Article

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Effects of Visual Function Impairment on Depression in Patients With Glaucoma

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Abstract

Background: This study aimed to investigate the relationship between the degree of visual impairment and depressive symptoms in patients with glaucoma, and examine whether disease duration moderates this relationship.

Methods: We enrolled 208 patients with glaucoma who received standardised treatment at The Affiliated Huaian No.1 People's Hospital of Nanjing Medical University from February 2022 to February 2025. Clinical data and visual function indicators were collected. Patient-reported visual function was assessed using the 25-item National Eye Institute Visual Function Questionnaire (NEI-VFQ-25), and depressive symptoms were assessed using the Self-Rating Depression Scale (SDS). Best-corrected visual acuity (BCVA) and central macular thickness (CMT) served as indicators of visual impairment. Statistical analyses, including descriptive statistics, correlation analysis, linear regression analysis and subgroup analysis with Fisher's r-to-z transformation, were performed using SPSS 26.0 software.

Results: The mean BCVA was 0.31 $\pm$ 0.12, and the mean CMT was 263.22 $\pm$ 29.01 μm. Depressive symptoms (SDS score $\geq$ 53) were present in 45.67% of patients. BCVA was negatively correlated with the SDS total score (r = -0.23, $p < 0.001$), whereas CMT was positively correlated with the SDS total score (r = 0.27, $p < 0.001$). The NEI-VFQ-25 total score was also negatively correlated with SDS scores (r = -0.22, $p = 0.002$). Linear regression showed that for every 0.1 increase in BCVA, SDS scores decreased by 1.53 points ($p < 0.001$); for every 10 μm increase in CMT, SDS scores increased by 0.74 points ($p < 0.001$). Subgroup analysis and formal interaction testing revealed that disease duration significantly moderated the associations of visual function with depression: the correlations between BCVA (r = -0.44 vs. -0.07, $p < 0.010$) and NEI-VFQ-25 (r = -0.49 vs. -0.03, $p < 0.001$) with SDS scores were significantly stronger in patients with longer disease duration ($\geq$5 years), with significant interaction terms (both $p < 0.010$).

Conclusions: The degree of visual impairment in patients with glaucoma was significantly associated with depressive symptoms. Objective measures (BCVA and CMT) and NEI-VFQ-25 were independently related to depression risk, and these relationships were more pronounced in patients with longer disease duration. Clinical practice should emphasize visual function protection and psychological treatments to improve patients' mental health.

Keywords

glaucoma; depression; visual function; disease duration

Introduction

Glaucoma is one of the leading causes of irreversible blindness worldwide and poses a serious threat to human visual health [1]. Epidemiological estimates indicate that glaucoma affects more than 7 million people globally, and disability-adjusted life years due to glaucoma are expected to increase gradually [2]. In China, the prevalence of glaucoma is considerable, and the number of patients is rising annually as the population ages [3]. Glaucoma not only severely impairs visual function but may also trigger a range of psychological problems such as anxiety and depression [4,5]. However, research on the relationship between the degree of visual impairment and emotional state in patients with glaucoma remains limited. Therefore, exploring the relationship between visual impairment and de-

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pressive mood in patients with glaucoma is of great practical significance for optimizing clinical management strategies and improving patient prognosis.

Visual impairment is the central feature of glaucoma, typically manifesting as visual field defects and reduced contrast sensitivity, which in severe cases can progress to tubular fields or even total blindness [6]. For patients with glaucoma, declining visual function limits daily activities such as reading, driving and housework, thereby reducing self-care ability and independence, which in turn affects their quality of life [7,8]. For example, patients may fail to detect nearby obstacles in time while walking, increasing the risk of collisions and falls. Several studies have shown that patients with glaucoma have a significantly higher risk of falls and fractures than the general population, especially among older patients [9,10]. Moreover, visual impairment may lead to difficulties in social activities and reduced interpersonal communication, further aggravating psychological burden.

Depressed mood is a common psychological problems in patients with glaucoma [11]. Depression is more prevalent among individuals with chronic diseases, and because glaucoma is a long-term progressive disease, patients often experience negative emotions due to vision loss, increased treatment burden and fear of blindness [12]. Several studies have shown that the prevalence of depressive symptoms is markedly higher in patients with glaucoma than in the general population, and the severity of depression may correlate with the degree of visual impairment [13,14]. As vision loss from glaucoma is gradual and irreversible, patients face tremendous psychological stress while managing the disease over a long period of time. They must cope not only with daily inconveniences caused by vision problems but also with worries about further disease progression and possible blindness [15]. This long-term psychological burden is very likely to trigger depression. Depression not only exacerbates psychological pain and reduces life satisfaction but also impair treatment adherence, thereby affecting the disease outcomes and prognosis [16]. Research on the relationship between visual impairment severity and depressive mood in patients with glaucoma remains relatively scarce. Moreover, few studies have simultaneously incorporated objective visual function measures and patient-reported visual function in the same cohort or systematically examined whether disease duration moderates these associations. Accordingly, this retrospective study extracted clinical data and archived questionnaire results from eligible patients to systematically explore the relationship between the degree of visual function impairment, patients' subjective perception of visual dysfunction and depression in patients with glaucoma, thereby providing more valuable references for clinical treatment and management.

Materials and Methods

Study Participants

This was a retrospective observational study. We selected 208 patients with glaucoma who received standardised treatment at The Affiliated Huaian No.1 People's Hospital of Nanjing Medical University between February 2022 and February 2025. A priori sample size calculation was performed using PASS 15.0 (NCSS, LLC, Kaysville, UT, USA) software based on the primary endpoint (correlation between visual function and depressive symptoms). Assuming a medium effect size (r = 0.20), α = 0.05 (two-sided), and power = 0.80, the minimum required sample size was 194. The enrolled 208 patients exceeded this threshold, providing sufficient statistical power for the analyses. Patient sources included outpatients and inpatients, covering different glaucoma types to ensure broad applicability of the results. All patients met the following inclusion criteria: (1) age $\geq$18 years; (2) meeting the diagnostic criteria for glaucoma confirmed by intraocular pressure measurement, fundus microscopy, perimetry and anterior chamber angle microscopy [17]; and (3) complete medical records including detailed visual function test results. The exclusion criteria were as follows: (1) comorbidities with other serious eye diseases (e.g. retinal detachment, diabetic retinopathy) that may affect visual function assessment; (2) past history of mental illness or use of antidepressant or antianxiety medication; (3) presence of severe systemic disease (e.g., malignancy) affecting psychological status assessment; (4) cognitive dysfunction or verbal communication difficulties preventing cooperation with questionnaires completion; or (5) pregnancy or breastfeeding. This study complies with all provisions of the Declaration of Helsinki. This study was approved by the Ethics Committee of The Affiliated Huaian No.1 People's Hospital of Nanjing Medical University (Approval date: 18 December 2025), and all patients provided informed consent.

Data Collection

All data were retrospectively extracted from the hospital's electronic medical record system and completed questionnaire archives, including detailed clinical information and scale assessment results. Extracted clinical data included age, sex, education level, place of residence, marital status, glaucoma type, disease duration, history of surgical treatment and medication records.

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Visual function indicators (best-corrected visual acuity (BCVA) and central macular thickness (CMT)) were retrieved from existing examination data. BCVA was measured using a standard logarithmic visual acuity scale during routine clinical visits and expressed as decimal visual acuity ranging from 0 to 1 (1.0 indicates normal vision; lower BCVA indicates worse visual function); BCVA was recorded for the better-seeing eye, and the better eye was selected for all subsequent analyses to ensure consistency and representativeness of visual function assessment.

CMT was measured by optical coherence tomography during clinical diagnosis and follow-up to assess the thickness of the macular area. Changes in CMT can reflect the pathological state of the macular area. In glaucoma, macular structural changes, including CMT alterations, are increasingly recognized as valid indicators of disease-related damage, particularly given that a proportion of retinal ganglion cells reside in the macular region. In addition, patients' depression levels were based on standard scales completed during clinical visits, which were archived in the medical record system and retrieved for this study.

Questionnaire and Scales

Patient-reported subjective visual function was assessed using the 25-item National Eye Institute Visual Function Questionnaire (NEI-VFQ-25), a standardised questionnaire widely used to evaluate patient-reported visual function in individuals with ocular disorders [18]. The NEI-VFQ-25 consists of 25 items forming 12 subscales, including general health, general vision, ocular pain, near activities, distance activities, vision-specific social functioning, vision-specific mental health, vision-specific role difficulties, vision-specific dependency, driving, colour vision and peripheral vision, plus a single-item general vision rating. For the purpose of this study, in addition to the composite score, we focused on five subscales most directly relevant to the functional impact of glaucoma: general vision, near vision, distance vision, peripheral vision and role difficulties. The composite score and subscale scores range from 0 to 100, with higher scores indicating better self-reported visual function. Based on established clinical criteria: a total score of 60–79 indicates moderate visual dysfunction, consistent with previous ophthalmic studies [8,18]. The Chinese version of the NEI-VFQ-25 has been validated in patients with various ocular disorders, demonstrating good internal consistency (Cronbach's α ranging from 0.71 to 0.94 across subscales) and established construct validity through significant correlations with clinical measures of visual function [19].

Depressed mood was assessed using the Self-Rating Depression Scale (SDS), a self-report psychometric tool for assessing depressive symptoms [20]. The scale consists of 20 items, each scored on a 4-point scale. The total score is calculated as the sum of item scores multiplied by 1.25 (rounded to the nearest whole number). A cut-off score of 53 was adopted as the threshold for depressive symptoms, which is the widely accepted standard based on Chinese normative data and has been validated in numerous clinical studies involving Chinese patient populations, with higher scores indicating more severe depressive mood [21,22]. Depressive symptom severity was graded according to the SDS standard classification: 53–62 = mild depression, 63–72 = moderate depression, and $\geq$73 = severe depression.

Patient completed the questionnaires during routine clinical visits under the guidance of uniformly trained medical staff. For those with severe visual impairment or reading difficulties, face-to-face assistance was provided at that time to ensure data accuracy. All completed questionnaires were archived in the hospital's medical record system and retrieved for data collation and analysis.

Statistical Analysis

SPSS 26.0 (IBM Corp., Armonk, NY, USA) software was used for data analysis. The Shapiro–Wilk test was used to evaluate the normality of continuous data. Normally distributed data are expressed as mean $\pm$ standard deviation (SD). Independent samples t-test or one-way analysis of variance (ANOVA) was used to compare groups for continuous variables that followed the normal distribution. Chi-square tests were used to analyse the counts. Pearson correlation coefficients were used to analyse the relationship between visual function indicators (e.g., BCVA, CMT, and NEI-VFQ-25 total and subscale scores) and depressive symptoms (SDS scores). Linear regression analyses were performed to examine the effects of visual function on depressive symptoms. Regression coefficients (β) and 95% confidence intervals (CI) were calculated. Multicollinearity among independent variables was assessed using the variance inflation factor (VIF), with a VIF $<$5 indicating no obvious multicollinearity. To examine whether disease duration moderates the relationship between visual function and depressive symptoms, subgroup analyses were conducted based on disease duration ($<$5 years vs. $\geq$5 years). Fisher's r-to-z transformation was used to compare the correlation coefficients between the two subgroups. To formally test the moderating effect, multiple linear regression analyses were additionally performed with an interaction term (disease duration group $\times$ visual function indicator), after ad-

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justing for age, sex and glaucoma type. Disease duration was coded as 0 (<5 years) and 1 (≥5 years). All statistical tests were performed using two-sided tests, and $p < 0.05$ was considered statistically significant.

Results

Participant Characteristics and Depression Prevalence

A total of 208 patients with glaucoma were included. Among these, 56.25% were aged ≥50 years, 53.85% were female, and 77.40% had primary angle-closure glaucoma. The majority (63.46%) had a disease duration <5 years (Table 1). Depressive symptoms (SDS score ≥ 53) were present in 45.67% (95/208) of patients. The severity distribution was as follows: mild in 35.58% (74/208), moderate in 9.62% (20/208), and severe in 0.48% (1/208; Fig. 1).

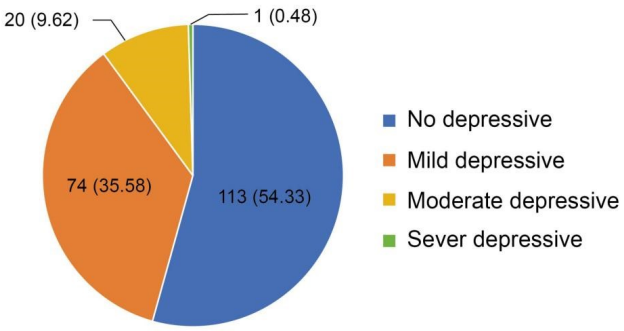


Fig. 1. Distribution of depressive symptom severity among glaucoma patients (n = 208). Mild depressive: SDS score 53–62. Moderate depressive: SDS score 63–72. Severe depressive: SDS score ≥ 73. SDS, Self-Rating Depression Scale.

Objective Visual Function Across Subgroups

Table 1 presents BCVA and CMT across patient subgroups. The mean BCVA was 0.31±0.12, and the mean CMT was 263.22 ± 29.01 μm. BCVA differed significantly by education level and glaucoma type. One-way ANOVA showed significant differences in BCVA across education level ($p = 0.019$); the lowest BCVA was observed in patients with primary education or below (0.28 ± 0.11), and the highest in those with college education or above (0.34 ± 0.14). Patients with primary angle-closure glaucoma had worse BCVA than those with other types (0.30 ± 0.12 vs. 0.35 ± 0.12, $p = 0.017$). No significant difference in BCVA was observed between patients with disease duration <5 years and those with ≥5 years (0.30 ± 0.11 vs. 0.33 ± 0.13, $p = 0.056$). CMT showed significant differences across multiple subgroups. Higher CMT was associated with age ≥50 years (268.21 ± 28.76 vs. 256.80 ± 28.22, $p = 0.005$), lower education level ($p = 0.004$), primary angle-closure glaucoma (265.82 ± 29.51 vs. 254.30 ± 25.59, $p = 0.016$), and use of ≥2 glaucoma medications (268.18 ± 28.04 vs. 257.96 ± 29.24, $p = 0.011$).

Patient-Reported Visual Function Across Subgroups

The mean NEI-VFQ-25 score was 65.43 ± 9.34, indicating moderate subjective visual dysfunction. No significant differences in NEI-VFQ-25 scores were observed across any demographic or clinical subgroup (all $p > 0.05$; Table 1).

Correlations Between Visual Function and Depression

Table 2 shows correlations between visual function indicators and SDS scores. All examined measures were significantly associated with depression severity. For objective function, BCVA correlated negatively with SDS scores ($r = -0.23$, $p < 0.001$), whereas CMT correlated positively ($r = 0.27$, $p < 0.001$). For patient-reported function, the total NEI-VFQ-25 score correlated negatively with SDS scores ($r = -0.22$, $p = 0.002$). All five subscales showed significant negative correlations, with the strongest effects for general vision ($r = -0.26$, $p < 0.001$) and near vision ($r = -0.26$, $p < 0.001$), followed by distance vision ($r = -0.24$, $p = 0.003$), peripheral vision ($r = -0.22$, $p = 0.001$), and role difficulties ($r = -0.17$, $p = 0.013$).

Independent Effects of Visual Function on Depression

Multivariate regression analyses (Table 3) examined independent predictors of SDS scores. Collinearity diagnostics revealed that all VIF values were below 5, indicating no significant multicollinearity among the independent variables. In unadjusted Model 1, BCVA ($\beta = -1.53$, $p < 0.001$), CMT ($\beta = 0.74$, $p < 0.001$), and NEI-VFQ-25 ($\beta = -0.18$, $p = 0.002$) were each significantly associated with depressive symptoms. After adjusting for age, sex, education level, glaucoma type, duration and drug treatment in Model 2, all three indicators remained significant: BCVA ($\beta = -1.09$, $p = 0.018$), CMT ($\beta = 0.54$, $p = 0.006$), and NEI-VFQ-25 ($\beta = -0.16$, $p = 0.005$). From a clinical perspective, a 1.53-point reduction in SDS score per 0.1 BCVA improvement represents a modest but meaningful change, given that a 5-point difference in SDS is considered clinically relevant for mild depression.

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Table 1. Visual function characteristics of patients with different features.

Variable	n (%)	BCVA, mean ± SD	*p*	CMT (μm), mean ± SD	*p*	NEI-VFQ-25, mean ± SD	*p*
Total	208 (100)	0.31 ± 0.12		263.22 ± 29.01		65.43 ± 9.34	
Age			0.077		0.005		0.135
<50 years	91 (43.75)	0.33 ± 0.12		256.80 ± 28.22		66.53 ± 10.05	
≥50 years	117 (56.25)	0.30 ± 0.12		268.21 ± 28.76		64.57 ± 8.71	
Sex			0.805		0.715		0.918
Female	112 (53.85)	0.31 ± 0.13		263.90 ± 30.27		65.37 ± 9.47	
Male	96 (46.15)	0.31 ± 0.11		262.42 ± 27.62		65.50 ± 9.24	
Education level			0.019		0.004		0.534
Primary and below	83 (39.90)	0.28 ± 0.11		270.84 ± 28.80		64.69 ± 8.38	
Middle and high	79 (37.98)	0.32 ± 0.12		260.60 ± 29.36		65.52 ± 10.13	
College and above	46 (22.12)	0.34 ± 0.14		253.98 ± 25.69		66.61 ± 9.66	
Residence			0.236		0.329		0.843
Urban	106 (50.96)	0.30 ± 0.12		261.29 ± 28.54		65.30 ± 10.26	
Rural	102 (49.04)	0.32 ± 0.12		265.23 ± 29.51		65.56 ± 8.34	
Marital status			0.896		0.859		0.622
Married	183 (87.98)	0.31 ± 0.12		263.09 ± 29.21		65.55 ± 9.49	
Unmarried/divorced	25 (12.02)	0.31 ± 0.14		264.19 ± 28.11		64.56 ± 8.35	
Glaucoma types			0.017		0.016		0.417
Others	47 (22.60)	0.35 ± 0.12		254.30 ± 25.59		66.40 ± 9.78	
Primary angle-closure glaucoma	161 (77.40)	0.30 ± 0.12		265.82 ± 29.51		65.14 ± 9.23	
Duration of illness			0.056		0.081		0.475
<5 years	132 (63.46)	0.30 ± 0.11		265.89 ± 29.15		65.08 ± 9.60	
≥5 years	76 (36.54)	0.33 ± 0.13		258.59 ± 28.37		66.04 ± 8.91	
Surgical treatment			0.964		0.83		0.86
No	121 (58.17)	0.31 ± 0.12		263.59 ± 28.64		65.33 ± 9.65	
Yes	87 (41.83)	0.31 ± 0.13		262.71 ± 29.68		65.56 ± 8.95	
Drug treatment			0.675		0.011		0.156
<2 types	101 (48.56)	0.31 ± 0.11		257.96 ± 29.24		66.38 ± 9.53	
≥2 types	107 (51.44)	0.31 ± 0.13		268.18 ± 28.04		64.53 ± 9.12	

Note: BCVA, best-corrected visual acuity; CMT, central macular thickness; NEI-VFQ25, 25-item National Eye Institute Visual Function Questionnaire; SD, Standard deviation.

Moderating Effect of Disease Duration

Subgroup analyses stratified by disease duration (<5 vs. ≥5 years) revealed significant moderating effects (Table 4). The negative correlation between BCVA and SDS scores was significantly stronger in the longer-duration group (r = −0.44 vs. −0.07; Z = 2.77, $p < 0.01$). Formal interaction analysis confirmed this moderating effect (β for interaction = −0.31, p for interaction = 0.006). Similarly, the correlation between NEI-VFQ-25 and SDS scores was significantly stronger in patients with longer disease duration (r = −0.49 vs. −0.03; Z = 3.45, $p < 0.001$), with a significant interaction term ($\beta = -0.28$, p for interaction = 0.002). No significant moderating effect was observed for the CMT–depression relationship (Z = −1.51, $p = 0.130$; p for interaction = 0.128).

Discussion

Glaucoma is a leading cause of irreversible blindness worldwide, impairing visual function, reducing quality of life, and contributing to depression [23]. In this study of 208 patients with glaucoma, the mean BCVA was 0.31 ± 0.12 and the mean CMT was 263.22 ± 29.01 μm, indicating a certain degree of visual impairment. BCVA and CMT varied significantly by glaucoma type, age, education level, treatment modality, and number of medications, suggesting that visual function impairment in glaucoma is multifactorial and requires individualized assessment.

Regarding patient-reported visual function, the total NEI-VFQ-25 score was 65.43 ± 9.34, indicating that subjective visual function was somewhat affected. This result is consistent with Nishida *et al.* [8], who found that patients with perimetric glaucoma had a mean NEI-VFQ-25

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Table 2. Correlation between the visual function and depression.

Indicators	Correlation coefficient	95% CI	*p* value
Objective visual function			
BCVA	−0.23	−0.36–−0.10	<0.001
CMT	0.27	0.14–0.39	<0.001
NEI-VFQ-25 scores			
Total scores	−0.22	−0.34–−0.08	0.002
General vision	−0.26	−0.38–−0.13	<0.001
Near vision	−0.26	−0.37–−0.11	<0.001
Distance vision	−0.24	−0.33–−0.07	0.003
Peripheral vision	−0.22	−0.35–−0.09	0.001
Role difficulties	−0.17	−0.30–−0.04	0.013

Note: NEI-VFQ-25, 25-item National Eye Institute Visual Function Questionnaire; CI, confidence interval; BCVA, best-corrected visual acuity; CMT, central macular thickness.

Table 3. Regression analysis of the impact of visual impairment on depressive mood.

Variables	Model 1			Model 2[a]		
	t	*p*	*β* (95% CI)	*t*	*p*	*β* (95% CI)
BCVA (per 0.1 increase)	−3.42	<0.001	−1.53 (−2.40–−0.65)	−2.38	0.018	−1.09 (−1.99–−0.19)
CMT (per 10 μm)	4.04	<0.001	0.74 (0.38–1.09)	2.75	0.006	0.54 (0.15–0.92)
NEI-VFQ-25 score	−3.15	0.002	−0.18 (−0.29–−0.07)	−2.84	0.005	−0.16 (−0.27–−0.05)

Note: [a]Adjusted for age, gender, education level, type of glaucoma, duration of illness and drug treatment. BCVA, best-corrected visual acuity; CMT, central macular thickness; CI, confidence interval; NEI-VFQ-25, 25-item National Eye Institute Visual Function Questionnaire.

score of 64.7 ± 8.9, highlighting the close association of visual field damage with reduced visual function. Regarding depression, the total SDS score was 52.27 ± 7.88, and depression scores were significantly higher in patients with a disease duration of ≥5 years than in those with duration <5 years, suggesting that disease duration may be an important factor affecting depression in patients with glaucoma. This finding aligns with Shin *et al*. [14], who reported that the prevalence of depressive symptoms was 37.2% in patients with glaucoma with disease duration >5 years, significantly higher than that in patients with shorter disease duration. Correlation analysis showed that BCVA was positively correlated with NEI-VFQ-25 scores and negatively correlated with SDS scores, whereas CMT was negatively correlated with NEI-VFQ-25 scores and positively correlated with SDS scores, further confirming a close relationship between the degree of visual impairment and depressive mood. These core correlational findings are consistent with Latif *et al*.'s [5] systematic review of 18 studies, which confirmed that better visual acuity is associated with lower depression risk in patients with glaucoma.

Multidimensional analysis of the NEI-VFQ-25 showed that BCVA and CMT were significantly correlated with overall visual acuity, near vision, distance vision, peripheral vision and role difficulties. Notably, CMT had the strongest negative correlations with distance vision (r = −0.416) and peripheral vision (r = −0.367), aligning with Moghimi *et al*. [6], who found that progressive visual field loss impairs spatial perception and distance-related activities. Furthermore, the positive correlation between BCVA and role functional difficulty (r = 0.249) in our study is supported by Bektaş and Tekeli [24], who reported a similar correlation (r = 0.26, $p < 0.001$) between visual acuity and role function in 320 patients with glaucoma, confirming that visual impairment weakens patients' social role identity. This finding suggests that pathological changes in the macula may have a more significant effect on spatial perception and environmental exploration, which is closely related to the phenomenon of 'functional blindness' in patients with glaucoma due to reduced visual field [25,26]. Furthermore, the positive correlation between BCVA and role functional difficulty (r = 0.249) indicates that visual impairment may further weaken patients' sense of social role identity by restricting occupational activities and social participation, forming a vicious 'physiology-psychology-society' cycle [24]. Regarding disease type, BCVA was significantly lower in patients with primary angle-closure glaucoma than in other types, which may be related to more severe optic nerve damage from acute

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Table 4. Subgroup analysis of the associations between ophthalmic indicators and SDS scores based on disease duration.

Variables	Subgroup analysis (r)			Interaction analysis	
	r (<5 years)	r (≥5 years)	*p* value[a]	Interaction term (β)	*p* for interaction[b]
BCVA	−0.07	−0.44	<0.01	−0.31	0.006
CMT	0.2	0.4	0.13	0.05	0.128
NEI-VFQ-25 score	−0.03	−0.49	<0.001	−0.28	0.002

Note: [a] The inter-group comparison was conducted using Fisher's r-to-z transformation to test whether there was a significant difference between the two independent correlation coefficients. [b] Interaction terms were calculated as (disease duration group × visual function indicator) after adjusting for age, gender, and glaucoma type. Disease duration group was coded as 0 = <5 years, 1 = ≥5 years. BCVA, best-corrected visual acuity; CMT, central macular thickness; NEI-VFQ-25, 25-item National Eye Institute Visual Function Questionnaire.

exacerbations [27]. CMT was higher in patients aged ≥50 years, which may be related to age-related macular metabolic decompensation or cumulative damage from long-term chronic high intraocular pressure [28,29]. The significant correlation between education level and CMT suggests that patients with low education level may lack disease awareness or follow-up adherence, leading to delayed treatment for macular lesions. This is consistent with Gamiochipi-Arjona *et al*.'s [13] finding that low health literacy is associated with delayed treatment and worse visual outcomes in patients with glaucoma, highlighting the importance of strengthening primary ophthalmic health education.

We found a significant negative correlation between BCVA and SDS scores, as well as a positive correlation between CMT and SDS scores. These findings confirm that worse visual impairment is associated with more severe depressive symptoms. Our results are consistent with Yin *et al*. [15], who identified visual loss as an independent risk factor for depression among patients with glaucoma, in line with the chronic disease stress model [30]. As a progressive and irreversible condition, glaucoma imposes persistent psychological stress related to vision loss, treatment burden and fear of blindness [31]. Such stress may exacerbate depressive symptoms, while depression can in turn reduce treatment adherence, forming a clinically relevant cycle [13,32]. Our findings support early psychological treatment to improve patient outcomes. Notably, the association of CMT with depression may reflect the psychological impact of central visual impairment, as macular dysfunction limits fine vision, social interaction and daily independence, increasing psychological distress [33,34]. No significant effects of sex or glaucoma type on depression were observed, indicating that depressive symptoms are a common concern among patients with glaucoma regardless of demographic or disease subtype.

This study has several limitations. Firstly, the retrospective, single-centre design may limit generalizability, and unmeasured confounding factors could influence the observed associations. Secondly, the cross-sectional nature precludes establishing causal relationships or determining temporal sequences. Thirdly, conventional visual field indices (e.g., mean deviation, pattern standard deviation) were not available, and future studies should incorporate them to complement CMT. Fourthly, self-reported questionnaires (e.g., NEI-VFQ-25 and SDS) may be subject to recall bias. Additionally, dichotomizing disease duration using a 5-year cutoff may oversimplify disease progression; future studies could treat duration as a continuous variable. Moreover, several residual confounding factors not measured in this study, including socioeconomic status, comorbidities, social support, and treatment adherence, may influence the observed associations of visual impairment with depressive symptoms. Future prospective studies should incorporate these factors to better isolate the specific contribution of visual impairment to depression in patients with glaucoma. Finally, data extraction depended on the completeness of electronic medical record entries. In conclusion, this retrospective analysis demonstrates a significant correlation between visual impairment and depressive symptoms in patients with glaucoma, underscoring the need to integrate psychological assessment into routine management. Future prospective, longitudinal, and multicentre studies are warranted to confirm these findings and evaluate integrated treatments.

Conclusions

This study demonstrates that objective measures (e.g., BCVA, CMT) and patient-reported (NEI-VFQ-25) visual function measures are significantly associated with depressive symptoms in patients with glaucoma. Furthermore, disease duration moderates these associations, with stronger correlations observed in patients with longer disease duration (≥5 years). These findings highlight the im-

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portance of integrating psychological assessment into routine glaucoma management and adopting comprehensive therapy to improve patients' mental health.

Availability of Data and Materials

All data included in this study can be obtained by contacting the corresponding author if needed.

Author Contributions

JJ and FW contributed to the conception and design of this work. JJ, LY, and YC contributed to the acquisition and analysis of the data. MS and FW contributed to the interpretation of data. JJ drafted the work. FW and MS revised it critically for important intellectual content. All authors reviewed and approved the final version of the manuscript. All authors agree to be accountable for all aspects of this work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

This study complies with all the provisions of the Declaration of Helsinki. This study has been approved by the Ethics Committee of The Affiliated Huaian No.1 People's Hospital of Nanjing Medical University (Approval Date: December 18, 2025), and informed consent has been obtained from the patients.

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Conflict of Interest

The authors declare no conflict of interest.

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