Research Article

Correlation of Peripapillary Vessel Density by OCTA with Visual Field Defects in Primary Open-Angle Glaucoma: A Cross-Sectional Study

Deepansh Garg*, **Lokesh Kumar Singh, Alka Gupta, Jaishree Dwivedi, Priyanka Gusain, Priyank Garg**

Upgraded Department of Ophthalmology, LLRM Medical College, Meerut, Uttar Pradesh, India.

Abstract

Glaucoma is one of the leading causes of irreversible blindness worldwide. Early detection is crucial for effective management. This study aims to evaluate the correlation between peripapillary vessel density as measured by optical coherence tomography angiography (OCTA) and visual field defects in patients with primary open-angle glaucoma (POAG). Methods: A prospective observational study was conducted at a tertiary care center and over a one-year duration. A total of 90 eyes from 48 already diagnosed POAG patients were included. OCTA was used to assess peripapillary vessel density, OCT was used for RNFL thickness, and Humphrey visual field analyzer (30-2, SITA Fast) for functional assessment. Results: Age distribution showed the highest incidence in patients over 60 years (34.4%). BCVA analysis showed 25.5% had 6/9 or better vision. Most patients (33.3%) had a CDR of 0.6. RNFL thickness was borderline (80–100 µm) in 42.2% and severely thinned (<60 µm) in 16.3%. MD was mild in 47.7%, moderate in 30%, and severe in 22.2%. Visual field defects included isopter contraction (21.1%), ring scotoma (16.6%), and inferior arcuate defects (7.7%). Vessel density was ≤40% in 44.4% of eyes. Strong correlations were found: Vessel Density vs. MD (r=0.9455), vessel density *vs.* CDR (r=-0.98), RNFL *vs.* CDR (r = -0.949), MD *vs.* CDR (r = -0.963). Conclusion: Peripapillary vessel density measured by OCTA is significantly correlated with structural (CDR, RNFL) and functional (MD) glaucoma parameters. OCTA serves as a valuable biomarker for glaucoma severity and progression.

Keywords: CDR, OCTA, Primary open-angle glaucoma, Vessel density, Visual field.

Introduction

Glaucoma refers to an optic neuropathy with characteristic changes in the optic nerve head, retinal nerve fiber layer, and visual fields, which are vital structures that reflect the eye and visual system health.[1] As the second cause of blindness worldwide, glaucoma poses a major public health problem[2] whose impact is irreversible after vision impairment has occurred. This raises the need and importance of proper diagnosis and treatment of the condition. Early detection through clinical and ancillary tests such as IOP measurement, optic disc evaluation, RNFL assessment, and visual field testing is critical. These tests are crucial since they yield critical information regarding the optic nerve status and general ocular health.[3,4] OCTA is a non-invasive imaging tool that enables visualization of the retinal microvasculature and is increasingly used to assess glaucomatous damage. Optical coherence tomography (OCT) is a high-tech imaging test that delivers high-resolution cross-sectional views of the retina and optic nerve, enabling the identification of early changes that may not be apparent with conventional means.[5]

UP JOURNAL OF OPHTHALMOLOGY

An Official Journal of Uttar Pradesh State Ophthalmological Society, UPSOS (Northern Ophthalmological Society, NOS)

p-ISSN: 2319-2062 | DOI: 10.56692/upjo.2025130203

Materials and Methods

Study Design and Setting

Prospective observational study at L.L.R.M. Medical College, Meerut, from August 2023 to July 2024.

Sample Size

90 eyes from 48 diagnosed POAG patients.

Inclusion and Exclusion Criteria

Diagnosed POAG cases with clear media and giving proper consent were included. Patients with non-glaucomatous optic

Address for correspondence: Deepansh Garg

Upgraded Department of Ophthalmology, LLRM Medical College, Meerut, Uttar Pradesh, India.

E-mail: deepansh.grg@gmail.com

How to cite this article: Garg D, Singh LK, Gupta A, Dwivedi J, Gusain P, Garg P. Correlation of Peripapillary Vessel Density by OCTA with Visual Field Defects in Primary Open-Angle Glaucoma: A Cross-Sectional Study. UP Journal of Ophthalmology. 2025;13(2): 51-55.

Received: 11-06-25, **Accepted:** 27-06-25, **Published:** 26-08-25

neuropathies, systemic or ocular diseases affecting visual field, media opacities and those who were uncooperative were excluded.

Study Tools

OCTA (HUVITZ HOCT-1F): 6x6 mm peripapillary scans, Humphrey Field Analyzer 3 (30-2, SITA Fast)

Statistical Analysis

Epi Info™ v3.7.2. Karl Pearson's correlation coefficient is used for association.

Observations and Results

A total of 90 eyes of 48 already diagnosed cases of primary open-angle glaucoma with clear media, given proper consent, were taken.

Age Distribution

The highest incidence was in patients over 60 years (34.4%).

Sex Distribution

There were more females than males. However, this difference was not statistically significant.

BCVA Analysis

Many patients retained central vision (6/9 or better), but a subset showed impaired vision, highlighting the need for early detection and intervention.

Anatomical Markers

Cup-to-Disc Ratio (CDR) and RNFL.

CDR Findings

Most patients (33.3%) had a CDR of 0.6, suggesting moderate disease. A higher CDR (≥0.9) was rare in the study due to poor cooperation in testing. CDR strongly correlated with disease severity and structural damage, *p-value* <0.00001

RNFL Thickness

42.2% had borderline RNFL thickness (80–100 µm), requiring close monitoring. 16.3% had severe thinning (<60 µm), indicative of advanced glaucoma. RNFL thinning is often detectable before visual field loss and serves as a sensitive early marker.

Functional Markers

Mean deviation & Visual Field defects.

Mean Deviation (MD)

47.7% had mild deviation, 30% moderate, and 22.2% severe. Grading of glaucoma severity based on HVF (Mean Deviation) is presented in Table 1. MD values correlated with both CDR and RNFL, reinforcing its diagnostic value ($p < 0.00001$).

Common Field Defects

Contraction of isopter (21.1%) — generalized visual field narrowing. Ring scotoma (16.6%) — linked to arcuate nerve fiber damage. Lower arcuate defect (7.7%) — a hallmark of early POAG.

Table 1: MD Humphrey Visual Field (HVF)

Mean deviation by HVF	*No of eyes*	*Percentage %*
≥ -6.00	43	47.7
-6.01–-12.00	27	30
≥12.01	20	22.2
Total	90	100

Table 2: Average vessel density interpretation by OCTA

Average vessel density by OCTA [percentage]	*No of eyes*	*Percentage*
≤40	40	44.4
40.01–45.00	27	30
45.01–50.00	17	18.8
≥50.01	6	6.6
Total	90	100

Peripapillary Vessel Density

30% of eyes had vessel density in the 40–45% range, consistent with moderate disease. 44.4% had vessel density in the severe range, while 18.8% were in the mild category. Proposed grading of glaucoma based on peripapillary vessel densityis shown in Table 2.[10-12]

Pharmacologic Treatment

The most common regimen was two anti-glaucoma medications (32.2% of eyes). About 15.5% required trabeculectomy alone; 6.6% needed medication even post-surgery.

Correlation Analyses

Table 3 shows vessel density vs. MD, with a strong positive correlation ($r = 0.9455$, $p < 0.00001$), meaning lower density is linked with worse visual field loss (Fig. 1). Vessel density vs. CDR showed a strong negative correlation ($r = -0.98$, $p < 0.00001$), indicating larger cup sizes are associated with poorer vascular perfusion (Fig. 2).

Table 3: Comparison of average cup disc ratio, average mean deviation in HVF, average vessel density and mean of average RNFL thickness

CDR	*Average of mean deviation in perimetry*	*Avg peripapillary vessel density*	*Avg RNFL thickness*
0.4	-2.52	50.47	90.12
0.5	-4.7	44.09	90.32
0.6	-6.73	42.08	88.46
0.7	-9.24	38.7	74.45
0.8	-17.76	34.45	63.5
0.9	-18.48	33.65	53.24

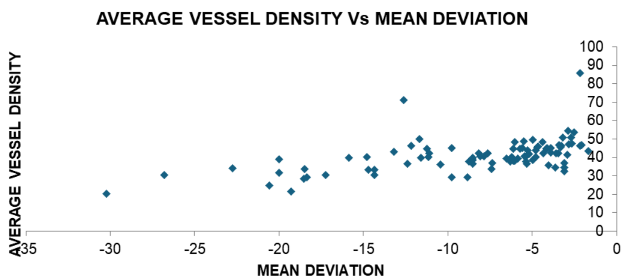

Fig. 1: Average vessel density *vs* mean deviation

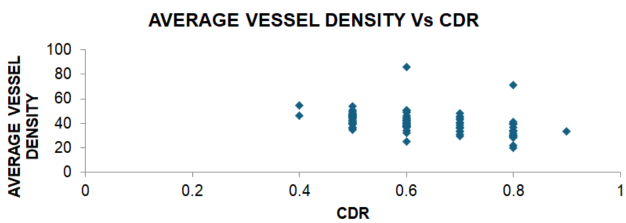

Fig. 2: Average vessel density *vs* CDR

Vessel density vs. MD

Strong positive correlation (r = 0.9455), *p-value* < 0.00001, meaning lower density is linked with worse visual field loss (Fig. 1).

Vessel density vs. CDR

Strong negative correlation (r = -0.98), *p-value* < 0.00001 indicating larger cup sizes are associated with poorer vascular perfusion (Fig. 2).

RNFL vs. CDR

Inverse relationship, supporting structural degeneration alongside functional loss [r =-0.949], *p-value* < 0.00001 (Fig. 3).

MD vs. CDR

Strong negative correlation (r = -0.963), *p-value* < 0.00001, confirming that visual field defects worsen with increasing optic nerve damage (Fig. 4).

Vessel density vs. RNFL

Strong positive correlation (r = 0.8943), *p* < 0.00001

Discussion

Glaucoma is one of the leading causes of permanent blindness throughout the world, with its pathophysiology highly related to progressive optic nerve injury, often accompanied by increased intraocular pressure (IOP) (Weinreb *et al*., 2016).[13] The findings of this study project that patients aged more than 60 years [34.4%] constitute the largest proportion of patients that are impacted, again supporting the direct association between age and the risk of glaucoma (Tham *et al*., 2014).[14] In this study, there were more females than males, but the difference was not significant. The best corrected visual acuity (BCVA) analysis in the study revealed that a majority of the patients retained functional vision (6/12 or better)due to preservation of central vision, but there was a subset with significant visual impairment, indicating the importance of early diagnosis and prompt intervention to preserve vision (Chauhan & Burgoyne, 2013).[15]

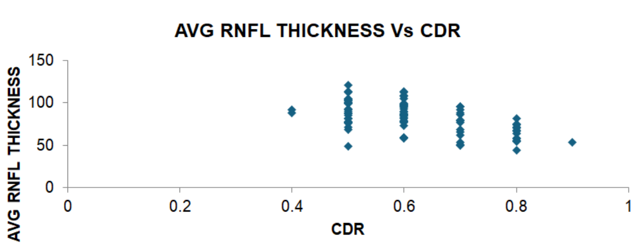

Fig. 3: Avg RNFL thickness *vs* CDR

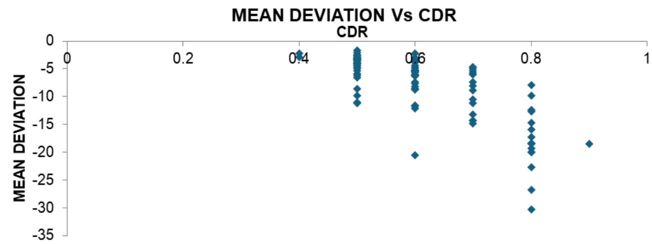

Fig. 4: Mean deviation *vs* CDR

Cup-to-disc ratio (CDR) is a key structural correlate of glaucomatous optic neuropathy and a high proportion of patients had a CDR of 0.6 [33.3%]. (Leung *et al*., 2011).[16] In our study, since all the patients were already diagnosed cases of primary open-angle glaucoma, and were on treatment that's why all eyes had IOP within the normal range.

Mean deviation is the degree of depression below the age-corrected visual field and is an integral parameter when deciding the severity of glaucoma. Clinically, early detection of mild MD values enables early intervention to prevent the progression of the disease. Our study shows mild mean standard deviation in 47.7%, moderate in 30% and severe in 22.2%. Glaucoma is also associated with visual field defects; the most common defect observed was contraction of the isopter, observed in 21.11% of the total eyes. Ring scotoma, present in 16.66% of the cases, reflects extensive glaucomatous injury to both the superior and inferior arcuate fibers, resulting in tunnel vision.

OCTA provided average peripapillary vessel density which was in the range of 40 to 45%, in about 30% eyes, which lies in the range of moderate glaucoma with similar results as in Liu L,[17] *et al*. 44.4% eyes had vessel density in the range of severe glaucoma category and 18.8% in mild perfusion range. Thin RNFL is an extremely sensitive marker of progressive glaucoma and often occurs prior to measurable visual field defects. In our study, about 42.2% eyes fall in the category of borderline RNFL thickness and about 16.3% have RNFL less than 60 micrometers.

The presence of microvascular damage on OCTA in patients with extensive RNFL loss supports the role of ischemia in glaucomatous damage (Shoji *et al*., 2017).[18] The present study establishes a strong relationship between optical coherence tomography angiography (OCTA) vessel density and visual field loss in glaucoma patients. The findings reveal a significant positive correlation (r = 0.9455, *p-value* <0.00001) between vessel density and mean deviation (MD) in Humphrey visual field (HVF) analysis. This suggests that as vessel density decreases, visual field defects worsen, indicating the potential utility of OCTA as a biomarker for glaucoma progression.

Moreover, the relationship between cup-to-disc ratio (CDR) and vessel density was found to be negatively correlated with r being -0.98 *p-value* <0.00001, suggesting that patients with a higher CDR (indicating glaucomatous optic neuropathy) exhibit lower vessel density, thereby confirming that vascular compromise plays a critical role in glaucoma progression. The study further confirms that glaucoma severity directly impacts vessel density, with patients in advanced stages exhibiting significantly lower vessel density compared to those in early and moderate stages. Regression analysis suggests that vessel density can serve as a predictive marker for visual field loss, reinforcing the importance of OCTA in clinical practice for early detection and, highlighting the high diagnostic accuracy of vessel density as a biomarker for disease progression.

The findings of this study are in concordance with previous research indicating that glaucoma is not only a neurodegenerative disorder but also a vascular pathology. Studies by *Chen et al. (2020)*[19] and *Hwang et al.(2019)*[20] have similarly reported a significant reduction in peripapillary vessel density in glaucomatous eyes, further strengthening the argument that vascular dysfunction contributes to optic nerve damage. Moreover, prior studies have emphasized the role of OCTA in detecting early microvascular changes before functional deficits appear, which supports our findings that vessel density reduction occurs progressively alongside worsening MD values in HVF. Additionally, the strong correlation between CDR and visual field loss (MD) underscores the role of structural damage in functional impairment. The negative correlation between OCT RNFL thickness and CDR [r value - 0.949, *p-value* <0.00001] further affirms that axonal loss is directly linked to optic nerve head changes. The association between worsening CDR, MD values and decreasing vessel density underscores the progressive nature of the disease and emphasizes the need for a multimodal diagnostic approach that combines structural and functional assessments (Chauhan & Burgoyne, 2013; Shoji *et al*., 2017).[15,18]

Limitations

Sample Size

Only 90 eyes—larger, more diverse populations needed for generalization.

Exclusion Bias

Patients with severe vision loss or poor cooperation were excluded.

Technical Challenges

OCTA is sensitive to eye movements and blinking**,** especially in older patients**.**

To conclude, glaucoma is both a neurodegenerative and vascular disease. Vessel density measured by OCTA is a valuable biomarker for assessing disease severity and progression. The study supports a multimodal approach—combining OCT, HVF, and OCTA—to improve diagnosis, monitor progression, and tailor treatment. Proactive management, including regular screening and patient education, is essential for preserving vision and quality of life. Technological advances, especially AI and improved imaging, hold promise for individualized glaucoma care in the future.

Conflicts of Interest

None.

Financial Support

None.

References

1. European Glaucoma Society Terminology and Guidelines for Glaucoma, 4th Edition - Chapter 2: Classification and terminologySupported by the EGS Foundation: Part 1: Foreword; Introduction; Glossary; Chapter 2 Classification and Terminology. Br J Ophthalmol. 2017; 101(5):73-127.
2. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol. 2006; 90(3):262-7.
3. Mitchell P, Smith W, Attebo K, Healey PR. Prevalence of open-angle glaucoma in Australia. The Blue Mountains Eye Study. Ophthalmology. 1996; 103(10):1661-9.
4. Keel S, Xie J, Foreman J, Lee PY, Alwan M, Fahy ET, et al. Prevalence of glaucoma in the Australian National Eye Health Survey. Br J Ophthalmol. 2019; 103(2):191-5.
5. Miguel AIM, Silva AB, Azevedo LF. Diagnostic performance of optical coherence tomography angiography in glaucoma: a systematic review and meta-analysis. Br J Ophthalmol. 2019; 103(11):1677-84.
6. Hodapp E, Parrish RK, Anderson DR. *Clinical Decisions in Glaucoma*. St. Louis: Mosby; 1993.
7. Brusini P, Filacorda S. Enhanced Glaucoma Staging System (eGSS) for classifying functional damage in glaucoma. Graefe's Archive for Clinical and Experimental Ophthalmology, 2006.
8. Chauhan BC, Garway-Heath DF, Goñi FJ, Rossetti L, Bengtsson B, Viswanathan AC, Heijl A. Practical recommendations for measuring rates of visual field change in glaucoma. Br J Ophthalmol. 2008; 92(4):569-73.
9. Caprioli J, et al. Comparison of visual field indices and evaluation of their usefulness in glaucoma management. *Am J Ophthalmol*. 2009.
10. Yarmohammadi A, Zangwill LM, Diniz-Filho A, Saunders LJ, Suh MH, Wu Z, et al. Peripapillary and Macular Vessel Density in Patients with Glaucoma and Single-Hemifield Visual Field Defect. Ophthalmology. 2017; 124(5):709-19.
11. Liu L, et al. Peripapillary vessel density in primary open-angle glaucoma and preperimetric glaucoma: an optical coherence

tomography angiography study.
12. Moghimi S. Macular and peripapillary vessel density in primary open-angle glaucoma: an optical coherence tomography angiography study. Graefes Arch Clin Exp Ophthalmol. 2018;256(4):729–37.
13. Weinreb RN, Leung CK, Crowston JG, Medeiros FA, Friedman DS, Wiggs JL, Martin KR. Primary open-angle glaucoma. Nat Rev Dis Primers. 2016 Sep 22;2:16067.
14. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. Ophthalmology. 2014;121(11):2081-90.
15. Chauhan BC, Burgoyne CF. From clinical examination of the optic disc to clinical assessment of the optic nerve head: a paradigm change. Am J Ophthalmol. 2013 Aug;156(2):218-27.
16. Leung CK, Liu S, Weinreb RN, Lai G, Ye C, Cheung CY, et al. Evaluation of retinal nerve fiber layer progression in glaucoma a prospective analysis with neuroretinal rim and visual field progression. Ophthalmology. 2011; 118(8):1551-7.
17. Liu L, Jia Y, Takusagawa HL, Pechauer AD, Edmunds B, Lombardi L, Davis E, Morrison JC, Huang D. Optical Coherence Tomography Angiography of the Peripapillary Retina in Glaucoma. JAMA Ophthalmol. 2015;133(9):1045-52.
18. Shoji T, Zangwill LM, Akagi T, Saunders LJ, Yarmohammadi A, Manalastas PIC, Penteado RC, Weinreb RN. Progressive Macula Vessel Density Loss in Primary Open-Angle Glaucoma: A Longitudinal Study. Am J Ophthalmol. 2017; 182:107-17.
19. Chen T, Kornblith S, Norouzi M, Hinton G. A simple framework for contrastive learning of visual representations. In: Proceedings of the International Conference on Machine Learning. 2020. p. 1597-607.
20. Hwang HS, Lee EJ, Kim H, Kim TW. Relationships of Macular Functional Impairment With Structural and Vascular Changes According to Glaucoma Severity. Invest Ophthalmol Vis Sci. 2023 Sep 1;64(12):5.