

Relationship between Optical Coherence Tomography Angiography Vessel Density and Severity of Visual Field Loss in Glaucoma

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Abstract

Background: A gradual, cumulative degradation of retinal ganglion cells and their axons characterizes glaucoma, a group of progressing optic neuropathies that cause a distinctive look of the optic disc and a concurrent pattern of vision loss, **Aim:** The work's main objective was to assess the connection between the vessels density determined by optical coherence tomography angiography (OCT-A), the ganglion cell complex, and the retinal nerve fiber layer (RNFL) utilizing OCT, and the degree of visual field loss in primary open-angle glaucoma (POAG). **Patients and Methods:** This was observational cross-sectional research that was carried out at department of ophthalmology Banha University from September 2021 to June 2022. The research was carried out on 20 glaucoma patients and 20 Healthy individuals. **Results:** there was statistically substantial decrease pattern standard deviation (PSD) in control group while there was statistically substantial elevation visual field median deviation in control group compared to glaucoma group. **Conclusion:** The degree of visual field impairment is highly correlated with OCT-A vascular density measures. In general, these relationships are stronger than common structural measurements like RNFL and rim area. Furthermore, the degree of visual field loss is still highly correlated with OCT-A vessel density assessments. Due to these factors, OCT-

A is a potential technique that will enable clinical tracking of vascular variations in glaucoma. Additionally, it may help us better understand the pathophysiology of the condition, particularly its underlying vascular mechanisms.

Key Words: Angiography Vessel Density; Visual Field; Optical Coherence Tomography; Glaucoma

Introduction

A gradual, progressive degradation of retinal ganglion cells and their axons characterizes glaucoma, a group of progressing optic neuropathies that cause a distinctive look of the optic disc and a concurrent pattern of vision loss. (1).

It is unclear what causes glaucoma biologically, and the elements that accelerate its advancement have not yet been completely identified. (2).

Because glaucoma may be asymptomatic up until it is severe, there is a great

possibility that there are many more people who are afflicted than are recognized to have the condition. (3).

Open-angle glaucoma and closed-angle glaucoma are the two main classifications for glaucoma.

Angle-closure and open-angle glaucoma may both be primary illnesses.

Trauma, certain drugs like corticosteroids, inflammation, tumors, or diseases like pigment dispersion or pseudo-exfoliation may all cause secondary glaucoma.

Even if the facts of this link are not yet known.

Optic coherence tomography (OCT), as opposed to ocular blood flow, allows for objective, precise, and quantitative assessments of the head and macula of optic nerve. OCT has become the industry standard for structural assessment in both glaucoma investigation and clinical treatment. However, there is only a weak association between structural data and reduction of vision field. (4).

OCT-A offers a repeatable, quantitative evaluation of the macula, peripapillary retina, and optic nerve head microvasculature. (5)

Recent research employing OCT-A has raised the possibility that this new technique might be helpful in the glaucoma identification, staging, and tracking processes (6).

The significance of microcirculation and blood flow of optic nerve in the development of glaucoma may also be clarified by this measurement.

The present work assesses the link between functional measures and OCT-A retinal vascular density characteristics and compares them to standard spectral domain OCT (SD-OCT) structural data.

The study's objective was to assess the connection between OCT-A measures of

vascular density, Ganglion cell complex, and RNFL and the intensity of visual field loss in POAG.

Patients and Methods

This was an observational cross-sectional investigation that was carried out at department of ophthalmology Banha University from September 2021 to June 2022. Twenty glaucoma sufferers and twenty healthy people participated in the research. The results of the ophthalmological assessment were included, as well as the best-corrected visual acuity (BCVA), which was calculated utilizing the Snellen charts and transformed to logMAR.

The diagnosis of glaucoma patients was carried out by measurements of intra ocular pressure using Goldman applanation tonometer, characteristic visual field defects utilizing SAP (standard automated perimetry), Cup /disc ratio using slit lamp with 90 D lens and OCT and Gonioscopy

Inclusion criteria: Healthy subjects: IOP of 21 mmHg or below, no previous history of excessive IOP, typical-appearing optic discs, unharmed neuroretina rims, typical findings on the RNFL typical visual field test expressed as a PSD within the 95% confidence limits, and typical findings on the Glaucoma Hemifield Test (GHT). **Glaucoma patients:** Only subjects over 18 with open angles on gonioscopy, increased iop over 21, and an irregular cup/disc ratio were included. aberrant SAP findings, such as those with a GHT outside of regular limits or a PSD outside of the 95% regular limits.

Exclusion criteria: The research excluded individuals with a history of intraocular surgery, secondary glaucoma, non-

glaucomatous optic neuropathies, vascular or non-vascular retinopathies, and any ocular or systemic conditions known to affect the visual field.

Technique: On the Humphrey Field Analyzer, visual field testing was performed on each subject using the 24-2 pattern. According to the degree of the damage to their visual fields, glaucoma patients were further divided into 2 groups: mild and medium to extreme. Mild glaucoma is recognized as a visual field mean deviation (MD) greater than or equal to 6 decibels (dB), and medium to extreme glaucoma as a visual field MD reduced than or equal to 6. In scans with a 4.54.5-mm field of view focused on the ONH, we employed vascular density measures inside the peripapillary RNFL for this investigation. RNFL posterior border to internal limiting membrane vessel density was assessed using common AngioVue software. Two locations were used to compute the measurements. The whole 4.5×4.5-mm scan field yielded whole-image vessels density (wiVD), and a 750 µm-wide elliptical annulus stretching from the edge of the optic disc was used to quantify the circumpapillary vessels density (cpVD), where the disc border on the OCT en face retinal angiography is fitted with an ellipse to generate the inner elliptical contour, and The circumpapillary area is defined as the distance around the ring between the inner and outer elliptical contours. All patients received spectral domain OCT imaging of the nerve fiber layer and ganglion cell layer (Avanti, Optovue; Fremont, CA)

Main Outcome Measures: connections between OCT-A vessel density and the degree of visual field loss as indicated by SAP MD

Ethical considerations: All participants were asked for their informed permission. After receiving clearance from the Faculty of Medicine at Benha University's ethics review board for human subject's research.

Statistical Analysis:

Data were collected, coded, revised and entered to the Statistical Package for Social Science (IBM SPSS) version 20, IBM SPSS version 20 armonk NY IBM corporation. **Chi-square test** was used in the comparison between two groups with qualitative data. The confidence interval was set at 95%, while the allowed margin of error was set at 5%. The p-value was thus deemed significant as follows: $P > 0.05$ denotes non significance (NS), $P < 0.05$ denotes significance (S), and $P < 0.01$ denotes highly significance (HS).

Research ethics committee: Ms.20.8.2021 Results

This observational cross-sectional research was carried out at department of ophthalmology Banha University. This study included 20 glaucoma patients as patient group and 20 Healthy individuals served as control group. Each patient's single eye was used in the analysis.

The BCVA values in the Control group show a median of 0.14 with a standard deviation of 0.20. On the other hand, the Patient group exhibits a higher median BCVA of 0.54 with a slightly larger standard deviation of 0.26. Comparing the patient group to the control group, BCVA logMAR was statistically substantially lower for the patient group.

Table (1): Comparison between study groups among whole image vessel density and parapapillary vessel density

	Control group (N.20)		Patient group (N.20)		Independent t test	
	Mean	SD	Mean	SD	t	p value
Whole image vessel density	50.25	2.06	34.16	5.48	12.287	0.001
Peripapillary vessel density	53.01	2.43	33.88	6.97	11.595	0.001

This table shows that in comparison to the control group, the patient group's peripapillary vascular density and total image vessel density was statistically considerably lower.

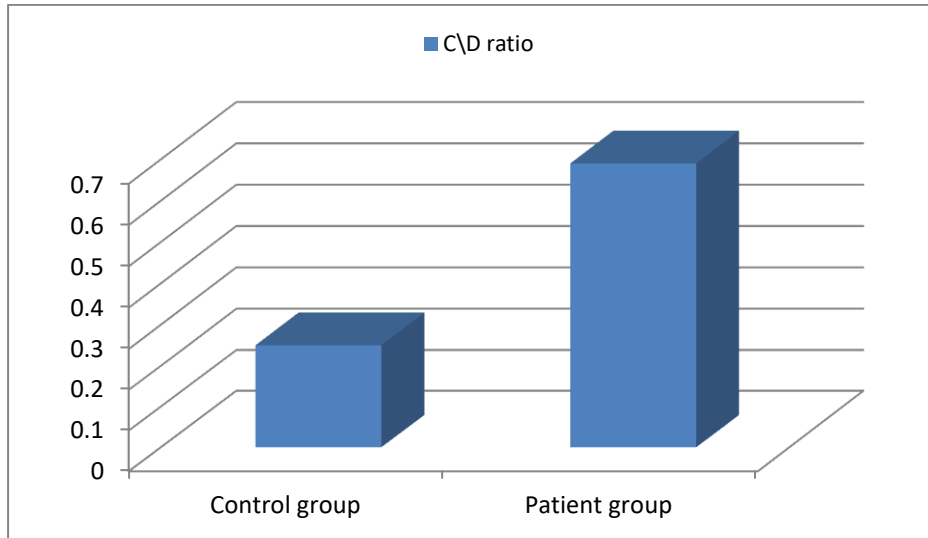


Figure 1: C/D ratio comparison between patient group and control group, that C/D ratio was significantly greater among patient group.

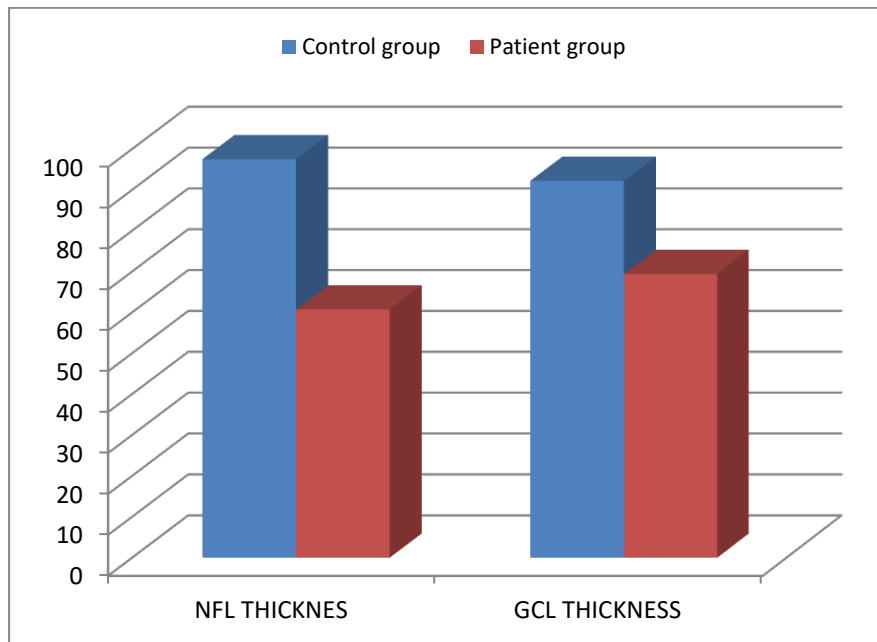


Figure2: NFL thickness and GCL thickness distribution between patient group and control group that they were lower among patients compared to control.

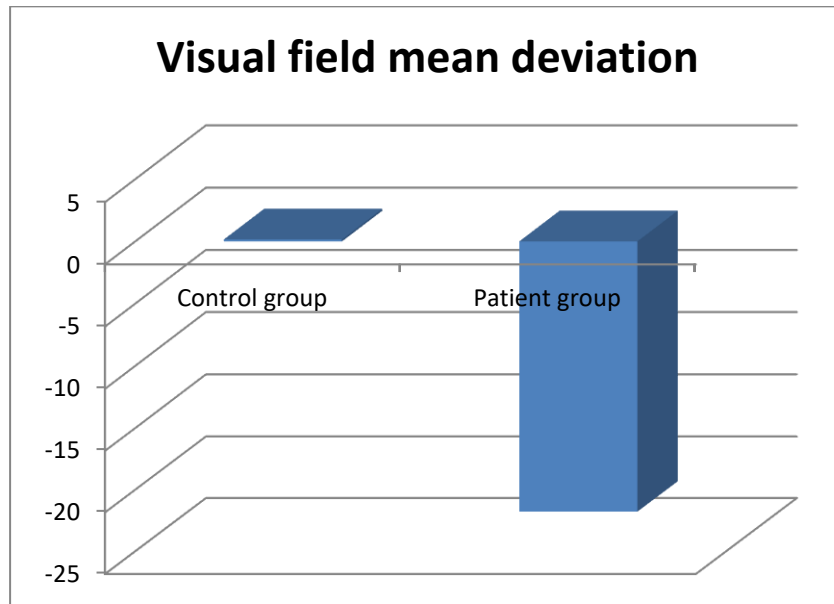


Figure 3: Visual field MD distribution between patient group and control group, that visual field MD was statistically significantly lower among patient group.

Table (2): Correlation between Visual Field MD among all studied parameters in patient group

	Visual Field MD	
	R	P value
BCVA	-0.491	0.028*
wiVD	0.869	0.010*
Peripapillary vessel density	0.810	0.001*
GCL THICKNESS	0.727	0.001*
NFL THICKNESS	0.400	0.081
IOP	0.116	0.627
C/D RATIO	0.252	0.283
RIM AREA (MM2)	0.149	0.531
Pattern Standard Deviation	0.080	0.736

Stronger correlations ($R^2=0.810$ and $R^2=0.869$) were found between the degree of visual field damage (MD) and peripapillary vascular density and entire vessel density. Compared to the connection between the variables VF MD and RNFL ($R^2=0.400$), rim area ($R^2=0.149$), and GCC ($R^2=0.727$).

Table (3): Multivariate regression analysis to identify potential factors linked to changes in Visual Field Mean Deviation.

	B	SE	Sig	95% CI For B	
				Lower	Upper
BCVA logMAR	-10.708	5.438	0.037*	-22.132	0.716
Whole image vessel density	-84.642	7.780	0.001*	-101.177	-68.107
Peripapillary vessel density	-70.190	6.472	0.001*	-83.78	-56.593
GCL thickness	-73.172	8.834	0.003*	-91.732	-54.611

This table shows that BCVA logMAR, wiVD, Peripapillary vessel density, and GCL thickness were substantially associated with Visual Field MD changes.

Discussion

A progressive optic neuropathy known as glaucoma is marked by structural and functional vision impairments. Visual field testing can evaluate functional damage, but structural damage may be found by utilizing OCT to thin the retinal ganglion cell layer and RNFL. (7).

This observational cross-sectional research was carried out at Banha University's department of ophthalmology. Twenty glaucoma sufferers and twenty healthy people participated in this research. (8).

The present investigation showed that there was no substantial variation between the study groups regarding age and sex. (9).

In line with the current study **Li et al., (10); Shen et al., (11)** reported that Regarding age and gender, there was no statistical considerable variation between study groups.

Regarding to the current research, the control group's BCVA was statistically substantially lower than that of the glaucoma group.

In line with the current research **Mohamed et al., (12)** revealed that Compared to the non-glaucoma group, the glaucoma group's BCVA was considerably greater ($p=0.004$). This was supported by **Shen et al., (11)** revealed that Between the examined groups, there was statistical relevant variance in terms of BCVA.

The current research also showed that there was increase in wiVD and peripapillary vessel density in control group compared to glaucoma group.

This was supported by **Shen et al., (11)** revealed that there was statistically considerable rise whole vessel density in control group.

Also, the research by **Li et al., (10)** showed that Compared to the glaucoma group,

there was a statistically considerable rise in parapapillary vessels density and wiVD in the control group.

In the current research we noted that both NFL thickness and GCL thickness were substantially rise in control group compared to glaucoma group.

In line with our findings **Shen et al., (11)** showed that RNFL thickness was substantially elevated in control group.

Also, **Li et al., (10)** revealed that when compared to the glaucoma group, the NFL thickness and GCL thickness in the control group were both considerably higher.

As well, **Rolle et al., (13)** reported that Median NFL thickness and median GCL thickness in the control group were substantially more than in the glaucoma group.

Additionally, in line with the recent findings **Abu Al Naga et al., (14)** found that Thickness of RNFL In comparison to the glaucoma group, peripapillary was substantially greater in the control group.

Similarly, **Yarmohammadi et al., (15)** showed that In comparison to the glaucoma group, the median RNFL thickness was substantially larger in the control group.

The current investigation showed that median cup/disc (C/D) ratio in the control group was considerably reduced than in the glaucoma group.

In line with this research **Li et al., (10)** showed that average cup/disc (C/D) ratio was substantially reduced in in control group than glaucoma patients.

Also, this was supported by **Rolle et al., (13)** showed that average cup/disc (C/D) ratio was substantially reduce in in control group than glaucoma patients.

The current study showed that there was statistically substantial rise RIM AREA (MM2) in control group compared to glaucoma group.

This was supported by **Li et al., (10)** who revealed that in glaucomatous eyes, the rim area was much lower and the C/D area ratios were increased in accordance with the severity of the illness.

Comparison between patient group and control group among PSD and visual field MD showed that there was statistically substantial decrease PSD in control group while there was statistical substantial increase visual field MD in control group compared to glaucoma group.

In line with the current study **Shen et al., (11)** showed that In comparison to the glaucoma group, there was a statistically considerable reduce in the PSD in the control group.

Also, **Li et al., (10)** showed that there was statistically substantial decrease PSD in control group while there was statistically considerable rise visual field MD in control group compared to glaucoma group.

As well, **Abu Al Naga et al., (14)** revealed that there was statistically substantial reduction PSD in control group compared to glaucoma group.

According to our findings, there was a negative connection between visual field MD and BCVA while there was a positive connection between wiVD, Peripapillary vessel density, and GCL Thickness when it came to the connection between visual field MD and all other studied parameters in the patient group. Additionally, in multivariate logistic regression, visual field MD and BCVA correlated negatively, but wiVD, peripapillary vascular density, and GCL Thickness correlated favorably.

This was supported by **Shoji et al., (16)** who reported that A substantial connection

between macular vessels density and visual field MD in comparison to MGC thickness and a gradual decrease in macula vessel density with no ganglion cell thinning in a longitudinal investigation of mild glaucoma eyes demonstrate the greater diagnostic effectiveness of macular vessels measuring.

Conclusion

The degree of visual field impairment is highly correlated with OCT-A vascular density measures. In general, these relationships are stronger than common structural measurements like RNFL and rim area. Furthermore, the degree of visual field loss is still highly connected with OCT-A vessel density assessments. OCT-A is a potential technique that will allow clinical evaluation of vascular alterations in glaucoma because of these causes. OCT-A may also help us better understand the pathophysiology of the condition, particularly its underlying vascular function.

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