Original article

Assessment of peripapillary retinal nerve fiber layer thickness in school-aged myopic eyes using optical coherence tomography

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Abstract

Background: Myopia is a major global health challenge, projected to affect 50% of the world population by 2050, with over 60% prevalence in Asian school-aged children. Assessment of peripapillary retinal nerve fiber layer (pRNFL) thickness using optical coherence tomography (OCT) provides critical insights into myopia-associated structural alterations.

Objectives: To characterize refractive and biometric parameters, pRNFL in school-aged myopic children and identify factors associated with pRNFL.

Materials and Methods: This cross-sectional study examined 123 eyes of 74 myopic children aged 6-18 years. Comprehensive ophthalmic evaluation included visual acuity, cycloplegic refraction, axial length measurement, and spectral-domain OCT for pRNFL quantification. Statistical analysis assessed correlations between pRNFL parameters, spherical equivalent refractive error (SE), and axial length.

Results: Mean participant age was 11.46 ± 3.10 years, with mean SE of -3.35 ± 1.76 diopters and axial length of 24.92 ± 0.97 mm. Global mean pRNFL thickness was 102.75 ± 9.15 µm. Quadrant measurements showed superior 133.31 ± 18.59 µm, inferior 130.85 ± 15.25 µm, nasal 65.77 ± 13.07 µm, and temporal 81.11 ± 13.03 µm. Global pRNFL thickness demonstrated significant positive correlations with SE ($p < 0.05$) and negative correlations with axial length ($p < 0.05$).

Conclusions: This study establishes normative pRNFL values for Vietnamese school-aged myopic patients, revealing significant correlations between pRNFL thickness, refractive error, and axial length, providing evidence-based clinical monitoring references.

Key words: *Myopia, peripapillary retinal nerve fiber layer, optical coherence tomography, school-aged children, axial length.*

1. BACKGROUND

Refractive errors are a leading cause of global blindness, with myopia being the primary concern. Currently affecting 30% of the world's population, myopia is projected to reach 50% by 2050. The prevalence is particularly alarming in Asia, with 12-year-old children showing rates of 62.0% in Singapore, 53.1% in Hong Kong, and 49.7% in Guangzhou, compared to 20.0% in the United States and 17.7% in Northern Ireland [1]. Vietnam demonstrates high myopia rates with rapid urban increases - approximately 52.6% among middle school students and 60% among high school students in urban areas according to 2020 surveys [2].

Research indicates that earlier myopia onset predicts faster disease progression. Myopic individuals face elevated risks for cataracts, glaucoma, and posterior ocular complications including posterior staphyloma, myopic retinopathy (myopic macular degeneration), and myopic traction retinopathy [1].

Axial myopization causes significant optic nerve head changes, complicating differentiation between myopic alterations and glaucomatous changes such as retinal nerve fiber layer thinning. Glaucomatous optic neuropathy prevalence is significantly higher in highly myopic versus emmetropic eyes, with lower intraocular pressure damage thresholds [3].

Assessing retinal nerve fiber layer changes in myopic eyes remains challenging due to unique anatomical characteristics, making physiological versus pathological change differentiation difficult. In school-age youth experiencing rapid myopia progression, evaluating retinal nerve fiber layer changes is crucial for understanding early structural modifications, implementing monitoring strategies, and developing appropriate interventions. These considerations motivated our research study.

2. MATERIALS AND METHODS

2.1. Research subjects

123 myopic eyes of 74 patients who visited the Ophthalmology Clinic at the Family Medicine Center

and Hospital of Hue University of Medicine and Pharmacy from April 2024 to May 2025.

2.1.1. Inclusion Criteria

- Myopic patients:

+ Age range from 6–18 years old.

+ Intraocular pressure within normal limits.

- Patient and family consent and cooperation to participate in the study and examination.

2.1.2. Exclusion Criteria

- Patients with previous history of ocular surgery.

- Patients with pathological conditions causing opacity of transparent optical media that would interfere with OCT examination, including: corneal scarring, keratitis or corneal ulceration, vitreous hemorrhage, other vitreoretinal pathologies, etc.

- Patients with optic nerve disorders, including: glaucoma, inflammatory optic nerve diseases, ischemic optic neuropathy, traumatic optic neuropathy, other optic nerve pathologies, etc.

- OCT scans with a signal strength index (SSI) of less than 6/10 were excluded < 6/10.

2.2. Research methods

Study design

A cross-sectional study was used in this research from April 2024 to May 2025.

In this study, the unit of analysis was the eye; therefore, each eye was considered an independent observational unit in the statistical analysis

Data collection

Detailed information regarding general characteristics (age, gender, location) and myopic features (uncorrected and best-corrected visual acuity, refractive data, axial length, peripapillary retinal nerve fiber layer (pRNFL) thickness) was documented for all study participants after routine ophthalmic examinations. Axial length was measured for all eyes using ultrasound biometry. Because OCT measurements around the optic nerve head may be affected by ocular magnification associated with axial length, axial length values were recorded and considered when interpreting peripapillary retinal nerve fiber layer measurements.

Definition

Spherical equivalent refraction (SE) was calculated as the spherical diopters (D) plus half of the cylindrical diopters.

Myopia was defined as a refractive condition with SE ≤ −0.50 D under relaxed accommodation. Based on the severity of refractive error, myopia was further classified into three categories: (1) low myopia: SE ≤ −0.50 D and > −3.00 D, (2) moderate myopia: SE ≤ −3.00D and > −6.00 D, (3) high myopia: SE ≤ −6.00 D. All measurements were obtained under relaxed ocular accommodation [4].

Equipment

Snellen visual acuity chart, Nidek ARK-1 autorefractor, trial lens set, retinoscope, Echoscan US-4000, Optical Coherence Tomography RS-3000 Advance 2.

2.3. Statistical analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Participants in the final analysis were stratified into three age groups (6–10, 11–14, and 15–18 years) corresponding to educational levels. Axial length measurements were categorized into four groups (< 23.5 mm, 23.5 to < 24.5 mm, 24.5 to < 25.5 mm, and ≥ 25.5 mm) based on the classification by Tham et al. (2016) [5].

The Kolmogorov-Smirnov test was used to assess normality of variable distributions. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means ± standard deviations. Correlations between continuous variables were evaluated using Pearson correlation coefficients. Linear regression analysis was performed to examine predictive relationships between independent and dependent variables.

3. RESULTS

3.1. General characteristics

Table 1. General characteristics of the study group (n = 74)

Characteristics		Number (n)	Percentage (%)
Age	6–10 years old	30	40.5
	10–14 years old	29	39.2
	15–18 years old	15	20.3
Gender	Male	34	45.9
	Female	40	54.1
Residence	Urban	56	75.7
	Rural	18	24.3

The study population had a mean age of 11.46 ± 3.10 years. The distribution across age groups showed that students aged 6–10 years constituted the largest segment (40.5%), followed by those aged 11–14 years (39.2%), while the 15–18 years age group represented the smallest proportion (20.3%). Female participants outnumbered males, accounting for 54.1% and 45.9%, respectively. The majority live in urban areas, with 75.7% of respondents residing in urban locations.

3.2. Refractive and biometric parameters with peripapillary retinal nerve fiber layer assessment

Table 2. Distribution of myopia severity (n = 123)

Degree of Myopia	Number (n)	Percentage (%)
Mild	51	41.5
Moderate	64	52.0
High	8	6.5
Total	**123**	**100**

The mean SE was -3.35 ± 1.76 D. Moderate myopia was the most prevalent category (52.0%), followed by mild myopia (41.5%). High myopia was observed in a small proportion of eyes (6.5%).

Table 3. Distribution of axial length (n = 123)

Axial Length	Number (n)	Percentage (%)
< 23.5 mm	7	5.7
23.5 mm to < 24.5 mm	41	33.3
24.5 mm to < 25.5 mm	38	30.9
≥ 25.5 mm	37	30.1
Total	**123**	**100**

The mean axial length was 24.92 ± 0.97 mm. Eyes with axial length < 23.5 mm represented the smallest proportion (5.7%), while the remaining groups showed relatively similar distributions: 33.3% in the 23.5 to < 24.5 mm group, 30.9% in the 24.5 to < 25.5 mm group, and 30.1% in the ≥ 25.5 mm group.

Table 4. Peripapillary retinal nerve fiber layer thickness

pRNFL thickness (μm)	Mean	Standard Deviation
Average	102.75	9.15
Inferior	130.85	15.25
Superior	133.31	18.59
Nasal	65.77	13.07
Temporal	81.11	13.03

The global pRNFL thickness measured 102.75 ± 9.15 μm. Quadrant-specific analysis revealed the characteristic pattern of pRNFL distribution: the superior quadrant showed the greatest thickness (133.31 ± 18.59 μm), followed by inferior (130.85 ± 15.25 μm), temporal (81.11 ± 13.03 μm), and nasal (65.77 ± 13.07 μm) quadrants.

3.3. Factors associated with peripapillary retinal nerve fiber layer thickness

Table 5. Correlation between pRNFL thickness and SE in myopic eyes

pRNFL thickness	Coefficient (r)	p	R^2	Linear Regression Equation
Average	0.401	< 0.05	0.161	y = 109.722 + 2.083x
Inferior	0.420		0.176	y = 143.029 + 3.636x
Superior	0.322		0.104	y = 144.707 + 3.436x
Nasal	0.348		0.121	y = 74.438 + 2.588x
Temporal	-0.171	> 0.05	0.029	y = 76.870 – 1.267x

Global pRNFL thickness and most quadrant measurements demonstrated statistically significant positive correlations with SE ($p < 0.05$). The strongest correlation in quadrant measurements was observed in the inferior quadrant ($r = 0.420$), followed by the nasal quadrant ($r = 0.348$), and the superior quadrant ($r = 0.322$). The temporal quadrant showed no significant correlation with myopia severity ($r = -0.171$, $p > 0.05$). The predictive power of myopia severity for pRNFL thickness variation was modest, with R^2 values ranging from 10.4% to 17.6%.

Table 6. Correlation between pRNFL thickness and axial length

pRNFL thickness	Coefficient (r)	p	R²	Linear Regression Equation
Average	-0.429	< 0.05	0.184	$y = 203.388 – 4.039x$
Inferior	-0.485		0.235	$y = 320.630 – 7.616x$
Superior	-0.432		0.187	$y = 339.491 – 8.274x$
Nasal	-0.152	> 0.05	0.023	$y = 116.869 – 2.051x$
Temporal	0.136		0.018	$y = 35.726 + 1.821x$

Global pRNFL thickness and the superior and inferior quadrants exhibited statistically significant negative correlations with axial length ($p < 0.05$). The inferior quadrant demonstrated a stronger inverse correlation ($r = -0.485$) than the superior quadrant ($r = -0.432$). Neither the nasal ($r = -0.152$, $p > 0.05$) nor the temporal ($r = 0.136$, $p > 0.05$) quadrants showed significant associations with axial length. Axial length explained 18.4% to 23.5% of the variance in pRNFL thickness for the significantly correlated parameters.

4. DISCUSSION

Our study was conducted on 123 myopic eyes from 74 patients. The mean age of participants was 11.46 ± 3.10 years, which is consistent with findings from several comparable studies. Specifically, Li et al. (2024) conducted research on 31,839 patients aged 6 - 18 years, of whom 55.46% had myopia with a mean age of 12.04 ± 2.65 years [6]. Similarly, Nguyen et al. (2023) studied 310 myopic patients with a mean age of 12.42 ± 3.34 years [7].

Regarding age distribution, participants aged 6–10 years constituted the largest cohort in our study (40.5%), followed by those aged 11–14 years (39.2%) and 15–18 years (20.3%). This demographic pattern is consistent with findings reported by Nguyen et al. (2023), who observed that the 6–10 years age group represented the highest proportion of their study population (34.2%) [7]. Children aged 6–10 years are in a critical transitional phase, shifting from predominantly play-based activities to formal academic learning with increased near-work demands, potentially leading to accelerated myopic progression.

Gender analysis revealed a higher prevalence of myopia among females (54.1%) compared to males (45.9%). This pattern is consistent with the findings of Nguyen et al. (2023), who found rates of 62.6% for females and 37.4% for males [7].

Our study documented a higher prevalence of childhood myopia in urban areas compared to rural areas, accounting for 75.7% and 24.3%, respectively. This urban-rural disparity is corroborated by Le et al. (2023), who reported myopia prevalence rates of 39.4% in urban children versus 19.3% in rural children [8]. This may be due to urban areas having higher population density and reduced green spaces from increased infrastructure development. Additionally, urban residents have better healthcare access, leading to higher myopia detection rates.

Our study demonstrated a mean SE of -3.35 ± 1.76 D. These findings are consistent with those of Tang et al. (2020), who found -3.21 ± 1.61 D [9]. Regarding myopia severity distribution, moderate myopia constituted the largest proportion (52.0%), followed by mild myopia (41.5%) and high myopia (6.5%). This pattern aligns with Sim et al. (2024), who reported moderate myopia as the predominant category (45%) [10]. This finding reinforces that moderate myopia is the most common severity level observed in school-age populations, underscoring the importance of timely intervention strategies to halt progression to high myopia.

Axial elongation plays a crucial role in the pathogenesis of myopia in children. The mean axial length in our study was 24.92 ± 0.97 mm, which closely corresponds to Tang et al. (2020), who reported 24.95 ± 0.99 mm [9]. This similarity is particularly noteworthy given the comparable age ranges (6–18 years) and mean ages between studies, though Tang et al. (2020) employed different inclusion criteria (spherical equivalent from -8.00 D to 0 D and astigmatism ≤ 3.00 D). Our analysis revealed that eyes with axial length < 23.5 mm represented the smallest proportion (5.7%), while the remaining groups showed relatively similar distributions: 33.3% in the 23.5 to < 24.5 mm group, 30.9% in the 24.5 to < 25.5 mm group, and 30.1% in the ≥ 25.5 mm group.

Our investigation revealed a mean pRNFL thickness of 102.75 ± 9.15 µm. This finding is consistent with Kavitha et al. (2021), who conducted research on 334 eyes from 205 children aged 6-18 years across four refractive groups, demonstrating similar mean pRNFL thickness in myopic subjects (102.03 ± 7.19 µm). Their study also documented pRNFL thickness in emmetropic (105.30 ± 7.73 µm), hyperopic (104.34 ± 8.15 µm), and astigmatic (104.58 ± 8.23 µm) groups, with statistically significant inter-group differences ($p < 0.05$) [11].

The ISNT rule is defined as the sequential pattern of optic nerve rim width or pRNFL thickness following the order I - S - N - T in normal eyes. However, a study by Poon et al. (2017) demonstrated that the ISNT rule was only applicable in 37.0% of cases when assessing optic nerve rim through fundus photography and 43.8% of cases when evaluating pRNFL thickness on OCT. Nasal deviation is the primary cause of ISNT rule inaccuracy in both optic disc imaging and RNFL thickness measurements. Excluding the nasal quadrant, the IST and IS rule variants demonstrated significantly higher accuracy: optic disc images: 70.9% (IST) and 76.4% (IS) vs. 37.0% (traditional ISNT) and pRNFL thickness: 70.9% (IST) and 71.8% (IS) vs. 43.8% (traditional ISNT) [12].

Contrary to the traditional ISNT rule expectations, our findings revealed a different quadrant-specific pattern. Our quadrant-specific evaluation identified the thickest pRNFL in the superior quadrant (133.31 ± 18.59 µm), followed by inferior (130.85 ± 15.25 µm), temporal (81.11 ± 13.03 µm), and nasal quadrants (65.77 ± 13.07 µm). Ma and Vu (2020) reported a parallel pattern: superior (120 ± 19.36 µm), inferior (117.98 ± 18.57 µm), temporal (78.55 ± 15.88 µm), and nasal (62.08 ± 10.99 µm) [13]. Sim et al. (2024) confirmed this quadrant-specific distribution pattern across mild, moderate, and high myopia groups [10].

The relationship between retinal nerve fiber layer thickness and refractive error unveils a complex interplay between structural and optical changes in the myopic eye. We identified a moderate positive correlation between mean pRNFL thickness and SE ($r = 0.401$, $p < 0.05$), expressed through the linear regression equation $y = 109.808 + 2.104x$. Yao et al. (2020) demonstrated a significant positive correlation using multivariate linear regression analysis ($p < 0.05$) [14]. This finding holds significant clinical implications for evaluating RNFL in myopic patients. Thinner RNFL in myopic individuals may represent normal physiological adaptation rather than pathological damage. Therefore, establishing separate reference values for different refractive groups is essential to prevent misdiagnosis and ensure accuracy in monitoring optic neuropathies.

Our analysis revealed positive correlations between pRNFL thickness and SE in the inferior ($r = 0.420$, $p < 0.05$), superior ($r = 0.322$, $p < 0.05$), and nasal ($r = 0.348$, $p < 0.05$) quadrants. No significant correlation was observed between temporal pRNFL thickness and SE in our study ($r = -0.171$, $p > 0.05$). Sim et al. (2024) demonstrated decreased pRNFL thickness in superior, inferior, and nasal quadrants with increasing myopia severity, but showed increased temporal pRNFL thickness with myopia progression [10]. This discrepancy may be attributed to their higher prevalence of tilted optic discs (80% in mild, 87% in moderate, and 92% in high myopia groups) compared to our study (10.2%), potentially altering pRNFL distribution patterns.

We identified a moderate inverse correlation between mean pRNFL thickness and axial length ($r = -0.429$, $p < 0.05$), expressed through the linear regression equation $y = 222.215 – 4.798x$, indicating that each 1 mm increase in axial length corresponds to a 4.798 µm decrease in mean pRNFL thickness. Hashemi et al. (2022) demonstrated an inverse relationship in univariate analysis ($\beta = -2.24$, 95% CI: -2.61 to -1.87, $p < 0.001$), with a stronger effect in multivariate analysis ($\beta = -3.34$, 95% CI: -3.78 to -2.90, $p < 0.001$). This relationship may be explained by mechanical stretching associated with axial elongation, leading to retinal thinning and subsequent pRNFL thickness reduction [15].

Our investigation revealed moderate inverse correlations between axial length and pRNFL thickness in the inferior ($r = -0.485$, $p < 0.05$) and superior ($r = -0.432$, $p < 0.05$) quadrants. However, no significant correlations were observed in the nasal ($r = -0.152$, $p > 0.05$) and temporal ($r = 0.136$, $p > 0.05$) quadrants. Sim et al. (2024) demonstrated decreased pRNFL thickness in superior and inferior quadrants with increasing axial length, but showed contrasting results in nasal (decreased) and temporal (increased) quadrants compared to our findings [10]. These differences may be attributed to variations in sample size (n = 1,000 versus our n = 123), age range

(7–16 versus 6–18 years), and ethnicity (Chinese versus Vietnamese populations).

5. CONCLUSION

This study establishes normative pRNFL thickness values for Vietnamese school-aged myopic patients and demonstrates significant correlations between RNFL thickness, spherical equivalent, and axial length. Global pRNFL thickness showed positive correlation with SE and negative correlation with axial length, indicating that myopic progression is associated with RNFL thinning. The inferior quadrant exhibited the strongest correlations with both parameters. These findings enhance understanding of myopia-related structural changes and inform clinical monitoring protocols, with quadrant-specific patterns providing insights for targeted assessment strategies.

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