply to the optic nerve head comes from branches from the short posterior ciliary artery in the peripapillary choroid. Studying the thickness of the peripapillary RNFL and choroid is of great significance for elucidating the developmental process of axial myopia and the pathogenesis of related complications.

This study showed that peripapillary RNFL thickness was distributed regionally. The inferotemporal sector was the thickest, followed by the superotemporal,

superonasal, inferonasal sector, temporal, and nasal sectors. Our results were consistent with the research of Wang et al.¹² The regional distribution of RNFL thickness was related to the spatial distribution of the retinal structure; studies have shown that retinal thickness is greatest in the fovea.¹² The macula is located below the temporal level of the optic nerve head,¹³ and this anatomical feature explains why RNFL thickness in the inferotemporal sector was the thickest.

The average RNFL thickness of the myopia group was thinner than that of the emmetropia group. Compared with the emmetropia group, the RNFL of the myopia group was thinner in the supertemporal and inferonasal sectors, and the difference was statistically significant without correcting for confounding factors. The P values did not change after adjusting for age, and the differences became insignificant when adjusting for AL. The AL result indicated that RNFL thinning in patients with myopia was related to ocular dilation. AL expansion of the eye axis causes enlargement of the gamma area next to the optic nerve head, while the macular area is unaffected.^{14,15}

In this study, the average PCT was $153.96 \pm 28.23 \mu\text{m}$, which differed from the results of Zha et al.¹⁶ ($165.80 \pm 39.86 \mu\text{m}$) and Jiang et al.¹⁷ ($134 \pm 53 \mu\text{m}$). The reason for the difference lies in the age of the selected patients. In Zha et al.'s study, the age range of the selected candidates was 6 to 12 years. The average age in Jiang et al.'s study was 64.4 ± 9.6 years (range, 50–93 years), while the average age of the patients enrolled in the current study was 18 to 35 years; the choroid thins with age.¹⁸ Shim et al.¹⁹ found that young patients with myopia had the same chance of developing glaucoma as older patients. Therefore, screening for complications related to high myopia should start earlier.

PCT showed a regional distribution. The superonasal sector was the thickest, followed by the nasal, supertemporal, inferonasal, and temporal sectors; the inferotemporal sector was the thinnest. There are different theories regarding the mechanism underlying the regional distribution of PCT. Wu et al.²⁰ believed that temporal dragging of the optic disc was the cause of choroidal thinning. Stoll et al.²¹ believed that during embryonic development, the optic nerve cleft under the optic disc closes,²¹ which leads to thinning of the inferotemporal sector. During the onset of glaucoma, the inferior sector of the optic disc narrows first, which supports this view.^{22,23}

Few studies have evaluated the relationship between the peripapillary RNFL and choroidal thickness, especially for people with myopia, and the results are inconsistent. Gupta et al.²⁴ studied the relationship between the RNFL and the choroid in normal people. The results showed that the choroid and RNFL were positively correlated in the superior and inferior sectors, while Huang et al.¹⁸ showed that there was no relationship between the choroid and RNFL. The reason for the difference between these studies and ours was that the patients in our study comprised people with myopia. Wu et al.²⁰ conducted a study of people with myopia of <6.0 D aged 7 to 18 years. The results showed that choroidal thickness was negatively correlated with RNFL thickness in the temporal sector. By analyzing the correlation between RNFL and choroidal thickness in the same sector, we found that RNFL and choroidal thicknesses were negatively correlated in the nasal sector ($r = -0.288$; $P < 0.05$). Previous studies found that RNFL thickness in the nasal sector was more susceptible to structural changes caused by myopia.^{25–28} Our results showed that the RNFL thins in the nasal sector as AL

increases, and that choroidal thickness increases, to compensate.

The limitations of this study are the retrospective design and the sample size. Our results revealed the characteristics of peripapillary changes in myopia, but a large sample and prospective studies are needed to verify our conclusions. Additionally, we did not consider diurnal fluctuations in choroidal thickness, which may have biased the study results.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.


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Author contributions

Authors DC, XH, and AS contributed to the study conception and design; XH and JL collected the data; XQ and TY performed the statistical analysis; DC, XH, and AS analyzed and interpreted the data; and DC and AS wrote manuscript.

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