DOI: 10.69605/ijlbpr_14.4.2025.193

Original Research

Comparison of Retinal Nerve Fiber Layer (RNFL) and Ganglion Cell–Inner Plexiform Layer (GC-IPL) Thickness in Low to Moderate Myopic Patients Using SD-OCT in the Rural Population of Western Uttar Pradesh

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Received date: 20 March 2025 Acceptance date: 22April 2025 Published: 25 April, 2025

Abstract

Introduction: Myopia, or nearsightedness, is a refractive error characterized by the elongation of the eyeball, leading to light focusing in front of the retina. This structural alteration can a ffect various retinal layers, notably the retinal nerve fiber layer (RNFL) and the ganglion cell–inner plexiform layer (GC-IPL), potentially increasing the risk of ocular complications.

Methods: A prospective observational cross-sectional study was conducted from September 2022 to October 2023 at the Department of Ophthalmology, Uttar Pradesh University of Medical Sciences, Saifai. Ninety myopic patients aged 20–30 years were enrolled, comprising 45 individuals with mild myopia (−0.5 to −1.5 diopters) and 45 with moderate myopia (−1.5 to −6.0 diopters). All participants had a best-corrected visual acuity of 6/6, intraocular pressure ≤21 mmHg, and no glaucomatous optic disc changes. Exclusion criteria included macular diseases, ocular trauma, diabetes, neurological disorders, corneal diseases, and prior intraocular surgery.

Results: The mean age of participants was 25.49 ± 3.13 years. Gender distribution included 53 males (58.89%) and 37 females (41.11%), with a statistically significant higher prevalence of myopia in males ($p = 0.04$). The average RNFL thickness was 86.80 ± 14.67 µm in mild myopic patients and 84.29 ± 11.59 µm in moderate myopic patients, a difference that was not statistically significant ($p = 0.185$). However, the average GC-IPL thickness was significantly reduced in moderate myopic patients (75.41 ± 11.40 µm) compared to mild myopic patients (82.13 ± 6.81 µm) ($p < 0.001$). Gender-based analysis revealed significant differences in GC-IPL thickness, with males exhibiting higher values than females in both myopia groups. Age-wise analysis indicated a significant reduction in GC-IPL thickness in the 24–27 years age group ($p = 0.022$), while RNFL thickness did not show significant age-related changes.

Conclusion: This study demonstrates a significant reduction in GC-IPL thickness in moderate myopic patients compared to those with mild myopia, highlighting the importance of monitoring GC-IPL changes in myopic individuals. The lack of significant RNFL thickness changes suggests that GC-IPL measurements may serve as a more sensitive indicator of retinal alterations in myopia.

Keywords: Myopia, Ganglion Cell–Inner Plexiform Layer (GC-IPL), Retinal Nerve Fiber Layer (RNFL), Optical Coherence Tomography (OCT)

DOI: 10.69605/ijlbpr_14.4.2025.189

Introduction

Myopia, commonly known as nearsightedness, is a refractive error where parallel rays of light focus in front of the retina when the eye is at rest, leading to blurred distance vision. This condition arises due to an elongated axial length or increased curvature of the cornea, causing the eye's optical power to be too strong for its length.[1]

Myopia is categorized based on the degree of refractive error: mild (−0.5 to −1.5 diopters), moderate (−1.5 to −6.0 D), high (−6.0 D or more), and pathological (typically beyond −8.0 D) . High and pathological myopia are associated with structural changes in the eye, particularly in the retina, increasing the risk of complications such as retinal detachment, macular holes, choroidal neovascularization, and retinoschisis.[2]

The retina is a complex, multilayered structure composed of ten distinct layers, each with specific functions in visual processing. These layers include, from innermost to outermost: inner limiting membrane, nerve fiber layer (NFL), ganglion cell layer (GCL), inner plexiform layer (IPL), inner nuclear layer, outer plexiform layer, outer nuclear layer, external limiting membrane, photoreceptor layer (rods and cones), and the retinal pigment epithelium (RPE). Within these layers reside various cell types, including photoreceptors (rods and cones), bipolar cells, horizontal cells, amacrine cells, and ganglion cells, which collectively process visual information.[3]

In myopic eyes, especially those with high myopia, the elongation of the eyeball leads to stretching and thinning of retinal layers. Studies utilizing Optical Coherence Tomography (OCT) have demonstrated that the thicknesses of the NFL, GCL, and IPL are reduced in myopic patients compared to emmetropic eyes . Additionally, the thickness of outer retinal layers, including the RPE and photoreceptor layers, varies with axial length, highlighting the importance of monitoring these changes to assess the risk of myopia-related complications.[4]

OCT is a non-invasive imaging modality that provides high-resolution cross-sectional images of the retina, enabling detailed analysis of retinal structures. There are three primary types of OCT: Time-Domain (TD-OCT), Spectral-Domain (SD-OCT), and Swept-Source (SS-OCT). TD-OCT, the earliest form, offers lower resolution and slower scan speeds. SD-OCT improves upon this with faster acquisition rates and higher resolution, allowing for more detailed imaging of retinal layers. SS-OCT further enhances imaging capabilities by using longer wavelengths (around 1050 nm) and faster scanning speeds, enabling deeper penetration into the choroid and wider field imaging.[5]

However, interpreting OCT results in highly myopic eyes requires caution. The elongation of the eye can lead to artifacts in OCT measurements, such as falsely reduced RNFL thickness, a phenomenon sometimes referred to as "red disease." This can mimic glaucomatous damage, leading to potential misdiagnosis . Therefore, it's crucial to consider axial length and other myopia-related changes when evaluating OCT findings.[6]

The Ganglion Cell-Inner Plexiform Layer (GC-IPL) analysis, which measures the combined thickness of the GCL and IPL, is particularly useful in assessing inner retinal health. Various SD-OCT devices, including Cirrus HD-OCT, Spectralis, RTVue-100, RS-3000 SD OCT, and 3D OCT, offer GC-IPL analysis with differing acquisition settings and analysis methods. Given that approximately half of the retinal ganglion cells are concentrated within the central 5 mm of the foveal zone, monitoring GC-IPL thickness is vital for early detection of glaucomatous changes and other myopia-related complications.[7-9]

Material and methods

This observational cross-sectional study was conducted from September 2022 to October 2023 in the Department of Ophthalmology at Uttar Pradesh University of Medical Sciences, Saifai. Institutional ethical committee clearance was obtained (Letter No. 106/2022-23), and written informed consent was secured from each participant prior to enrollment.

A total of 90 myopic patients were selected, comprising 45 individuals with mild myopia and 45 with moderate myopia. Inclusion criteria encompassed patients aged between 20 and 30 years with best-corrected visual acuity (BCVA) of 6/6, intraocular pressure (IOP) within normal limits (≤21 mmHg), normal optic disc without glaucomatous changes, and a refractive error of ≥ -0.50 D (spherical equivalent). Exclusion criteria included the presence of macular diseases (e.g., age-related macular degeneration, macular edema, epiretinal membrane), history of ocular trauma, diabetes, neurological diseases (e.g., stroke, intracranial tumor, multiple sclerosis, intracranial infection), corneal diseases (e.g., keratopathy), and history of intraocular surgery.

All participants underwent comprehensive ophthalmic evaluations. Refractive error was measured using an automated keratometer (GR-3300K, Grand Seiko, Japan), IOP was assessed with a Goldmann applanation tonometer, and fundoscopy was performed using both direct and indirect ophthalmoscopes. Optical coherence tomography (OCT) examinations were conducted using the CIRRUS HD-OCT model 500 (Zeiss Cirrus 500 HD OCT system). Standardized OCT protocols were employed to measure retinal nerve fiber layer (RNFL) and ganglion cell-inner plexiform layer (GC-IPL) thicknesses. A macular cube scan (512 × 128) was utilized to assess GC-IPL thickness in the macular area, while an optic disc cube/3D scan (200 × 200) was used to evaluate RNFL thickness and optic disc area. Patients were categorized into two groups based on spherical equivalent: mild myopia and moderate myopia.

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Statistical Analysis

Collected data were coded and entered into a Microsoft Excel spreadsheet, and statistical analyses were performed using IBM SPSS Statistics version 20.0. Quantitative variables are expressed as mean ± standard deviation (SD) and were compared between groups using the unpaired t-test. Qualitative variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

Results

In this observational cross-sectional study, 90 patients were enrolled, with 45 individuals each in the mild and moderate myopia groups. The mean age of participants was 25.49 ± 3.13 years (range: 20–30 years). Gender distribution included 37 females and 53 males.

In the mild myopia group, the mean age was 26.11 ± 3.63 years, whereas in the moderate myopia group, it was 24.87 ± 2.44 years, indicating a statistically significant difference ($p = 0.030$). Gender-wise distribution revealed a higher number of females in the mild myopia group (23 females and 22 males), while the moderate myopia group had more males (31 males and 14 females), with this difference being statistically significant ($p = 0.027$).

The mean average RNFL thickness was 86.80 ± 14.67 µm in mild myopic patients and 84.29 ± 11.59 µm in moderate myopic patients, a difference that was not statistically significant ($p = 0.185$). However, the average GC-IPL thickness showed a significant reduction in moderate myopic patients (75.41 ± 11.40 µm) compared to mild myopic patients (82.13 ± 6.81 µm) ($p < 0.001$).

No significant gender-based differences were observed in RNFL thickness within both mild and moderate myopia groups. However, significant gender-based differences were noted in GC-IPL thickness. In the mild myopia group, males had an average GC-IPL thickness of 84.41 ± 6.41 µm, while females had 79.96 ± 6.59 µm. In the moderate myopia group, males had an average GC-IPL thickness of 77.92 ± 5.53 µm, and females had 69.86 ± 17.92 µm. These differences were statistically significant ($p < 0.001$ for males and $p = 0.009$ for females).

Age-wise analysis (20–30 years) did not reveal significant changes in average RNFL thickness ($p > 0.05$). However, a significant difference in GC-IPL thickness was observed in the 24–27 years age group ($p = 0.022$).

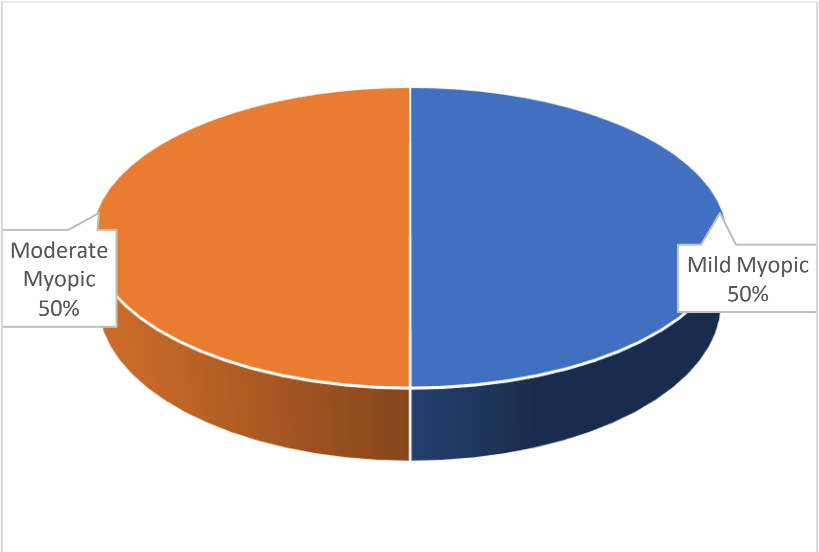


Table : 2. Age wise distribution

Age (years)	n	%
20 - 23yrs	33	36.67%
24 - 27yrs	31	34.44%
28 - 30yrs	26	28.89%
TOTAL	**90**	**100%**
mean±sd	25.49	±3.13

Table 3 Gender wise distribution of Myopic patients.

Gender	n	%
Male	53	58.89%
Female	37	41.11%
TOTAL	**90**	**100%**

Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.189

Table 4 Comparison of Age wise distribution of Mild and Moderate myopic patients.

Age (years)	Mild Myopic		Moderate Myopic	
	n	**%**	**N**	**%**
20 - 23	16	35.56%	17	37.78%
24 - 27	6	13.33%	25	55.56%
28 - 30	23	51.11%	3	6.67%
TOTAL	**45**	**100%**	**45**	**100%**
mean±sd	26.11	±3.63	24.87	±2.44
p-value	0.030			

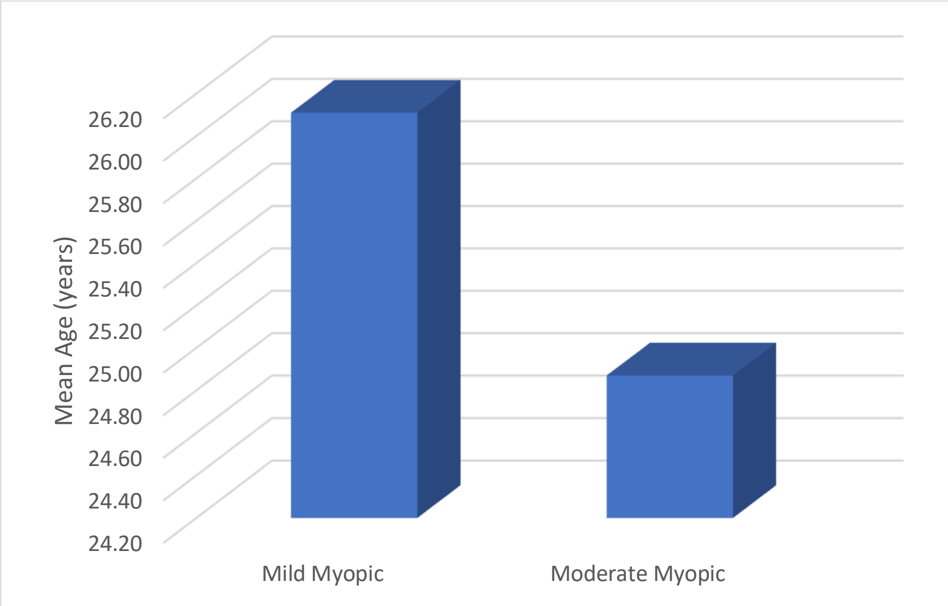
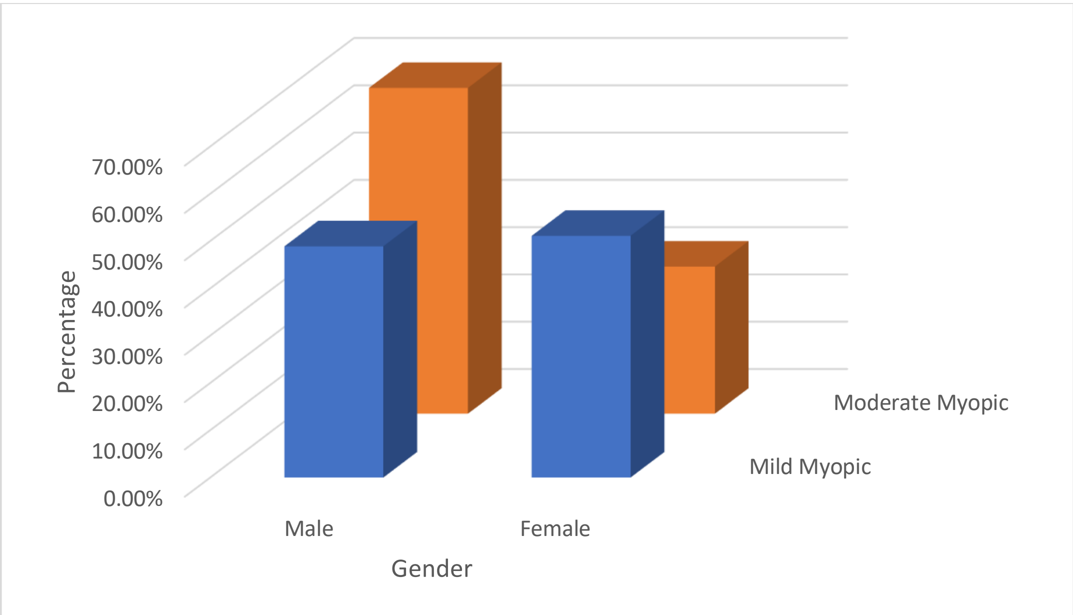


Table: 6 Gender wise distribution of Myopic patients

Gender	Mild Myopic		Moderate Myopic		Gender
	n	**%**	**n**	**%**	
Male	22	48.89%	31	68.89%	0.027
Female	23	51.11%	14	31.11%	
TOTAL	**45**	**100%**	**45**	**100%**	

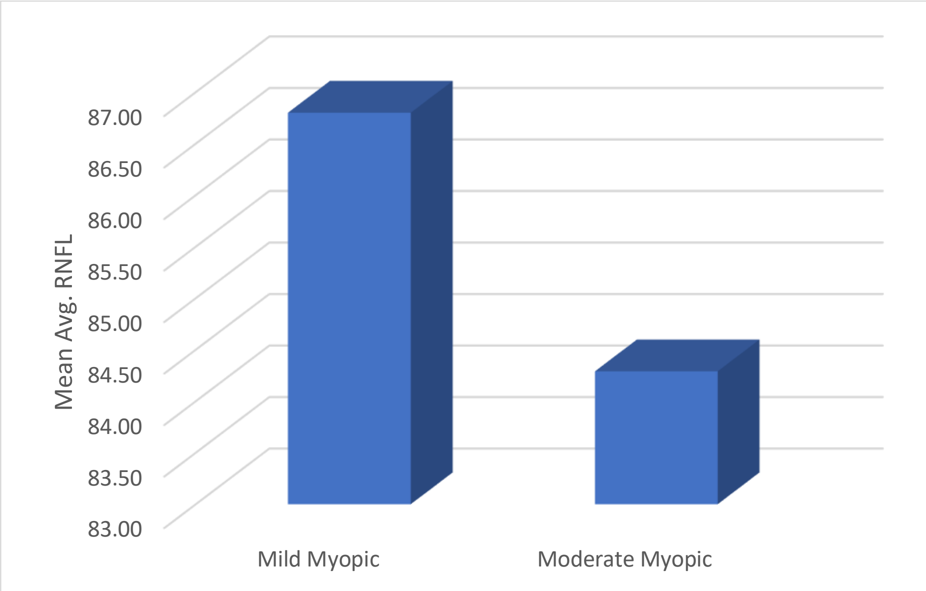


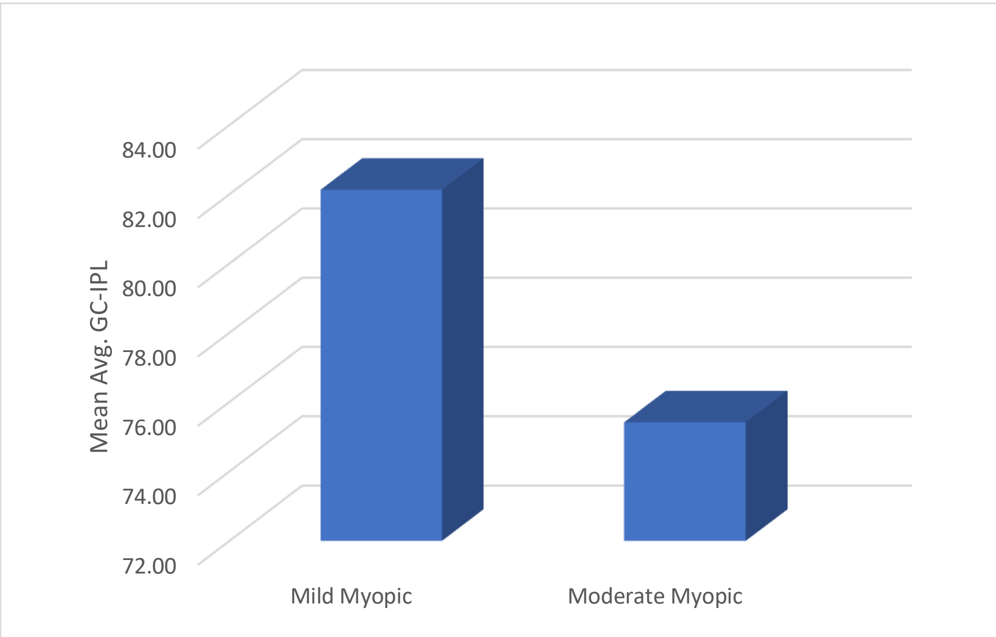
Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.189

Average RNFL and GC-IPL changes in mild and moderate myopic Eye.

	Mild Myopic		Moderate Myopic		p-value
	mean	±sd	mean	±sd	
Avg. RNFL	86.80	±14.67	84.29	±11.59	0.185
Avg. GC-IPL	82.13	±6.81	75.41	±11.4	<0.001



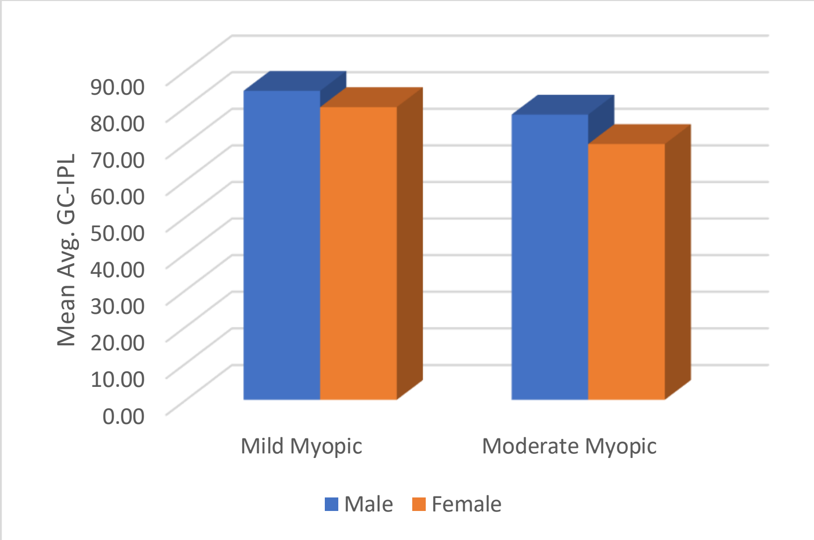


Gender wise changes in Average GC-IPL in Mild and Moderate myopic patients:

	Mild Myopic		Moderate Myopic		p-value
	mean	±sd	mean	±sd	
Male	84.41	±6.41	77.92	±5.53	<0.001
Female	79.96	±6.59	69.86	±17.92	0.009

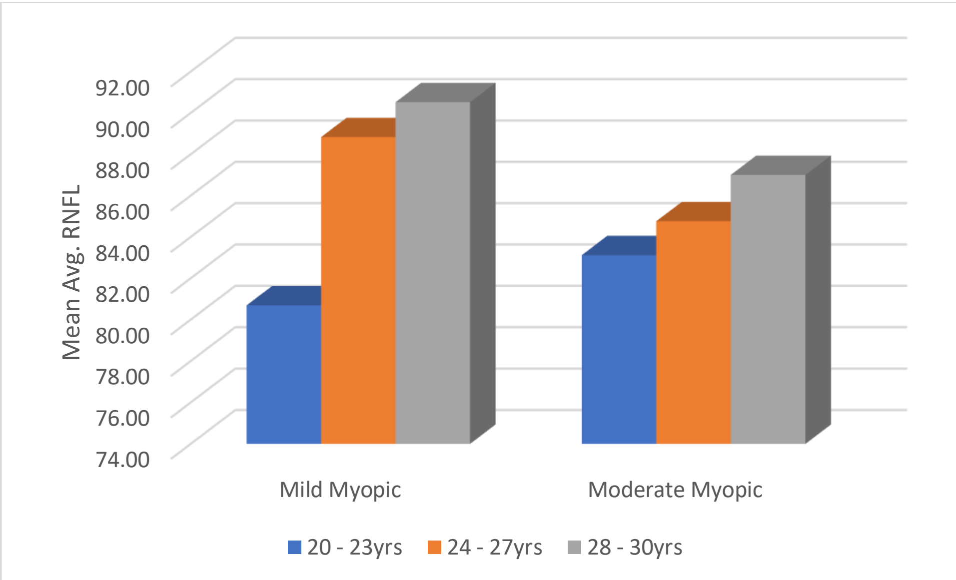
Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.189



Age wise changes in average RNFL in Mild and Moderate Myopic patients:

Avg. RNFL	Mild Myopic		Moderate Myopic		p-value
	mean	±sd	mean	±sd	
20 - 23yrs	80.69	±14.39	83.12	±10.19	0.289
24 - 27yrs	88.83	±6.55	84.76	±12.8	0.230
28 - 30yrs	90.52	±15.38	87.00	±11.53	0.354



Age wise distribution of average GC-IPL in Mild and Moderate Myopic patients:

Avg. GC-IPL	Mild Myopic		Moderate Myopic		p-value
	Mean	±sd	mean	±sd	
20 - 23yrs	79.69	±7.56	75.68	±10.79	0.114
24 - 27yrs	84.50	±4.18	73.92	±11.97	0.022
28 - 30yrs	83.22	±6.54	86.33	±0.58	0.213

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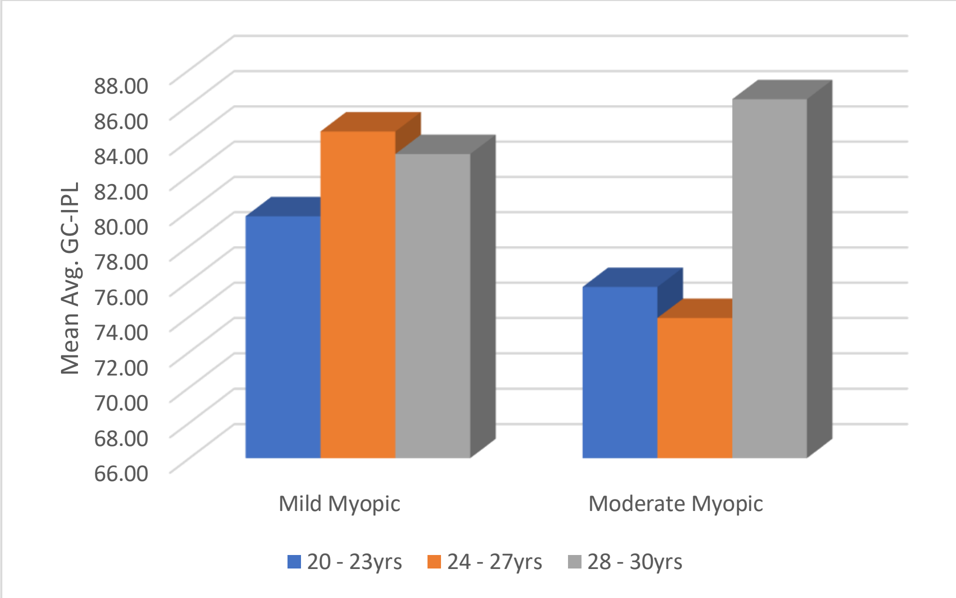

Discussion

In our prospective observational study, we evaluated the ganglion cell–inner plexiform layer (GC-IPL) and retinal nerve fiber layer (RNFL) thickness in 90 myopic patients, comprising 45 mild and 45 moderate myopic cases. Our study found a higher prevalence of male participants (53 males) compared to females (37 females), which was statistically significant ($P = 0.04$). This finding aligns with studies by Wadhwani M et al.[9] and Alsaif et al.[10], who reported a higher prevalence of myopia in males compared to females. Similarly, S.O. Wajuihian et al. (2020)[11] found a statistically significant higher prevalence of myopia in males, consistent with our results ($P < 0.05$).

Studies by Singh D et al.[12] and Cui D et al.[13] have demonstrated significant changes in RNFL thickness in high and moderate myopic patients compared to emmetropic individuals. However, in our study, no significant changes were observed in RNFL thickness between mild and moderate myopic patients.

Ganekal et al.[14] reported that RNFL thickness was significantly thinner in high myopic groups compared to low myopic groups, except in the temporal quadrant ($P < 0.05$). They also observed GC-IPL thinning in moderate and high myopia across all sectors. In contrast, our study did not find significant changes in RNFL thickness but did observe significant GC-IPL thinning in both mild and moderate myopic groups, particularly in patients aged 24–27 years. This is consistent with findings by Wei Wei Wang et al.[15] and Min Woo Lee et al.[16], who reported significant GCC thinning in myopic patients.

Kocamis et al.[17] investigated the relationship between central corneal thickness (CCT) and GC-IPL thickness in myopic patients. They found that GC-IPL thickness was decreased in patients with CCT below 555 micrometers compared to those with CCT above 555 micrometers ($P = 0.002$ and $P = 0.007$, respectively). While our study observed a decrease in GC-IPL thickness with increasing myopia, we did not include CCT as a parameter.

Conclusion

Our study demonstrates a significant reduction in average GC-IPL thickness in moderate myopic patients compared to mild myopic patients, indicating that GC-IPL thinning correlates with the degree of myopia. However, no significant changes were observed in average RNFL thickness between the two groups. These findings underscore the importance of careful interpretation of OCT maps in myopic eyes, particularly concerning macular changes reflected in GC-IPL measurements. Further studies incorporating additional parameters such as central corneal thickness and axial length may provide a more comprehensive understanding of retinal changes in myopia.

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