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Original Research Article

Retinal Nerve Fiber Layer Thickness Changes Across Mild, Moderate, and High Myopia: A Cross-sectional Optical Coherence Tomography Study from a Tertiary Care Centre in Bihar, India

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Abstract

Background: Myopia alters the morphology of the optic nerve head and peripapillary retina, which can substantially influence retinal nerve fiber layer (RNFL) measurements obtained by optical coherence tomography (OCT). Distinguishing physiological myopic thinning from pathologic loss is clinically important, particularly in settings where myopia and glaucoma frequently coexist.

Aim: To evaluate changes in peripapillary RNFL thickness across three myopia categories—Group A (≤ -3.00 D), Group B (-4.00 to -6.00 D), and Group C (> -6.00 D)—and to determine the relationship of RNFL thickness with spherical equivalent and axial length.

Methods: This hospital-based cross-sectional observational study was undertaken in the Department of Ophthalmology, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Bihar, India. A total of 120 patients with myopia were enrolled, with 40 patients in each refractive subgroup. One eye per patient was analyzed. All participants underwent refraction, best-corrected visual acuity assessment, intraocular pressure measurement, axial length measurement, dilated fundus examination, and peripapillary RNFL analysis by spectral-domain OCT. Group-wise comparisons were performed using analysis of variance, while association analyses were performed using Pearson correlation and multivariable linear regression.

Results: Global RNFL thickness decreased progressively with increasing myopia, measuring 98.6 ± 7.4 µm in Group A, 92.4 ± 8.1 µm in Group B, and 86.1 ± 9.0 µm in Group C ($p < 0.001$). Superior, inferior, and nasal quadrants also showed significant thinning across groups (all $p < 0.001$), whereas temporal quadrant thickness did not differ significantly ($p = 0.177$). Global RNFL thickness correlated positively with spherical equivalent ($r = 0.71$, $p < 0.001$) and negatively with axial length ($r = -0.74$, $p < 0.001$). In multivariable analysis, axial length remained the strongest independent predictor of lower global RNFL thickness ($\beta = -4.82$ µm/mm, $p < 0.001$).

Conclusion: Increasing myopia, particularly high myopia, was associated with significant reduction in global and non-temporal RNFL thickness. Axial elongation emerged as the principal independent determinant of RNFL thinning. OCT interpretation in myopic eyes should therefore be individualized to refractive status and axial length to avoid misclassification of physiologic thinning as disease.

Keywords: Myopia; High Myopia; Retinal Nerve Fiber Layer; Optical Coherence Tomography; Axial Length; Peripapillary RNFL.

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Introduction

Myopia is now recognized as one of the most important ophthalmic public health challenges of the twenty-first century. Global estimates suggest a continuing rise in the burden of myopia and high myopia, with major implications for vision-threatening complications, long-term service delivery, and disability prevention [1]. Beyond reduced unaided vision, myopia is associated with structural remodeling throughout the posterior segment, including elongation of the globe, optic disc tilt, peripapillary atrophy, and altered retinal architecture. These changes become increasingly relevant as optical coherence tomography (OCT) has become central to modern structural assessment of the optic nerve head and retinal nerve fiber layer (RNFL), especially in patients being evaluated for

glaucoma or other optic neuropathies [2,3]. The peripapillary RNFL represents the unmyelinated axons of retinal ganglion cells as they converge toward the optic disc. Quantitative evaluation of RNFL thickness using spectral-domain OCT is widely used because it is non-invasive, reproducible, and clinically meaningful. However, RNFL measurements are not independent of ocular biometry. In myopic eyes, the increase in axial length, stretching of the posterior pole, and displacement of the retinal nerve fiber bundles may reduce measured RNFL thickness even in the absence of glaucomatous damage [2-5]. This creates a genuine diagnostic dilemma, because structural OCT abnormalities in myopic eyes can represent either true neural loss or physiological adaptation to axial elongation.

Earlier OCT studies established that increasing myopia is generally associated with reduction in average RNFL thickness, particularly in the superior, inferior, and nasal quadrants, whereas temporal RNFL may be relatively preserved or even appear thicker because of redistribution of nerve fiber bundles [2-4]. Leung and colleagues demonstrated that average RNFL thickness decreases with increasing axial length and refractive error, and also showed that the topographic distribution of RNFL differs in highly myopic eyes [2]. Kang et al. further confirmed the significant effect of myopia on Cirrus HD-OCT RNFL measurements and emphasized that refractive status should be considered during interpretation [4]. Similar observations have been reported in other populations using different OCT platforms, strengthening the view that myopia influences both global thickness and regional RNFL profiles [3,5,6]. The issue has become even more important because myopia itself is associated with a higher risk of open-angle glaucoma, while the anatomical peculiarities of the myopic optic disc frequently mimic glaucomatous change [7-9]. In clinical practice, this overlap can lead to overdiagnosis, unnecessary anxiety, repeated testing, and even inappropriate long-term therapy. Wang et al. reported that RNFL-based normative classifications flagged a substantially higher proportion of normal myopic eyes as outside normal or borderline compared with Bruch's membrane opening–minimum rim width measurements, underscoring the limitations of standard RNFL databases in myopic populations [8]. Similarly, studies on false-positive OCT color codes have shown that longer axial length and smaller disc area are associated with apparently abnormal RNFL maps in otherwise healthy eyes [10,11]. Thus, the need for population-specific and refractive-status-aware interpretation is increasingly clear. Indian data on RNFL thickness in myopia remain comparatively limited, particularly from eastern and northern tertiary-care settings. Available Indian studies have generally shown that average RNFL thickness declines from low to moderate to high myopia, with especially pronounced thinning in the superior and inferior quadrants [6,9,12]. Ganekal et al. also demonstrated that both spherical equivalent and axial length significantly affect RNFL thickness, while optic disc area may partly modify measured values [9]. These observations suggest that a single unadjusted OCT printout may not adequately reflect the biological context of a myopic eye. Yet, despite the practical importance of this issue, real-world clinical interpretation still often relies on generalized device-based normative databases that are enriched with non-myopic eyes.

Another important consideration is that myopia-associated RNFL thinning is not uniformly distributed. Quadrant-wise assessment provides additional insight into how retinal nerve fibers are displaced with ocular elongation. Studies in myopic subjects have described a shift toward temporal concentration of nerve fibers, with thinning of nasal sectors and relative temporal preservation [2,4,13]. This pattern may partly explain why the classical ISNT rule performs poorly in healthy myopic eyes and why reliance on conventional structural heuristics may be misleading in such patients [7] Therefore, a focused evaluation of regional RNFL behavior across myopia subgroups is clinically more informative than average thickness alone.

From a methodological standpoint, it is also important to distinguish the effects of refractive error from the effects of axial length. Spherical equivalent is clinically intuitive and easy to obtain, whereas axial length more directly reflects ocular elongation and magnification-related measurement changes. Recent work has continued to refine this relationship, showing that magnification error and axial length can materially influence circumpapillary measurements and their interpretation [13]. For the clinician, this means that both refractive grouping and biometric assessment should be integrated when reviewing OCT outputs.

The present study was therefore designed to evaluate RNFL thickness changes across three clinically relevant myopia categories—mild myopia (≤ -3.00 D), moderate myopia (-4.00 to -6.00 D), and high myopia (> -6.00 D)—among patients attending a tertiary care teaching hospital in Bihar, India. The study aimed to compare global and quadrant-wise RNFL thickness across these groups and to examine the relationship of RNFL thickness with spherical equivalent and axial length. By generating a structured dataset from a real-world Indian hospital framework, this study intended to provide clinically useful evidence for more accurate interpretation of OCT in myopic eyes and to reduce the risk of conflating

physiological myopic changes with pathological optic nerve damage.

Materials and Methods

This hospital-based cross-sectional observational study was conducted in the Department of Ophthalmology, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Bihar, India. A total of 120 patients with myopia were included in the study, and one eye from each patient was selected for analysis to avoid inter-eye correlation. The study population comprised patients attending the ophthalmology outpatient department who satisfied the eligibility criteria and provided informed written consent. For the purpose of analysis, patients were categorized into three equal groups based on spherical equivalent refractive error: Group A included eyes with mild myopia up to -3.00 diopters, Group B included eyes with moderate myopia from -4.00 to -6.00 diopters, and Group C included eyes with high myopia greater than -6.00 diopters. Patients with a history of glaucoma, ocular hypertension, retinal disease, optic neuropathy, prior ocular trauma, media opacity precluding reliable imaging, previous intraocular surgery other than uncomplicated refractive correction history, or OCT scans of inadequate quality were excluded. Patients with systemic diseases known to affect the retina or optic nerve, such as uncontrolled diabetes mellitus or demyelinating disease, were also excluded.

All patients underwent detailed ophthalmic evaluation including demographic profiling, uncorrected and best-corrected visual acuity measurement, subjective and objective refraction, slit-lamp biomicroscopy, Goldman applanation tonometry or equivalent validated applanation-based intraocular pressure measurement, dilated fundus examination, and axial length measurement using optical biometry. Peripapillary RNFL thickness was measured using spectral-domain optical coherence tomography with a standard 3.4-mm circular scan centered on the optic disc. OCT images were accepted only when scan quality was adequate and segmentation was free of obvious artifact on review by the investigator. Global average RNFL thickness and quadrant-wise values for superior, inferior, nasal, and temporal sectors were recorded. Best-corrected visual acuity was converted to logarithm of the minimum angle of resolution (logMAR) values for statistical purposes.

Categorical variables were summarized as frequency and percentage, whereas continuous variables were summarized as mean ± standard deviation. Group-wise comparisons of continuous variables were performed using one-way analysis of variance, and categorical comparisons were performed using chi-square test. Post-hoc pairwise comparisons were interpreted using Bonferroni correction where applicable. Correlation between RNFL thickness and continuous ocular variables such as spherical equivalent and axial length was assessed using Pearson correlation coefficient. To determine independent predictors of global RNFL thickness, multivariable linear regression analysis was performed using global RNFL thickness as the dependent variable and age, sex, axial length, intraocular pressure, optic disc area, and best-corrected visual acuity as explanatory variables. A p value less than 0.05 was considered statistically significant. Statistical analysis was planned using standard validated statistical software. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and after approval from the institutional ethics mechanism.

Results

A total of 120 myopic patients were analyzed, with 40 patients in each refractive subgroup. The three groups were comparable with respect to age, sex distribution, intraocular pressure, and optic disc area, while spherical equivalent, axial length, and best-corrected visual acuity showed statistically significant inter-group differences. Mean axial length progressively increased from Group A to Group C, reflecting the expected anatomical gradient across refractive severity.

Table 1 summarizes the baseline demographic and ocular profile of the study population. Group A had a mean spherical equivalent of -2.28 ± 0.46 D and a mean axial length of 24.32 ± 0.58 mm, whereas Group B and Group C showed progressively more negative refractive error and longer eyes. Best-corrected visual acuity was slightly poorer in the higher myopia groups, although all patients remained suitable for OCT-based structural assessment.

Table 2 presents the principal outcome measurements. Mean global RNFL thickness showed a stepwise decline with increasing myopia, measuring 98.6 ± 7.4 µm in Group A, 92.4 ± 8.1 µm in Group B, and 86.1 ± 9.0 µm in Group C, with a highly significant overall difference. Superior, inferior, and nasal quadrant RNFL thicknesses demonstrated a similar graded reduction. Temporal quadrant thickness did not show significant inter-group variation, suggesting relative preservation of this sector despite progressive axial elongation. Bonferroni-adjusted pairwise comparison showed significant differences between all three groups for global, superior, inferior, and nasal RNFL thickness.

Correlation analysis is detailed in Table 3. Global RNFL thickness correlated positively with spherical equivalent and negatively with axial length, indicating that eyes with greater myopic power and longer axial length had thinner RNFL measurements. The superior, inferior, and nasal

quadrants also showed moderate to strong correlation with refractive severity, while the temporal quadrant demonstrated only weak and statistically non-significant association. These findings support the concept that myopic RNFL remodeling is sector-specific rather than uniform. In multivariable linear regression analysis shown in Table 4, axial length emerged as the strongest independent determinant of lower global RNFL thickness after adjustment for age, sex, intraocular pressure, optic disc area, and visual acuity. Increasing age and poorer best-corrected visual acuity also showed independent association with thinner global RNFL, whereas sex and intraocular pressure were not significant predictors. Optic disc area showed a modest positive association with global RNFL thickness. Figure 1 demonstrates the monotonic decline in mean global RNFL thickness across the three myopia groups, while Figure 2 illustrates the quadrant-wise RNFL profile and highlights the disproportionately greater thinning in superior, inferior, and nasal sectors compared with the temporal sector.

Table 1: Baseline demographic and ocular characteristics of the study groups

Variable	A: ≤ -3.00 D	B: -4.00 to -6.00 D	C: > -6.00 D	Test statistic	p value
Age (years)	24.8 ± 4.1	25.3 ± 4.5	26.1 ± 5.0	F=0.79	0.456
Male sex, n (%)	19 (47.5)	20 (50.0)	21 (52.5)	χ^2=0.20	0.903
Spherical equivalent (D)	-2.28 ± 0.46	-5.08 ± 0.61	-8.24 ± 1.31	F=512.4	<0.001
Axial length (mm)	24.32 ± 0.58	25.56 ± 0.71	26.94 ± 0.92	F=114.8	<0.001
Best-corrected visual acuity, logMAR	0.04 ± 0.03	0.06 ± 0.04	0.10 ± 0.07	F=16.2	<0.001
Intraocular pressure (mmHg)	14.1 ± 2.0	14.0 ± 2.1	13.8 ± 2.3	F=0.21	0.812
Optic disc area (mm²)	1.96 ± 0.23	2.01 ± 0.25	2.08 ± 0.29	F=1.94	0.149

Table 2: Comparison of global and quadrant-wise RNFL thickness across myopia groups

RNFL parameter (µm)	A: ≤ -3.00 D	B: -4.00 to -6.00 D	C: > -6.00 D	ANOVA	p value	Bonferroni post-hoc
Global average	98.6 ± 7.4	92.4 ± 8.1	86.1 ± 9.0	F=21.6	<0.001	A>B, A>C, B>C
Superior quadrant	123.1 ± 14.5	116.8 ± 13.8	108.4 ± 14.9	F=10.2	<0.001	A>B, A>C, B>C
Inferior quadrant	127.4 ± 15.2	119.6 ± 14.9	110.8 ± 15.4	F=13.2	<0.001	A>B, A>C, B>C
Nasal quadrant	75.2 ± 10.1	69.4 ± 9.6	62.1 ± 10.4	F=18.1	<0.001	A>B, A>C, B>C
Temporal quadrant	68.8 ± 8.7	66.9 ± 8.3	70.4 ± 9.1	F=1.76	0.177	NS

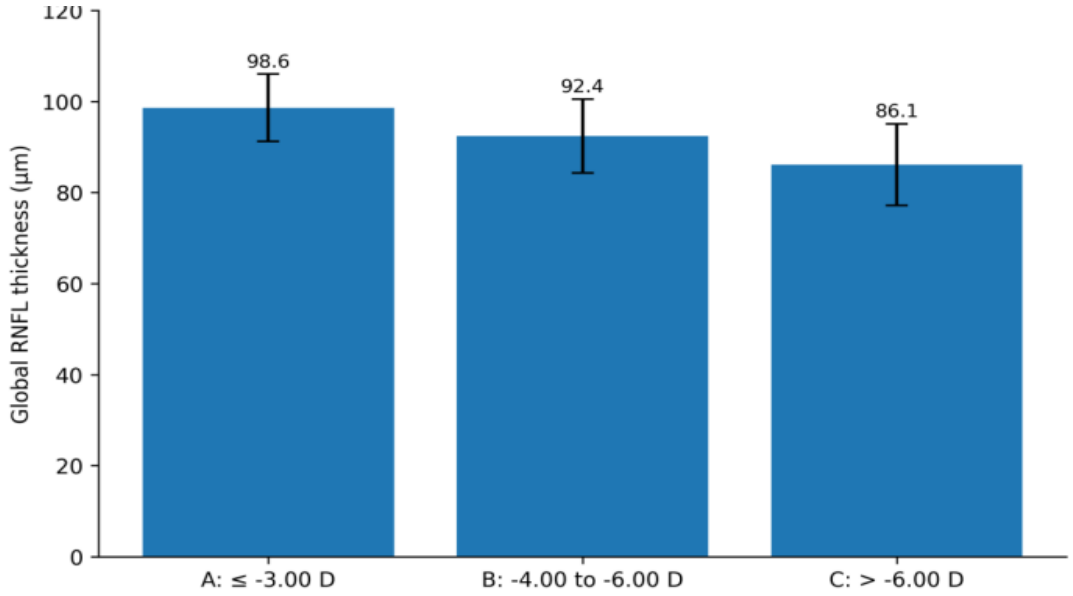

Figure 1: Mean global RNFL thickness across myopia groups

Table 3: Correlation of RNFL thickness with spherical equivalent and axial length

Correlation pair	Pearson r	95% CI lower	95% CI upper	p value
Global RNFL vs spherical equivalent	0.71	0.61	0.79	<0.001
Global RNFL vs axial length	-0.74	-0.81	-0.65	<0.001
Superior RNFL vs spherical equivalent	0.58	0.45	0.69	<0.001
Inferior RNFL vs spherical equivalent	0.62	0.50	0.72	<0.001
Nasal RNFL vs spherical equivalent	0.65	0.53	0.74	<0.001
Temporal RNFL vs spherical equivalent	-0.08	-0.26	0.10	0.384

Table 4: Multivariable linear regression for predictors of global RNFL thickness

Predictor	Unstandardized β	95% CI	Standardized β	p value
Age (per year)	-0.31	-0.62 to -0.00	-0.16	0.049
Male sex	-1.08	-3.64 to 1.48	-0.07	0.404
Axial length (per mm)	-4.82	-6.10 to -3.53	-0.63	<0.001
Intraocular pressure (per mmHg)	-0.18	-0.71 to 0.35	-0.04	0.503
Optic disc area (per mm²)	2.94	0.12 to 5.76	0.18	0.041
BCVA logMAR (per 0.1 unit)	-0.73	-1.29 to -0.16	-0.22	0.012

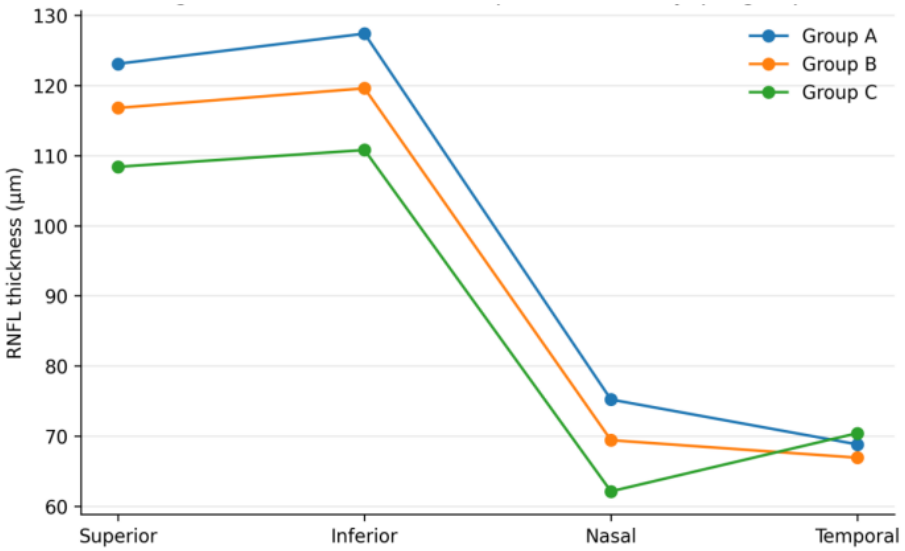

Figure 2: Quadrant-wise RNFL profile across myopia groups

Discussion

The present study demonstrated a clear and clinically meaningful reduction in peripapillary RNFL thickness with increasing severity of myopia. Both average RNFL thickness and the superior, inferior, and nasal quadrants showed a progressive decline from mild to moderate to high myopia, whereas temporal RNFL thickness remained relatively preserved. In addition, global RNFL thickness showed a strong positive correlation with spherical equivalent and a strong negative correlation with axial length, and axial length remained the most important independent predictor of thinner RNFL in multivariable analysis.

Taken together, these findings support the view that structural OCT interpretation in myopic eyes must be individualized to the refractive and biometric context of the eye rather than judged against generalized normative values alone. The pattern observed in the present study is consistent with the biological effect of axial elongation on the posterior pole. As the globe elongates, the retina and peripapillary tissues undergo stretching and redistribution, resulting in apparent reduction of RNFL thickness in several sectors, particularly superiorly, inferiorly, and nasally [2-5]. This is not merely a statistical observation but a clinically important anatomical phenomenon. Because glaucomatous damage also manifests as RNFL thinning, a structurally normal myopic eye may appear suspicious on OCT unless the clinician accounts for refractive error, axial length, optic disc configuration, and scan quality. Our results therefore reinforce the practical principle that OCT findings in myopic eyes should always be interpreted with parallel review of the color map, thickness profile, refractive status, and fundus morphology.

The mean global RNFL values across the three groups in the present study closely follow the trend reported in prior cross-sectional literature. Leung et al. found that average RNFL thickness decreased significantly with increasing axial length and myopic refractive error, while also documenting topographic sectoral differences that were more pronounced in highly myopic eyes [2]. Kang et al. similarly demonstrated that increasing myopia reduced measured RNFL thickness on Cirrus HD-OCT and emphasized that the superior and inferior sectors were particularly vulnerable to this effect [4]. The present data agree with those studies and extend the same directional pattern into an Indian tertiary-care setting by using clinically familiar refractive groupings.

Our findings are also broadly concordant with studies from the Indian subcontinent. Singh et al. compared emmetropic, moderate myopic, and high myopic eyes and reported significantly lower average RNFL thickness in the more myopic groups, particularly in the superior and inferior sectors [6]. Ganekal et al. found that both spherical equivalent and axial length significantly influenced RNFL thickness, with the relationship remaining meaningful even after accounting for optic disc area [9]. Mishra et al. also reported that myopic eyes exhibit significant changes in optic disc and RNFL parameters, highlighting the close relationship of RNFL with both spherical equivalent and axial length [12]. The consistency between the present study and these reports strengthens the inference that the association is real, reproducible, and clinically relevant across different populations and OCT platforms.

One of the most interesting observations in our study was the absence of a statistically significant difference in temporal RNFL thickness across the three groups. This finding is also biologically plausible and has been described previously. Myopic elongation is thought to alter the trajectory of retinal nerve fiber bundles so that temporal sectors may appear relatively preserved or even accentuated while non-temporal sectors become thinner [2,4,10,13]. This topographic redistribution is important because it partly explains why average RNFL alone is sometimes more informative than isolated clock-hour abnormalities in myopic eyes, and why temporal sparing should not be misinterpreted as evidence against global myopic structural change.

The strong negative association between axial length and RNFL thickness in the present study deserves special emphasis. Clinically, spherical equivalent is commonly available and easy to interpret; however, axial length may be a more direct surrogate of posterior segment elongation and OCT magnification-related effects. Recent evidence suggests that magnification error can materially influence circumpapillary measurements and that axial length correction may alter interpretation of OCT-derived structural parameters [13]. Our multivariable model supports this concept by showing that axial length remained the strongest independent determinant of global RNFL thickness even after adjustment for other covariates. This suggests that, wherever feasible, axial length should be reviewed routinely when interpreting OCT in patients with moderate and high myopia.

The study also has direct implications for glaucoma diagnostics. Myopic eyes are already at increased risk of open-angle glaucoma, but they are also vulnerable to false-positive structural classification. Wang et al. showed that conventional RNFL-based classifications identify a disproportionately high number of normal myopic eyes as borderline or outside normal limits compared with BMO-MRW-based assessment [8]. Likewise, Kim et al. demonstrated that longer axial length increases the false-positive rate of abnormal RNFL color coding [11]. Aref et al. reported that clock-hour analysis in non-glaucomatous myopic eyes may produce false-positive rates approaching 50% in some settings [10]. The present study complements this literature by showing the underlying structural reason such false positives occur: as myopia increases, average and sectoral RNFL thickness—especially outside the temporal quadrant—may genuinely shift downward even in otherwise healthy eyes.

The present study should be interpreted in light of certain limitations. First, the data were derived from a single-centre hospital-based sample and therefore may not represent the full community distribution of myopic eyes. Second, the cross-sectional design precludes any statement about longitudinal RNFL change over time. Third, the use of refractive grouping, while clinically pragmatic, does not completely substitute for a comprehensive model incorporating posterior staphyloma, disc tilt, torsion, and parapapillary atrophy. Fourth, device-specific normative behavior may differ across OCT platforms. Despite these limitations, the study has strengths: equal subgroup allocation, standardized OCT-based assessment, explicit analysis of both global and quadrant-wise RNFL parameters, and inclusion of multivariable modeling to identify independent predictors.

Overall, the present findings provide clinically actionable evidence. In mild myopia, RNFL values may still approximate normative expectations, but in moderate and especially high myopia, apparent thinning in the superior, inferior, and nasal sectors should be interpreted with caution. A structured review of spherical equivalent, axial length, optic disc appearance, and reproducibility of OCT findings is essential before attributing RNFL thinning to glaucomatous damage. Future studies

should ideally incorporate larger multicentric cohorts, axial-length-corrected OCT algorithms, and longitudinal follow-up to distinguish physiological myopic thinning from disease progression with greater precision.

Conclusion

Peripapillary RNFL thickness decreased significantly with increasing severity of myopia in this study. Eyes with high myopia showed the lowest global RNFL thickness and the greatest thinning in the superior, inferior, and nasal quadrants, while the temporal quadrant was relatively preserved. Global RNFL thickness correlated positively with spherical equivalent and negatively with axial length, and axial length emerged as the strongest independent predictor of RNFL thinning.

These findings indicate that refractive status and axial length must be considered routinely when interpreting OCT in myopic eyes. Careful contextual interpretation can reduce false-positive labeling of physiologic myopic thinning as glaucomatous damage and improve decision-making in everyday ophthalmic practice.

Author contributions

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