



CORRELATION OF CONTRAST SENSITIVITY WITH RETINAL NERVE FIBRE LAYER THICKNESS IN PATIENTS WITH PRIMARY OPEN ANGLE GLAUCOMA

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ABSTRACT

Background: Primary Open Angle Glaucoma is a progressive optic neuropathy characterized by retinal ganglion cell loss and retinal nerve fibre layer thinning, leading to visual dysfunction. Visual field defects are traditionally used for diagnosis; however, these defects may become evident only after substantial axonal loss. CS (Contrast Sensitivity) has been shown to decline earlier and may serve as a useful functional marker of glaucomatous damage. This study aimed to evaluate the relationship between contrast sensitivity and pRNFLT (peripapillary Retinal Nerve Fibre Layer Thickness) in patients with POAG.

Methods: A hospital-based prospective observational study was conducted at a tertiary care centre from October 2019 to November 2021. Sixty-four eyes of 32 patients diagnosed with POAG and maintained on topical anti-glaucoma medications with intraocular pressure below 21 mmHg were included. Contrast sensitivity was assessed using the Pelli–Robson chart, and retinal nerve fibre layer thickness was measured using SD-OCT (Spectral Domain Optical Coherence Tomography). Patients were evaluated over three follow-up visits, and correlations between CS, pRNFLT, and other optic nerve parameters were analysed.

Results: The study population had a mean age of 50.75 ± 3.28 years, with males constituting 59% of participants. A log CS score of 2.00 was observed in 19% of patients, while 75% had scores between 1.85 and 1.55. The mean pRNFLT was 82 ± 11.97 μm . Among patients with CS scores between 1.85 and 1.55, 83% demonstrated borderline or outside-normal-limit pRNFLT values. Treatment adherence was observed in 72% of patients. Reduced contrast sensitivity was associated with thinner pRNFLT measurements and greater glaucomatous structural damage.

Conclusion: Contrast sensitivity is a valuable functional biomarker for assessing and monitoring POAG and may aid in evaluating treatment adherence. The peripapillary retinal nerve fibre layer thickness serves as an important structural biomarker. A significant association between reduced contrast sensitivity and RNFL thinning suggests that combining both parameters may improve the monitoring of glaucomatous progression.

Keywords: Primary Open Angle Glaucoma, Contrast Sensitivity, Retinal Nerve Fibre Layer Thickness, Optical Coherence Tomography, Pelli–Robson Chart, Glaucoma Biomarkers.



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INTRODUCTION

Glaucoma is a progressive optic neuropathy characterized by the loss of retinal ganglion cells, resulting in structural changes in the RNFL (Retinal Nerve Fibre Layer) and optic nerve, with consequent deterioration of visual function.^[1] It is one of the leading causes of irreversible blindness worldwide.

The proportion of global blindness attributable to glaucoma increased from 4.4% in 1990 to 6.6% in 2010, and the number of individuals affected is projected to rise from 64.3 million in 2013 to 111.8 million by 2040.^[2] In India, approximately 11.2 million people aged 40 years and above are affected by glaucoma, of whom 6.48 million have POAG (Primary Open Angle Glaucoma).^[3]

Glaucomatous damage results in both structural and functional visual impairment. Functional losses may be reflected by reduced CS (Contrast Sensitivity) and diminished vision-related quality of life.^[4] Patients with glaucoma experience greater difficulty in reading and performing complex visual tasks compared to healthy individuals of similar age, even when visual field defects are minimal.^[5,6] Studies have demonstrated a significant relationship between CS and RNFL thickness, suggesting that reduced CS may serve as an early indicator of glaucomatous damage and may predict RNFL changes.^[7] Furthermore, CS has been shown to correlate with activities of daily living assessed by the CAARV (Compressed Assessment of Ability Related to Vision) test.^[8]

Contrast sensitivity, defined as the ability to distinguish an object from its background, is often affected earlier than visual fields in glaucoma. Reduced CS has been significantly associated with visual field loss even in patients with relatively preserved visual acuity.^[9] The Pelli–Robson chart is a simple, reliable, and widely used method for assessing CS. Structural evaluation of glaucomatous damage is commonly performed using OCT (Optical Coherence Tomography), which provides accurate, objective, and reproducible measurements of RNFLT and aids in monitoring disease progression.^[10]

AIMS AND OBJECTIVES

The aim was to evaluate the correlation between contrast sensitivity and RNFLT in patients diagnosed with POAG. The objectives were to assess visual function using the PR (Pelli–Robson) Letter Chart for contrast sensitivity testing, evaluate structural retinal changes by measuring RNFLT using OCT, and determine the relationship between functional impairment (CS) and structural damage (RNFLT) in patients with POAG.

MATERIALS AND METHODS

Study Design

This was a prospective observational cohort study conducted in the Department of Ophthalmology, GSL Medical College and General Hospital, Rajamahendravaram, under Dr. NTR University of Health Sciences (Dr. NTRUHS). The study was carried out over a period of two years, from October 2019 to November 2021, after obtaining approval from the Institutional Ethics Committee. A total of 64 eyes from 32 patients diagnosed with POAG were enrolled according to predefined inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

The study included patients diagnosed with POAG who provided informed consent to participate. Patients were excluded if the OCT signal strength was less than 8/10, if the IOP (Intraocular Pressure) difference between the two eyes exceeded 4 mmHg, or if they had a history of incisional ocular surgery or laser therapy. Subjects with visual impairment unrelated to glaucoma and those with systemic diseases such as diabetes mellitus or hypertension were also excluded from the study.

Data Collection Procedure

All patients with diagnosed POAG attending the ophthalmology outpatient department were evaluated using a comprehensive ophthalmic examination protocol. This included assessment of uncorrected and best-corrected visual acuity, contrast sensitivity using the Pelli–Robson chart, intraocular pressure measurement by Goldmann Applanation Tonometry, anterior segment evaluation, gonioscopy, visual field analysis with the Humphrey Visual Field Analyzer, fundus examination using a 90D lens, and OCT (Optical Coherence Tomography) assessment of the ONH (Optic Nerve Head) and RNFL. Contrast sensitivity was measured under standardized conditions using the Pelli–Robson chart, while structural retinal parameters such as average RNFLT, rim area, disc area, cup-to-disc ratio, and cup volume were obtained using Spectral Domain OCT (PRIMUS 200, Carl Zeiss Meditec AG., Germany). Treatment history was recorded for all participants. For statistical analysis, measurements were obtained after controlling elevated intraocular pressure, only patients with an inter-eye IOP difference of less than 4 mmHg were included, and observations from the right eye at the third follow-up visit were considered to ensure greater reliability and consistency of the recorded parameters.

RESULT

Variable	Category	Male n (%)	Female n (%)	Total n (%)
Age (in years)	46–50	7 (21.9)	7 (21.9)	14 (43.8)
	51–55	10 (31.3)	6 (18.7)	16 (50.0)
	56–60	2 (6.3)	0	2 (6.2)
Sex	Male	-	-	19 (59.4)
	Female	-	-	13 (40.6)
BCVA	6/6	-	-	13 (40.6)
	6/9	-	-	12 (37.5)
	6/12	-	-	5 (15.6)
	6/18	-	-	2 (6.3)

Table 1. Demographic and Baseline Characteristics of the Study Population (n=32)

Table 1 illustrates the demographic and baseline clinical characteristics of the study population. Most participants belonged to the 51–55 years age group (50%), with males constituting 59.4% of the study

population. The majority of subjects maintained good visual acuity, with 78.1% having a BCVA of 6/9 or better.

Contrast Sensitivity (log CS)	Number of Patients	Percentage (%)
2.00	6	18.8
1.85–1.55	24	75.0
<1.55	2	6.2
Total	32	100

Table 2. Distribution of Contrast Sensitivity in POAG Patients

Table 2 highlights the distribution of contrast sensitivity among POAG patients. Reduced contrast sensitivity was observed in most patients, with 75%

exhibiting log CS values between 1.85 and 1.55. Only 18.8% demonstrated normal contrast sensitivity.

Contrast Sensitivity (log CS)	Males (n=19)	Females (n=13)	Total
2.00	3	3	6
1.85–1.55	14	10	24
<1.55	2	0	2
Total	19	13	32

Table 3. Contrast Sensitivity According to Gender

Table 3 shows the distribution of contrast sensitivity according to gender. Both males and females predominantly exhibited contrast sensitivity scores

between 1.85 and 1.55. Severe contrast sensitivity loss (<1.55) was observed only among male participants.

Contrast Sensitivity (log CS)	BCVA >6/12	BCVA =6/12	BCVA <6/12
2.00	6	0	0
1.85–1.55	19	5	0
<1.55	0	0	2
Total	25	5	2

Table 4. Association between Contrast Sensitivity and Visual Acuity

Table 4 demonstrates a clear relationship between visual acuity and contrast sensitivity. All patients with normal contrast sensitivity had BCVA better than 6/12, whereas those with severe reduction in contrast sensitivity (<1.55) had BCVA below 6/12.

Parameter	Good Compliance	Poor Compliance	Total
Number of Patients	23	9	32
CS = 2.00	6	0	6
CS = 1.85–1.55	17	7	24
CS <1.55	0	2	2

Table 5. Treatment Compliance and Contrast Sensitivity

Table 5 highlights the association between treatment adherence and contrast sensitivity. Good compliance was observed in 71.9% of patients, whereas all

patients with severe contrast sensitivity loss belonged to the poor compliance group.

Change in Contrast Sensitivity	Good Compliance	Poor Compliance
Improved	7	0
Remained Same	25	1
Deteriorated	14	17

Table 6. Longitudinal Changes in Contrast Sensitivity According to Treatment Adherence

Table 6 illustrates the trend of contrast sensitivity during follow-up. Improvement was observed only among treatment-compliant patients, whereas

deterioration was markedly more common among poorly compliant subjects.

Parameter	Mean ± SD	Median
pRNFLT (µm)	82.0 ± 11.97	83
Neuroretinal Rim Area (mm ²)	1.08 ± 0.24	1.09
Optic Disc Area (mm ²)	2.39 ± 0.58	2.23

Table 7. Structural Optic Nerve Head and RNFL Parameters

Table 7 summarizes the structural biomarkers assessed by OCT. The mean peripapillary retinal nerve fibre layer thickness was 82 µm, while the mean neuroretinal rim area and optic disc area were 1.08 mm² and 2.39 mm², respectively. These parameters reflect the structural glaucomatous changes observed in the study population.

DISCUSSION

The present study evaluated the relationship between contrast sensitivity and pRNFLT in patients with primary open-angle glaucoma. The mean age of the study population was 50.75 ± 3.28 years, with most participants belonging to the 46–55-year age group. This finding is comparable with studies by Ronnie George et al.,^[11] Vijaya et al.,^[12] and Dandona et al.,^[13] who reported a similar age distribution among patients with POAG. Age-related structural and molecular changes affecting the trabecular meshwork and optic nerve have been

implicated in the increasing prevalence of POAG with advancing age.^[14,15]

Males constituted 59% of the study population, indicating a male predominance. This observation is consistent with the meta-analysis by Kapetanakis et al.,^[16] the review by Rudnicka et al.,^[17] and the analysis by Vajaranant et al.,^[18] all of which reported a higher prevalence of POAG among males. However, Mitchell et al.,^[19] reported a higher prevalence among females in the Blue Mountains Eye Study.

Although 94% of the participants had a BCVA of 6/12 or better, reduced contrast sensitivity was observed in 81% of cases. Similar findings were reported by Owidzka et al.,^[20] who demonstrated impaired contrast sensitivity in POAG despite relatively preserved visual acuity. Likewise, Bambo et al.,^[21] found a significant reduction in contrast sensitivity among glaucoma patients. These findings support the concept that contrast sensitivity may

detect functional impairment earlier than conventional visual acuity testing.^[22,23]

The present study also demonstrated that lower contrast sensitivity scores were associated with poorer visual acuity. However, several patients with normal visual acuity already exhibited reduced CS. Similar observations were reported by Ying-Zi Xiong et al.,^[24] who showed that contrast sensitivity deficits may occur despite preserved visual acuity. Hawkins et al.,^[25] further demonstrated that glaucoma preferentially affects contrast sensitivity compared to visual acuity.

Treatment adherence was observed in 72% of patients. Better contrast sensitivity scores were seen among patients compliant with anti-glaucoma therapy, whereas poorer scores were associated with non-compliance. Evans et al.,^[26] similarly reported improvement in contrast sensitivity following glaucoma pharmacotherapy, suggesting that contrast sensitivity may serve as a useful functional marker of treatment response. The importance of adherence in preventing disease progression has also been emphasized by Muir and Lee.^[27]

The mean pRNFLT in the present study was $82 \pm 11.97 \mu\text{m}$, which is lower than the normative values reported by Budenz et al.,^[28] Similar RNFL thinning in glaucoma patients has been reported by Bowd et al.,^[29] and Moghimi et al.,^[30] confirming that progressive loss of retinal nerve fibres is a hallmark of glaucomatous damage.

A major finding of the present study was the significant correlation between contrast sensitivity and pRNFLT ($p < 0.00001$). Subjects with lower CS scores exhibited thinner RNFL measurements, whereas higher CS scores were associated with better preserved RNFL thickness. These findings closely agree with those of Amanullah et al.^[7] who demonstrated a significant association between contrast sensitivity and RNFL thickness in glaucoma patients. Similarly, Sung et al.,^[31] reported a positive correlation between structural and functional visual parameters in glaucoma. Together, these findings support the use of contrast sensitivity as a functional biomarker and pRNFLT as a structural biomarker for monitoring POAG progression.

The mean CDR (Cup-to-Disc Ratio) in the present study was 0.68 ± 0.10 , which is comparable to the value reported by Pankaj Soni et al.^[32] Larger cup-to-disc ratios were associated with smaller NRR (Neuro-Retinal Rim) areas, supporting the observations of Betz et al.^[33] and Jonas et al.^[34] who

demonstrated that glaucomatous optic neuropathy is characterized by progressive neuroretinal rim thinning and optic cup enlargement.

The mean NRR area was $1.08 \pm 0.24 \text{ mm}^2$. Airaksinen et al.,^[35] reported that NRR values below 1.09 mm^2 are commonly associated with glaucoma, supporting the findings of the present study. Similarly, Jonas et al.,^[34] observed significant reduction in NRR area in glaucomatous eyes. The mean optic disc area in the present study was $2.39 \pm 0.58 \text{ mm}^2$, which is comparable to observations by Parikh et al.,^[36] who described structural optic disc changes associated with glaucomatous optic neuropathy.

The findings of the present study demonstrate a significant association between structural retinal damage and functional visual impairment in POAG. The results corroborate previous observations by Amanullah et al.,^[7] supporting the utility of contrast sensitivity measured by the Pelli-Robson chart as a simple functional biomarker and pRNFLT measured by OCT as a reliable structural biomarker for the diagnosis and monitoring of POAG.

Limitations

The present study has certain limitations. OCT is a relatively expensive imaging modality, which may limit its accessibility in routine clinical practice. The presence of cataract or other media opacities can adversely affect image quality and the accuracy of retinal nerve fibre layer measurements. In addition, OCT has limited transverse sampling capability, which may restrict detailed assessment of some retinal structures. Furthermore, pupillary dilatation may be required in certain patients to obtain acceptable peripapillary measurements, potentially increasing examination time and patient discomfort.

CONCLUSION

The present study demonstrated a significant association between contrast sensitivity and peripapillary retinal nerve fibre layer thickness in patients with primary open-angle glaucoma. Most patients showed reduced contrast sensitivity and RNFL thinning despite relatively preserved visual acuity. Better contrast sensitivity scores were associated with good treatment adherence, while poorer scores were observed in non-compliant patients. A statistically significant correlation was found between decreased contrast sensitivity and reduced pRNFLT, indicating that functional visual

impairment parallels structural retinal damage in POAG. Additionally, glaucomatous optic nerve changes were reflected by increased cup-to-disc ratio, reduced neuroretinal rim area, and alterations in optic disc morphology. These findings suggest that contrast sensitivity assessed using the Pelli-Robson chart may serve as a simple and cost-effective functional biomarker, while pRNFLT measured by OCT can be used as a reliable structural biomarker for the diagnosis, monitoring, and follow-up of patients with primary open-angle glaucoma.

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