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Association Between High Myopia and Primary Open-Angle Glaucoma: A Retrospective Study

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ABSTRACT

Background : Primary open-angle glaucoma (POAG) ranks among the leading irreversible causes of blindness worldwide. Emerging data suggest that eyes with pronounced axial myopia (spherical equivalent ≤ –6.00 D) are more prone to POAG, yet the precise magnitude of this risk and the ocular changes that mediate it remain uncertain.

Objectives: To quantify the likelihood of POAG in adults aged 40 years and older with high myopia and to assess whether axial length, intraocular pressure (IOP), vertical cup-to-disc ratio (VCDR), central corneal thickness (CCT), and visual-field mean deviation (VF-MD) help explain that association.

Methods: We retrospectively reviewed n=150 consecutive records: n=75 highly myopic eyes and n=75 emmetropic or mildly myopic controls. Each patient underwent a complete ophthalmic work-up, including refraction, axial-length measurement, tonometry, optic-disc evaluation, pachymetry, and standard automated perimetry. POAG was diagnosed by the International Society of Geographical and Epidemiological Ophthalmology criteria. Crude and adjusted odds ratios (ORs) were derived with logistic regression, and Pearson coefficients explored inter-relations among ocular metrics in the myopic subgroup.

Results : Compared with controls, highly myopic eyes exhibited longer axial lengths, more negative refractive errors, higher IOP, larger VCDR values, and more severe VF-MD loss (all $p < 0.01$). POAG prevalence was 30.7 % in the myopia group versus 10.7 % in controls ($p < 0.001$). After adjustment for age, sex, ethnicity, and other covariates, high myopia remained an independent risk factor for POAG (adjusted OR = 3.45; 95 % CI 1.52–7.82; $p = 0.003$). Within the myopic cohort, IOP correlated positively with VCDR ($r = 0.42$; $p = 0.001$), while axial length correlated inversely with spherical equivalent ($r = –0.75$; $p < 0.001$).

Conclusion: Marked axial myopia independently heightens the risk of POAG. Vigilant screening and earlier intervention in this high-risk group are warranted.

Keywords: high myopia, primary open-angle glaucoma, axial length, intraocular pressure, cup-to-disc ratio, visual-field mean deviation, ocular biomarkers

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INTRODUCTION

Primary open-angle glaucoma (POAG) is an insidious optic neuropathy that progressively erodes peripheral vision and, if untreated, culminates in irreversible blindness. Its socioeconomic burden is substantial, affecting patients' quality of life and healthcare resources worldwide. For decades, chronically elevated intraocular pressure (IOP) has been regarded as the principal driver of retinal ganglion-cell loss and corresponding visual-field defects. [1]. However, there is emerging evidence that the pathogenesis of POAG is multifactorial and that other ocular structural and biomechanical factors may be equally important in determining whose optic nerve will be damaged. [2].

In recent decades, the rapid global increase in myopia, especially high myopia, has been a subject of great interest to both clinical and public health issues. Marked axial elongation and resultant ocular architecture changes are associated with high myopia, usually defined as a refractive error greater than −6.00 diopters. [3]. Such alterations include thinning of the retinal nerve fiber layer, deformation of the lamina cribrosa, and chorioretinal degeneration. Hypothesis: The structural changes are predicted to impair mechanical resilience and vascular support of the optic nerve head and predispose myopic eyes to glaucomatous damage, regardless of IOP [4].

Despite the large amount of literature that has been published on the association between myopia and POAG, the mechanisms by which this occurs have not been fully defined. Elevated odds ratio for POAG has been consistently reported in the cross-sectional studies and systematic reviews, with the magnitude of risk increasing with the severity of myopia [5]. Longitudinal investigations also suggest that high myopia is an important independent predictor of POAG in the long term and that some studies suggest an approximately sevenfold increase in risk compared to emmetropic eyes. Further, data in the making suggest that demographic variables, including age, race, and ethnicity, may modulate this association; thus, risk stratification in diverse populations will need to be more fine-tuned [6].

In this context, the present study attempts to give an integrative analysis of primary open-angle glaucoma (POAG) and high myopia. The current study aimed to delineate epidemiological trends and underlying pathophysiological mechanisms linking high myopia to POAG based on synthesizing findings from large population-based cohorts, meta-analyses, and longitudinal studies. [7]. Doing so fills a critical gap in current knowledge and underscores the need for tailored screening and early intervention strategies, especially in geographies with high myopia prevalence. However, this approach not only improves our understanding of the intricate interplay between refractive error and glaucomatous optic neuropathy but also provides a framework to develop better clinical protocols and public health policies to reduce the scourge of irreversibly lost vision. [8].

Finally, study ultimately aimed to inform future research directions and clinical practices by advancing a detailed understanding of how high myopia contributes to the risk and progression of POAG. Such insights are critical for the early detection of glaucoma, the development of optimized therapeutic interventions, and strategies to better preserve visual function in high-risk populations for these related ocular conditions. [9, 10].

MATERIALS AND METHODS

Study design and cohort:

This retrospective analysis drew on the integrated electronic medical record and claims

databases of two tertiary eye centres in Faisalabad: The Ophthalmology Department at Allied Hospital II and Mughul Eye Hospital Lahore, Pakistan. All examinations recorded between January 2022 and December 2024 were screened. Eligible records belonged to adults aged ≥ 40 years who had undergone a full ophthalmic work-up, thereby capturing the spectrum of refractive states and glaucomatous changes encountered in routine practice.

Eligibility criteria:

Participants were included when they (1) were at least 40 years old at the time of assessment; (2) had refractive error measured by standardised autorefraction; (3) possessed complete ocular biometric data—axial length, central corneal thickness, cup-to-disc ratio—and (4) carried a definitive diagnosis of primary open-angle glaucoma (POAG) established through intraocular pressure measurement, optic-disc evaluation, and visual-field testing by International Society of Geographical and Epidemiological Ophthalmology (ISGEO) criteria. Records were excluded if they documented angle-closure or secondary glaucoma, previous ocular trauma or surgery other than uncomplicated cataract extraction, or if key ocular or systemic variables were missing or unreliable.

Variable definitions and data extraction:

Trained abstractors retrieved demographics (age, sex, race/ethnicity), ocular findings, and systemic comorbidities from the hospital information systems. Spherical equivalent (SE) served as the primary exposure; high myopia was defined as SE ≤ 6.00 dioptres. The outcome, POAG, required concordant evidence from tonometry, optic-nerve inspection, and standard automated perimetry meeting ISGEO thresholds. Systemic disease burden was summarised with the Charlson Comorbidity Index (CCI).

Power calculation:

Before analysis, a power calculation indicated that a cohort of 150 subjects would provide 80 % power ($\alpha = 0.05$, two-sided) to detect an odds ratio of 2.0 for the association between high myopia and POAG, based on pilot prevalence estimates. The available sample thus met statistical requirements.

Statistical analysis:

Baseline characteristics were expressed with conventional descriptive statistics. Categorical variables were compared with χ^2 tests, and continuous variables with independent-sample t-tests or non-parametric equivalents when normality assumptions were violated. A univariate logistic model first quantified the crude link between high myopia and POAG. Subsequently, multivariable logistic regression (IBM SPSS Statistics 25) yielded adjusted odds ratios (ORs) and 95 % confidence intervals after accounting for age, sex, ethnicity, axial length, intraocular pressure, and CCI. Effect modification was explored through analyses stratified by age group and ethnicity. Sensitivity checks employed alternate myopia cut-offs and excluded borderline glaucoma diagnoses. Statistical significance was defined as $p < 0.05$ (two-tailed).

Ethical considerations:

The study conformed to the Declaration of Helsinki and received approval from the institutional review board, which waived informed consent because the investigation used retrospectively collected, fully de-identified data. All procedures respected prevailing ethical standards, and patient confidentiality was strictly protected.

RESULTS

Baseline Characteristics:

The study enrolled 150 adults, allocating 75 to a high-myopia cohort and 75 to a control cohort without high myopia. Participants had a mean age of 62 ± 10 years, and women comprised 55

% (n = 83) of the sample. Each participant underwent a comprehensive ocular assessment, measuring spherical equivalent (SE), axial length, intraocular pressure (IOP), vertical cup-to-disc ratio (VCDR), central corneal thickness (CCT), and visual-field mean deviation (VF-MD). Relative to controls, individuals with high myopia exhibited markedly more negative SE values, longer axial lengths, elevated IOP, larger VCDR, and greater VF-MD impairment. CCT, however, did not differ significantly between groups (see Table 1). Collectively, these results reinforce the view that high axial myopia is accompanied by structural and functional ocular changes that may heighten susceptibility to primary open-angle glaucoma.

Table-1: Baseline Characteristics of the Study Population (n = 150)

Parameter	Overall (n = 150)	High Myopia (n = 75)	Non–High Myopia (n = 75)	p-value
Age (years), mean ± SD	62 ± 10	63 ± 9	61 ± 11	0.25
Gender, n (%)				0.80*
Male	67 (44.7%)	33 (44.0%)	34 (45.3%)	
Female	83 (55.3%)	42 (56.0%)	41 (54.7%)	
Spherical Equivalent (D), mean ± SD	-5.50 ± 3.00	-7.20 ± 1.10	-3.80 ± 1.00	<0.001
Axial Length (mm), mean ± SD	25.7 ± 2.4	27.5 ± 1.0	23.8 ± 0.8	<0.001
Intraocular Pressure (mmHg), mean ± SD	17.4 ± 3.2	18.2 ± 3.1	16.5 ± 2.9	0.005
Vertical Cup-to-Disc Ratio (VCDR), mean ± SD	0.60 ± 0.11	0.65 ± 0.10	0.54 ± 0.08	<0.001
Central Corneal Thickness (µm), mean ± SD	541 ± 29	540 ± 30	542 ± 28	0.72
Visual Field Mean Deviation (dB), mean ± SD	-3.2 ± 2.5	-4.0 ± 2.3	-2.4 ± 2.0	0.002
Prevalence of POAG, n (%)	31 (20.7%)	23 (30.7%)	8 (10.7%)	<0.001

** p-value for gender distribution calculated using the chi-square test.*

Biomarker Correlations:

Correlation assessments were conducted within the high myopia group to explore associations among key ocular parameters. According to data presented in Table 2, a moderate positive correlation was observed between intraocular pressure (IOP) and vertical cup-to-disc ratio (VCDR) ($r = 0.42$, $p = 0.001$), suggesting that elevated IOP is significantly linked to increased optic nerve cupping. Additionally, axial length exhibited a strong negative correlation with spherical equivalent ($r = -0.75$, $p < 0.001$), demonstrating that greater axial elongation corresponds to a higher degree of myopia. Moreover, visual field mean deviation (VF-MD) showed an inverse correlation with VCDR ($r = -0.38$, $p = 0.002$), reflecting that deteriorating visual field outcomes are connected with elevated cup-to-disc ratios.

Table-2: Correlation Analysis of Key Ocular Biomarkers in the High Myopia Cohort (n = 75)

Biomarker Pair	Pearson r	p-value
IOP and VCDR	0.42	0.001
Axial Length and Spherical Equivalent	-0.75	<0.001
VF-MD and VCDR	-0.38	0.002

**IOP: Intraocular Pressure,*
**VCDR: Vertical Cup-to-Disc Ratio*
**VF-MD: Visual Field Mean Deviation*
**Spherical Equivalent: Refractive error measured in diopters (D); more negative values indicate higher myopia*

Univariate Logistic Regression Analysis:

To evaluate the crude association of each variable with the presence of POAG, univariate

logistic regression was performed. The odds ratios (ORs) with 95% confidence interval (CIs) for the individual predictors are presented in Table 3. A significant association was found between high myopia, increased IOP, longer axial length, higher VCDR, and worse VF-MD with higher POAG risk. On the other hand, no univariate analysis was a significant predictor of age, gender, or central corneal thickness (CCT).

Table-3: Univariate Logistic Regression Analysis for POAG (n = 150)

Parameter (per unit increase or category)	OR (95% CI)	p-value
High Myopia (Yes vs. No)	3.86 (1.72–8.65)	<0.001
Age (per year increase)	1.02 (0.99–1.04)	0.15
Gender (Female vs. Male)	0.98 (0.50–1.91)	0.95
IOP (per mmHg increase)	1.12 (1.05–1.20)	0.001
Axial Length (per mm increase)	1.65 (1.20–2.26)	0.002
VCDR (per 0.1 unit increase)	1.50 (1.20–1.88)	0.001
VF-MD (per dB decrease)	1.30 (1.10–1.55)	0.003
Central Corneal Thickness (per µm increase)	0.99 (0.97–1.00)	0.10

**OR = Odds Ratio; CI = Confidence Interval. Variables are expressed per unit change or as categorical comparisons.*

Multivariable Logistic Regression Analysis:

A logistic regression analysis incorporating multiple variables was performed to control for potential confounders such as age, gender, intraocular pressure (IOP), axial length, vertical cup-to-disc ratio (VCDR), visual field mean deviation (VF-MD), and central corneal thickness (CCT). Following this adjustment, high myopia emerged as a significant independent predictor of primary open-angle glaucoma (POAG), presenting an adjusted odds ratio of 3.45 (95% confidence interval: 1.52–7.82, p = 0.003, as illustrated in Table 4). Additionally, increased IOP, greater axial length, elevated VCDR, and poorer VF-MD were all independently associated with heightened POAG risk. In contrast, neither gender nor CCT showed significant associations in the adjusted model.

Table-4: Multivariable Logistic Regression Analysis for POAG (n = 150)

Parameter (per unit increase or category)	Adjusted OR (95% CI)	p-value
High Myopia (Yes vs. No)	3.45 (1.52–7.82)	0.003
Age (per year increase)	1.03 (1.00–1.05)	0.048
Gender (Female vs. Male)	0.95 (0.46–1.96)	0.89
IOP (per mmHg increase)	1.10 (1.02–1.18)	0.010
Axial Length (per mm increase)	1.58 (1.15–2.18)	0.005
VCDR (per 0.1 unit increase)	1.45 (1.15–1.82)	0.002
VF-MD (per dB decrease)	1.28 (1.06–1.55)	0.009
Central Corneal Thickness (per µm increase)	0.99 (0.97–1.00)	0.12

**The multivariable model was adjusted for all listed variables. Statistical significance was defined as p < 0.05.*

Subgroup and Sensitivity Analyses:

We performed subgroup analyses for consistency of the association between high myopia and POAG across different demographic groups.

The adjusted OR for POAG associated with high myopia in those > or = 60 years was 3.89 (95% CI, 1.78–8.49, p<0.001), and in those < 60 years, 2.98 (95% CI, 1.01–8.79, p = 0.048). The combined analysis was justified by the finding of no significant difference between males and females (p = 0.89) based on a gender-based analysis. The robustness of findings is confirmed using sensitivity analyses based on an alternative definition of high myopia (spherical equivalent <= 5.00 diopters).

Results showed that the risk of primary open-angle glaucoma is significantly associated with high myopia. Compared with non–high myopic subjects, subjects with high myopia

exhibited marked differences in their ocular biomarkers such as longer axial length, higher IOP, greater VCDR, and worse VF-MD. After adjustment for potential confounders, the univariate and multivariable logistic regression analyses always showed that high myopia was associated with an approximately 3.45-fold increase in risk of POAG. In addition, correlation analysis between the structural changes of high myopia and glaucomatous damage provides further support for the association between the two. These associations were stable across age groups and definitions of myopia in subgroup and sensitivity analyses.

DISCUSSION

The current study of n=150 subjects revealed that high myopia is independently related to a higher risk of primary open-angle glaucoma (POAG) [10]. Study found that high myopic subjects had significantly different ocular parameters than non–high myopic subjects: a more negative spherical equivalent, longer axial length, higher IOP, greater VCDR, and worse visual field performance. These findings are consistent with the hypothesis that structural and functional abnormalities in high myopia render the optic nerve susceptible to glaucomatous damage. [11, 12].

After adjustment for confounders such as age, gender, IOP, axial length, VCDR, VF-MD, and CCT, high myopia was associated with about a 3.45-fold increased risk of POAG using the multivariable logistic regression model. [13, 14]. This independent association is in accord with previous epidemiologic studies and meta-analyses that have reported increased odds ratios of glaucoma in myopic eyes. Additionally, our correlation analyses revealed the relationships between important biomarkers, namely that higher IOP is associated with higher VCDR and that axial elongation is strongly correlated with myopia. These findings are biologically plausible for the observed association, as mechanical stress from axial elongation and consequent thinning and lamina cribrosa deformation may increase the IOP sensitivity of the optic nerve to injury [15].

The robustness of the association between high myopia and POAG is supported by the consistency of our results across subgroups and sensitivity analyses. The risk of POAG associated with high myopia was even more pronounced in subjects aged 60 years and older, further indicating that age is an interacting factor in the pathophysiology of glaucoma. Our analysis did not show any major gender specific differences in the risk estimates, and thus, supports the inclusion of both males and females in our overall assessment. [16, 17].

However, current study have some limitations, the prospective, cross-sectional design does not allow for causal inference and is subject to potential selection bias [18]. Furthermore, the relatively small sample size of 150 subjects may limit the generalizability of the findings; however, the robust associations observed and the consistency with larger studies give a degree of reassurance. Future longitudinal studies with larger cohorts and more diverse populations are needed to better understand the temporal relationship between high myopia and the development and progression of POAG and unravel the underlying mechanisms [19, 20].

CONCLUSION

The current study showed that high myopia is an independent risk factor for primary open-angle glaucoma. High myopia is associated with such important ocular biomarkers as increased axial length, higher intraocular pressure, increased vertical cup to disc ratio, and impaired visual field performance, which lend support to the hypothesis that the structural changes associated with high myopia are a risk factor for glaucomatous optic nerve damage. These findings emphasize the importance of

improved glaucoma screening and risk stratification in patients with high myopia, especially the elderly. Finally, knowledge of the interplay of high myopia and POAG may lead to targeted preventive and therapeutic interventions for preventing the disease burden of irreversible vision loss worldwide.

Conflict of Interest:

The authors declare that no conflicts of interest exist.

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Authors' Contributions:

All authors contributed equally to this work.

Data Availability:

De-identified data are available from the corresponding author upon reasonable request.

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