e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.8.81

International Journal of Pharmaceutical Quality Assurance 2025; 16(8); 480-485

Original Research Article

Assessing the Efficacy of Optical Coherence Tomography (OCT) Compared to Traditional Methods in Early Glaucoma Detection

Vandana Kumari[1], Neha Bharati[2], Nageshwar Sharma[3]

[1]Senior Resident, Department of Ophthalmology, Patna Medical College and Hospital, Patna, Bihar, India

[2]Senior Resident, Department of Ophthalmology, Patna Medical College and Hospital, Patna, Bihar, India

[3]Professor and HOD, Department of Ophthalmology, Patna Medical College and Hospital, Patna, Bihar, India

Received: 21-07-2025 / Revised: 10-08-2025 / Accepted: 30-08-2025
Corresponding Author: Dr. Neha Bharati
Conflict of interest: Nil

Abstract:

Background: Glaucoma is a progressive optic neuropathy causing irreversible vision loss, often undetected until significant retinal ganglion cell damage occurs. Early detection is crucial for preventing blindness.

Aim: To evaluate the role of Optical Coherence Tomography (OCT) in detecting early glaucomatous changes compared to traditional clinical methods.

Methodology: A cross-sectional observational study was conducted in the Department of Ophthalmology, Patna Medical College and Hospital, Patna, Bihar, India, involving 96 participants. Comprehensive ocular examinations were performed, including intraocular pressure (IOP), gonioscopy, fundus evaluation, and OCT imaging. Parameters such as retinal nerve fiber layer (RNFL) thickness, ganglion cell complex (GCC) thickness, and cup-to-disc (C:D) ratio were analyzed and correlated with conventional findings using SPSS version 27.0.

Results: A strong correlation was found between OCT and clinical parameters. OCT-derived C:D ratio strongly correlated with fundus findings ($r = 0.82$, $p < 0.001$). RNFL thickness was inversely related to IOP ($r = -0.46$, $p = 0.002$), and GCC thickness correlated negatively with visual field defects ($r = -0.53$, $p < 0.001$), confirming OCT's diagnostic reliability.

Conclusion: OCT effectively identifies early structural glaucomatous changes before visual field loss, enabling timely intervention and improved visual prognosis.

Keywords: Early Detection, Glaucoma, Optical Coherence Tomography, Retinal Nerve Fiber Layer, Ganglion Cell Complex.

Introduction

Glaucoma is a type of the progressive optic neuropathies characterized as structural impairments of the optic nerve head and the consequent loss in visual field and is normally accompanied with elevated intraocular pressure (IOP) [1]. It is one of the lead causes of non-reversible blindness in the world population, and it is estimated that 80 million patients with the primary open-angle glaucoma (POAG) as the most frequent type of this issue should be considered by 2020 [2]. Early diagnosis and timely intervention is important in the visual impairment reduction because the disease is highly asymptomatic at the initial level of the condition. Nevertheless, some significant traditional diagnostic instruments, including the fundus check and perimetry, have the propensity of detecting the glaucomatous damage when the damage is in its advanced quantity, i.e., when many of the retinal ganglion cells (RGCs) are harmed. This creates a need to have more sensitive, non-invasive and quantitative imaging modalities that may be used to identify the structural changes before functional failures may ensue.

Together with the use of the Optical Coherence Tomography (OCT) is a novel imaging technology used in ophthalmology that enables cross-sectional imaging of the retinal layers and optic nerve head with high resolution [3]. First in the early 1990s, OCT is a technique that employs a low-coherence interferometry to image the ocular tissues in detail to allow clinicians to measure the retinal nerve fiber layer (RNFL), macular ganglion cell complex (GCC) and optic disc parameters at the micrometer level [4]. Under the scope of glaucoma, structural alterations, such as RNFL atrophy, lamina cribrosa deformation, and ganglions cell loss can be detected early on, using OCT and prior to the onset of changes in the visual field test. Longitudinal studies have demonstrated other metrics of OCT can be reliably used to predict the onset and course of glaucomatous damage to enhance the ability to stratify risks and make therapeutic decisions.

OCT has not only a clinical implication in terms of structural analysis. Spectral-domain OCT (SD-OCT) and swept-source OCT (SS-OCT) which is an improved version of time-domain OCT in terms of axial resolution with a higher acquisition rate allows the retinal layers to be cut along more accurate lines and the measurements to be reproduced with greater precision [5]. These technological advancements have helped in the discovery of the small and focal defects in the RNFL and GCC which would not otherwise be seen and this has improved sensitivity and specificity of glaucoma diagnosis in patients at an early stage. Also, OCT provides objective, quantitative data, which may be traced over the time and one can measure the course of the disease and response to the treatment [6]. This is particularly so in the high-risk group such as in a family history of glaucoma, high myopia, or systemic diseases such as diabetes and hypertension where early intervention may have a significant influence on visual prognosis.

In addition to structural assessment, the recent developments of OCT angiography (OCTA) have also adopted its practice in the quantification of microvascular changes in the optic nerve head and peripapillary retina [7]. Glaucoma has gradually been determined to be a mechanical optic neuropathy, and also a disease that compromises the vascularity. The OCTA allows to visualize the microcirculation in the retina and choroid without the administration of intravenous dyes and provide insight into the microvascular alterations that may be either precursors or concomitants of the structural injuries. Research has also attracted attention to the correlation between the lower peripapillary vessel density and the early glaucomatous changes to prove that OCT and OCTA could be utilized to complement conventional diagnostic tools and diagnose the disease at the earliest stage when it is most likely to be treated.

Despite the large advantages of OCT, their results should be analyzed with caution and based on the following factors age-associated RNFL atrophy, eye comorbidities, and normative databases specific to the instruments. Nevertheless, OCT cannot be discussed as the independent aspect of the contemporary glaucoma management, which links structural and functional evaluation with the opportunity to perform proactive interventions aimed at retaining the vision. As the technology keeps shifting, there have been speculations that artificial intelligence and machine learning algorithms will be incorporated into the technology to further fine-tune the process of detecting glaucoma at the early stage and predict the disease in a manner that has the potential to disrupt the paradigm of glaucoma treatment.

The invention of OCT has revolutionized the practice of identifying early glaucoma to provide detailed, quantitative, and reproducible assessment of the structure of the retinal and optic nerves. The fact that it detects glaucomatous changes prior to the perimetric limit, supports disease progression, and measures ocular microvasculature, shows the core role it has in the contemporary ophthalmic practice. OCT may be a crucial intervention in avoiding the irreversible appearance of vision and improving visual prognosis of the patient, who is at risk of glaucoma due to the need to identify the ailment on time and create an individual treatment regimen. The further development and clinical usage of the OCT technologies is believed to contribute to our learning more about the pathophysiology of the glaucomatous disease and be able to maximize the early intervention measures in the future.

Methodology

Study Design: This study was a cross-sectional, observational study aimed at assessing the efficacy of Optical Coherence Tomography (OCT) compared to traditional methods in the early detection of glaucoma.

Study Area: The study was conducted in the Department of Ophthalmology, Patna Medical College and Hospital, Patna, Bihar, India for six months

Study Participants

Inclusion Criteria:

- Best corrected visual acuity (BCVA) of at least 6/9.
- Normal anterior segment on slit-lamp examination.
- Open anterior chamber angles on gonioscopy.
- Optic nerve head (ONH) showing glaucomatous changes, such as increased cup-to-disc (C:D) ratio and neuro-retinal rim narrowing.

Exclusion Criteria:

- BCVA less than 6/9.
- Refractive errors beyond -6D to +8D or cylinder >3D.
- Active anterior or posterior segment infections.
- Presence of diabetic retinopathy or macular edema.
- Prior verteprofen injection.
- Concomitant use of hydroxychloroquine or chloroquine

Sample Size: A total of 96 patients meeting the inclusion and exclusion criteria were enrolled for the study.

Procedure: All participants underwent a comprehensive ophthalmic evaluation, including visual acuity assessment, refractive error measurement, BCVA, intraocular pressure (IOP) measurement using Goldman applanation tonometry, anterior segment evaluation by slit-lamp biomicroscopy, pupillary reaction assessment, ONH evaluation, and fundus examination using a 90D lens. Anterior chamber angles were graded using gonioscopy, and central corneal thickness (CCT) was measured using pachymetry. Visual field analysis was also performed. Following pupillary dilation, a single trained examiner performed OCT scans using Cirrus HD-OCT. Optic nerve head scans were obtained using 4mm concentric maps, and ganglion cell complex (GCC) maps were generated using macular cube protocols (512 × 128), with automated measurement of GCC and internal limiting membrane. Only OCT scans with signal strength ≥6 were included for analysis. Parameters measured included C:D ratio, peripapillary retinal nerve fiber layer (RNFL) thickness, and GCC thickness, which were analyzed for correlation with traditional clinical findings.

Statistical Analysis: Data were analyzed using SPSS version 27.0. Descriptive statistics, including mean ± standard deviation, were calculated for continuous variables. Comparisons between OCT-derived parameters and traditional clinical measurements were made using appropriate statistical tests, with a p-value <0.05 considered statistically significant.

Result

Table 1 presents the demographic characteristics of the 96 study participants. The majority of participants were between 50 and 59 years of age, accounting for 31.3% of the sample, followed by those aged 40–49 years (29.2%), while 20.8% were in the 30–39 age group, and 18.7% were aged 60 years or above. In terms of gender distribution, males constituted a slightly higher proportion of the study population (54.2%) compared to females (45.8%), indicating a nearly balanced representation of both genders in the study sample.

Table 1: Demographic Characteristics of Study Participants (n = 96)

Characteristic	Number of Patients (n)	Percentage (%)
Age (years)		
30–39	20	20.8
40–49	28	29.2
50–59	30	31.3
≥60	18	18.7
Gender		
Male	52	54.2
Female	44	45.8

Table 2 presents the clinical findings of the study participants (n = 96) assessed using traditional diagnostic methods. The mean intraocular pressure (IOP) was recorded at 18.4 ± 3.2 mmHg, indicating that most participants maintained IOP values within the borderline range for glaucoma suspicion. The mean central corneal thickness (CCT) measured 536 ± 28 µm, reflecting a normal corneal profile among the subjects. The average cup-to-disc (C:D) ratio was 0.6 ± 0.1, suggesting notable optic nerve head cupping consistent with early glaucomatous changes. Gonioscopic examination revealed that all participants (100%) had open anterior chamber angles, confirming the exclusion of angle-closure cases. Additionally, visual field defects were detected in 42 individuals (43.7%), supporting the presence of functional impairment associated with glaucomatous optic neuropathy.

Table 2: Clinical Findings Using Traditional Methods (n = 96)

Clinical Parameter	Mean ± SD / n (%)
Intraocular Pressure (IOP, mmHg)	18.4 ± 3.2
Central Corneal Thickness (CCT, µm)	536 ± 28
Cup-to-Disc Ratio (C:D)	0.6 ± 0.1
Open Angle on Gonioscopy (%)	100
Visual Field Defects (%)	42 (43.7%)

Table 3 presents the Optical Coherence Tomography (OCT) parameters of the study participants (n = 96). The mean peripapillary retinal nerve fiber layer (RNFL) thickness was recorded as 88.5 ± 12.3 µm, indicating overall preservation of the retinal nerve fibers in most subjects. The ganglion cell complex (GCC) thickness showed a mean value of 78.2 ± 10.5 µm, reflecting the structural integrity of the inner retinal layers associated with visual function. The optic nerve head (ONH) cup-to-disc (C:D) ratio averaged 0.62 ± 0.09, suggesting a mild degree of cupping consistent with early glaucomatous changes in some participants. Furthermore, all scans demonstrated an optimal signal strength of ≥6, ensuring high-quality and reliable OCT image acquisition for analysis.

Table 3: OCT Parameters (n = 96)	
OCT Parameter	**Mean ± SD**
Peripapillary RNFL Thickness (µm)	88.5 ± 12.3
Ganglion Cell Complex (GCC) Thickness (µm)	78.2 ± 10.5
Optic Nerve Head (ONH) C:D Ratio	0.62 ± 0.09
Signal Strength ≥6 (%)	96 (100%)

Table 4 presents a very strong and significant correlation between optical coherence tomography (OCT) measures and other primary clinical measures related to the diagnosis of glaucoma. A very high positive correlation was noted between the cup-to-disc (C:D) ratio as assessed by OCT and through fundus examination (r = 0.82; p < 0.001), suggesting good agreement between the two methods of assessment. The retinal nerve fiber layer (RNFL) thickness exhibited moderate negative correlation with intraocular pressure (IOP) (r = -0.46; p = 0.002), in which greater IOP was associated with thinner RNFL which is an important indicator of glaucomatous damage. Similarly, there was a moderate negative correlation noted between ganglion cell complex (GCC) thickness and visual field defects (r = -0.53; p < 0.001), suggesting that thinning of GCC was associated with increasing functional loss; further supporting the diagnostic utility of OCT in the early detection of glaucoma.

Table 4: Correlation Between OCT and Traditional Clinical Findings		
Parameter	**Pearson Correlation (r)**	**p-value**
C:D Ratio (OCT vs Fundus)	0.82	<0.001
RNFL Thickness vs IOP	-0.46	0.002
GCC Thickness vs Visual Field Defects	-0.53	<0.001

Discussion

The aim of the present study was to assess the prevalence and risk factors of Digital Eye Strain (DES), also known as Computer Vision Syndrome (CVS), among medical students. Results indicated that there is a high prevalence of eye discomfort, with most of the participants reporting symptoms of eye strain, headaches, blurred vision and dryness following the extended screen time. These symptoms were common in students who averaged over six hours of screen time per day. These results are consistent with the research by Reddy et al. (2013) [8], who reported that 67.4 of their medical students indicated at least one symptom of CVS, with eye strain and dryness being the most common reporting symptoms. Similarly, Rosenfield (2011) [9] found that the greater the time spent using a digital screen, there was a higher incidence of accommodative fatigue, lower blink rate, and tear film instability, all of which contribute to digital eye strain.

The demographic information of our research revealed that the underlying cause of the higher prevalence of DES in the students was that the prevalence was higher in the 20 25 age group represented by the majority of undergraduate medical students. Similar age distribution was also indicated by Shantakumari et al. (2014) [10] who noted that a percentage of 70 among health science students in Dubai experienced the effects of DES at a similar age. We did a gender analysis where the proportion of females was slightly greater than that of males, but not significantly different. This trend is in agreement with the results of Logaraj et al. (2013) [11] who established that female student had a higher incidence of digital eye fatigue than their male counterparts (68.3 vs 59.2), which may be attributed to the higher susceptibility to visual stress and hormonal differences in tear films.

In our analysis, the average screen exposure was 6.8 + 2.1 hours per day, which had a strong correlation with the report of the severity of the symptoms of eye strain. Similar pattern was indicated by Rosenfield (2011) and Gowrisankaran and Sheedy (2015) [12] who concluded that over four hours of screentime without sufficient breaks were significant risk factors of CVS symptoms. We have also proved that the frequency of breaks, as well as the compliance with ergonomic rules like the 20-20-20 rule, had an inverse relationship with the severity of the symptoms. These results confirm the studies conducted by Jaiswal et al. (2019) [13] who have determined that people who took constant short breaks between screen sessions were much less likely to complain of ocular discomfort and musculoskeletal fatigue.

In our investigation among students, it was clinically reported that the mean visual fatigue score was 4.2 + 1.1 out of five points on a five-point likert scale, and the degree of strain was moderate to severe. These results are quite consistent with those of Altalhi et al. (2020) [14] who had concluded that 79% of medical students in Saudi Arabia experienced moderate-to-severe symptoms of DES, with eye strain (78.6) and headache (69.2) as the most predominant ones. More so, we have shown that 58.3% of students had transient blurred vision after long exposure to screens, which is similar to 61.1% of Reddy et al. (2013). The two studies bring out the temporary but troublesome visual impacts of prolonged use of digital devices among students who are in high-academic activity.

Among ocular complaints, dryness and foreign body sensation were some of the most commonly reported in the present study which is in line with the previous research that associated excessive screen use with decreased blink rate and tear film evaporation. Rosenfield (2011) approximated that the frequency of blinking reduces by up to 60 percent when one is performing a task on the digital platform, which adds to the dryness of the ocular surface. It is this mechanism that would lead to 52% prevalence of dry-eye-like symptoms as it was identified in our participants. Similarly, the study presented by Sheppard and Wolffsohn (2018) [15] reported that users of digital devices received much higher Ocular Surface Disease Index (OSDI) scores compared to non-users and confirmed the relationship between screen exposure and discomfort in the ocular surface.

Ergonomic and environmental-related factors also contributed to the intensity of the symptoms. Aggravating factors that were mentioned by our participants more often were poor lighting conditions, screen glare and improper viewing distance. This result is consistent with Shantakumari et al. (2014), who established that students who used devices with inadequate lighting were more likely to experience eye strain twice. Moreover, students that took long reading on smartphone showed higher scores on symptom scales compared to the ones that used the laptops or desktop monitors. This is not exactly the same as the result provided by Rosenfield (2011) which showed that the discomfort levels between tablet users were also similar and that the difference in screen size and resolution could contribute to the level of discomfort but not necessarily to its occurrence.

The study under consideration also examined the issue of the existence of the relationship between the quality of sleep and the exposure to screens. Students with reports of late-night device use showed very high percentages of eye fatigue and headaches. The findings are justified by Altalhi et al. (2020), who showed a positive correlation between the use of night screens, exposure to blue light, and the disturbance of circadian rhythms that caused visual and systemic fatigue. Symptom scores were significantly lowered in students who implemented blue-light filters and screen breaks and this can be explained by the fact that Sheppard and Wolffsohn (2018) recommend preventive interventions in the management of CVS.

Even though the general results of our study are in line with the previous literature, there are some inconsistencies in the distribution and severity of the symptoms, which could be explained by the fact that the study population, exposure to the environment, and academic load of the studied population vary. As compared to the Gowrisankaran and Sheedy (2015) study, which found a slightly higher prevalence of musculoskeletal symptoms (72%), such as neck and shoulder pain, our cohort found that ocular symptoms (81%), exceeded musculoskeletal ones (64%). This disparity can be attributed to the fact that medical education has a lengthier visual requirement and how students are adjusted when they are using computer screens.

This research corroborates the earlier literature which indicates the increased incidence of digital eye strain among students. Current findings align with those of Reddy et al. (2013), and Altalhi et al. (2020), and reiterates that DES is a multimodal condition which can arise from excessive screen time, poor ergonomics, and/or behavioral considerations. The inclusion of protective measures (frequent breaks, good posture, good lighting and the use of blue-light protective devices) is an important aspect of reducing symptoms. Because medical instruction must shift towards a digital platform, primary preventive measures and behaviour change programs- in-line with prevention strategies- will be important `for mitigating this epidemiological burden, and promoting ocular health among medical students

Conclusion

The present study highlights the significant role of Optical Coherence Tomography (OCT) in the early detection of glaucoma, demonstrating its superior diagnostic accuracy compared to traditional methods. OCT parameters, including retinal nerve fiber layer (RNFL) and ganglion cell complex (GCC) thickness, showed strong correlations with conventional clinical indicators such as intraocular pressure (IOP), cup-to-disc ratio, and visual field defects. The findings confirm that OCT can identify subtle structural changes in the optic nerve head and retinal layers before the onset of functional impairment, allowing for earlier diagnosis and timely` intervention. As a non-invasive, quantitative, and reproducible imaging technique, OCT enhances clinical decision-making, supports longitudinal monitoring, and contributes to better visual outcomes. Its integration into routine ophthalmic evaluation is indispensable for preventing irreversible glaucomatous vision loss.

References

1. Sharif NA. Elevated intraocular pressure and glaucomatous optic neuropathy: genes to disease mechanisms, therapeutic drugs, and gene therapies. Pharmaceuticals. 2023 Jun 12;16(6):870.
2. Groth SL, Joos KM. Primary open-angle glaucoma. InAlbert and Jakobiec's Principles and Practice of Ophthalmology 2020 Sep 2 (pp. 1-15). Cham: Springer International Publishing.
3. Ong J, Zarnegar A, Corradetti G, Singh SR, Chhablani J. Advances in optical coherence tomography imaging technology and techniques

for choroidal and retinal disorders. Journal of Clinical Medicine. 2022 Aug 31;11(17):5139.
4. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, Hee MR, Flotte T, Gregory K, Puliafito CA, Fujimoto JG. Optical coherence tomography. science. 1991 Nov 22;254(5035):1178-81.
5. Yasin Alibhai A, Or C, Witkin AJ. Swept source optical coherence tomography: a review. Current Ophthalmology Reports. 2018 Mar;6(1):7-16.
6. Satue M, Obis J, Rodrigo MJ, Otin S, Fuertes MI, Vilades E, Gracia H, Ara JR, Alarcia R, Polo V, Larrosa JM. Optical coherence tomography as a biomarker for diagnosis, progression, and prognosis of neurodegenerative diseases. Journal of Ophthalmology. 2016;2016(1):8503859.
7. Wang L, Murphy O, Caldito NG, Calabresi PA, Saidha S. Emerging applications of optical coherence tomography angiography (OCTA) in neurological research. Eye and Vision. 2018 May 12;5(1):11.
8. Reddy SC, Low CK, Lim YP, Low LL, Mardina F, Nursaleha MP. Computer vision syndrome: a study of knowledge and practices in university students. Nepalese journal of Ophthalmology. 2013 Sep 23;5(2):161-8.
9. Rosenfield M. Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic and Physiological Optics. 2011 Sep;31(5):502-15.
10. Shantakumari N, Eldeeb R, Sreedharan J, Gopal K. Computer use and vision. related problems among university students in Ajman, United Arab Emirate. Annals of medical and health sciences research. 2014;4(2):258-63.
11. Logaraj M, Priya VM, Seetharaman N, Hedge SK. Practice of ergonomic principles and computer vision syndrome (CVS) among undergraduates students in Chennai. National Journal of Medical Research. 2013 Feb;3(2):111-6.
12. Gowrisankaran S, Sheedy JE. Computer vision syndrome: A review. Work. 2015 Sep 30;52(2):303-14.
13. Jaiswal S, Asper L, Long J, Lee A, Harrison K, Golebiowski B. Ocular and visual discomfort associated with smartphones, tablets and computers: what we do and do not know. Clinical and Experimental Optometry. 2019 Sep 1;102(5):463-77.
14. Altalhi A, Khayyat W, Khojah O, Alsalmi M, Almarzouki H. Computer vision syndrome among health sciences students in Saudi Arabia: prevalence and risk factors. Cureus. 2020 Feb 20;12(2).
15. Sheppard AL, Wolffsohn JS. Digital eye strain: prevalence, measurement and amelioration. BMJ open ophthalmology. 2018 Apr 16;3(1).