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Optical Coherence Tomography Angiography (OCTA) findings in patients with ocular hypertension

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Abstract

Purpose: Using optical coherence tomography angiography, we will evaluate normal people and patients with ocular hypertension regarding optic disc perfusion and peripapillary RNFL thickness (OCTA). Methods: This research involved twenty patients diagnosed with ocular hypertension (the hypertensive group) and twenty healthy volunteers (the control group). The optic nerve head was the focus of a 4.5 mm by 4.5 mm rectangle scan in each eye. Peripapillary vessel density and RNFL thicknesses were determined. Results: The average ages of those in the control group were 46.5% while those in the hypertensive group were 48.7%. The average IOP in the hypertension group was 23 mm Hg, compared to 15.6 mm Hg in the control group. Patients with ocular hypertension had decreased optic disc perfusion and RNFL thickness in the total peripapillary, superior hemi, inferior hemi, superior, inferior, nasal, and temporal quadrants (P 0.001, 0.001, 0.001, 0.001, 0.001, 0.001, 0.001, and 0.001 for each comparison, respectively) compared to healthy controls. Moreover, in patients with ocular hypertension, there was a negative correlation between IOP and optic disc perfusion across all peripheries (r= -0.625, P=0.003), the superior hemisphere (r= -0.581, P=0.007), the inferior hemisphere (r=-0.644, P=0.002), the superior quadrant (r=-0.762, P0.001), the inferior quadrant (r=-0.697, P=0.001) Total peripapilary (r = -0.717, P 0.001), superior hemi (r = -0.644, P = 0.002), inferior hemi (r = -0.745, P 0.001), superior quadrant (r = -0.677, P = 0.001), inferior quadrant (r = -0.757, P 0.001), inferior quadrant (r = -0.596, P = 0.006), and nasal quad Conclusion. In patients with ocular hypertension, OCTA may be used to evaluate vascular density in the peripapillary area and to detect changes in optic disc perfusion and RNFL thickness at their earliest stages.

Key words: Retinal nerve fiber layer, Optical coherence tomography angiography.

1. Introduction

When increased IOP is accompanied by a normal visual field and no evidence of glaucomatous optic disc alterations, a diagnosis of ocular hypertension (OHT) is made [1]. Untreated, these individuals had a 9.5% 5-year cumulative likelihood of developing primary open-angle glaucoma (POAG) [2]. While it is true that OHT medicines may improve vision, the fact that some patients still experience visual loss even after their IOP has been stabilised suggests a role for vascular and hemodynamic variables in the aetiology of glaucomatous optic neuropathy. Factors that may contribute to the onset of glaucoma may be uncovered by an analysis of the ocular blood flow alterations seen by OHT patients [3].

Glaucoma is one of the most prevalent causes of permanent vision loss and blindness globally, and vascular dysregulation of the optic nerve head and the peripapillary retina has been considered as a risk factor for decades [4].

There has been a lot of focus on measuring and researching optic nerve head blood flow because of the significance that vascular insufficiency in the optic nerve head plays in glaucomatous optic neuropathy. The pulsatile ocular blood flow method, magnetic resonance imaging, laser Doppler flowmetry, scanning laser Doppler flowmetry, colour Doppler imaging, transcranial Doppler, laser Doppler flowmetry, fluorescein fundus angiography, and scanning laser fluorescein angiography have all been used in the past [5]. Recent years have shown that optical coherence tomography angiography (OCTA) is an effective tool for investigating and quantitatively assessing the microcirculation of the optic nerve head and peripapillary area [6].

While the European Glaucoma Prevention Study (EGPS) failed to show the significance of reducing IOP in preventing the onset of the disease, the Ocular Hypertension Treatment Study (OHTS) established that medically treating ocular hypertension is efficacious in delaying or preventing the onset of glaucoma [7]. Vascular dysregulation has been linked to glaucoma in several studies both experimental and clinical [8].

Optical coherence tomography (OCT) angiography is an innovative noninvasive functional imaging tool that can detect vascular density and perfusion in the optic nerve head and peripapillary retina independently. To better understand the pathophysiology of glaucoma and identify glaucomatous development, OCT angiography may be used to selectively investigate perfusion in the region of a structural anomaly, which facilitates correct diagnosis [4].

Quantifying blood flow is possible with the use of the split-spectrum amplitude-decorrelation angiography (SSADA) technique [9]. Damage to the RNFL and RGC axons are characteristic signs of

glaucoma, and the radial peripapillary capillaries (RPC) are a network of capillary beds inside the RNFL that supply the RGC axons. For this reason, OCTA may be used to detect the preclinical vascular density (VD) variations of OHT by quantitatively characterising the microvasculature surrounding the nerve head [10].

2. Materials and Methods

This is a case control study and was conducted in the period from March 2021 to March 2022. Patients were recruited from subjects attending the out-patient clinic in Ophthalmology department, Banha university hospital. 20 patients with a diagnosis of ocular hypertension (Hypertensive group) and 20 healthy patients (control group) were consecutively enrolled in this study. The ocular hypertension was diagnosed as IOP > 21 mmHg ,normal optic disc appearance without glaucomatous changes , normal visual field test and open anterior chamber angle determined with gonioscopy. All patients were subjected to a complete ophthalmic examination , including : Snellen visual acuity test , best corrected visual acuity , IOP measurement by applanation tonometer , slit lamp biomicroscopy and dilated fundoscopy , visual field test and OCTA.

Exclusion criteria was patients with systemic diseases diabetes mellitus or hypertension, glaucomatous optic disc changes, previous intraocular surgery or media opacity that may interfere with imaging like corneal opacity, cataract or vitreous hge.

Before examining each patient, we dilated their pupils. The patient's pupils were dilated, and they were placed in front of an OCT scanner while being instructed to fixate their gaze internally. The operator was able to see the imaging region on the fundus in real time with an en face view.

As part of the longitudinal investigation, the AngioVue OCT (Optovue.) was used to perform OCT angiography of the optic nerve head and peripapillary retina. Images were chosen for this case series only if they had high enough image quality (SSI >50) and were free of artefacts such vitreous floaters and motion blur. The AngioVue OCT has a scan rate of 70,000 A-scans/sec, a light source of 840 nm wavelength, and a bandwidth of 50 nm, all of which together provide angiographic pictures with high amplitude decorrelation. There are 304 A-scans and 304 B-scans in total in every OCT-A volume, with two B-scans taken in a row at each fixed point before moving on to the next sample site. To get at the OCT angiography data, a technique called split-spectrum amplitude-decorrelation angiography is used. Motion correction is used to reduce the effects of microsaccades and fixation shifts, both of which may introduce unwanted motion artefacts.

2.1Stastical Analysis

Data management and statistical analysis were done using SPSS version 25 (IBM, Armonk, New York, United States).

Quantitative data were assessed for normality using the Shapiro-Wilk test and direct data visualization methods. Numerical data were summarized as means and standard deviations. Categorical data were summarized as numbers and percentages. Correlation analyses were done using Spearman's correlation.

All statistical tests were two-sided. P values less than 0.05 were considered significant.

3. Results

This case-control study was conducted on 40 eyes divided into two groups:

- **Group (I):** Twenty eyes with ocular hypertension.
- **Group (II):** Twenty healthy eyes.

❖ ***Demographics***

No significant differences were noted between both groups regarding age (P = 0.310) and gender (P = 0.749) ***(Table 1).***

Table (1) Demographic characteristics in the studied groups

		Group I (n = 20)	Group II (n = 20)	P-value
Age (years)	Mean ±SD	48 ±7	46 ±5	0.31
Gender	Males n (%)	8 (40.0)	9 (45.0)	0.749
	Females n (^)	12 (60.0)	11 (55.0)	

Independent t-test was used for age. Chi-square test was used for gender

❖ ***IOP & BCVA***

IOP was significantly higher in cases (23 mmHg) than controls (15.6 mmHg) (P < 0.001). In contrast, BCVA was significantly lower in cases (0.82 decimal) than controls (0.95 decimal) (P = 0.001) ***(Table 2).***

Table (2) IOP & BCVA in the studied groups

		Group I (n = 20)	Group II (n = 20)	P-value
IOP (mmHg)	Mean ±SD	23 ±1	15.6 ±1.8	<0.001
BCVA (decimal)	Mean ±SD	0.82 ±0.14	0.95 ±0.06	0.001

Independent t-test was used IOP: Intra ocular pressure BCVA: Best corrected visual acuity

❖ ***Optic disc perfusion***

Regarding optic disc perfusion, in total peri-papillary, it was significantly lower in cases (49.7%) than controls (64.3%) (P < 0.001). In superior hemi, it was significantly lower in cases (50.1%) than controls (62.7%) (P < 0.001). In inferior hemi, it was significantly lower in cases (49.8%) than controls (61.7%) (P < 0.001). In superior quadrant, it was significantly lower in cases (49.8%) than controls (61.6%) (P < 0.001). In inferior quadrant, it was significantly lower in cases (51.7%) than controls (62.6%) (P < 0.001). In nasal quadrant, it was significantly lower in cases (46.8%) than controls (61.5%) (P < 0.001). In temporal quadrant, it was significantly lower in cases (51.8%) than controls (61.8%) (P < 0.001) ***(Table 3 & figure 1).***

Table (3) Optic disc perfusion in the studied groups

		Group I (n = 20)	Group II (n = 20)	P-value
Total peri-papillary	Mean ±SD	49.7 ±3.9	64.3 ±1.8	<0.001
Superior hemi	Mean ±SD	50.1 ±4.2	62.7±1.7	<0.001
Inferior hemi	Mean ±SD	49.8 ±3.8	61.7 ±2	<0.001
Superior quadrant	Mean ±SD	49.8 ±5.3	61.6 ±2.3	<0.001
Inferior quadrant	Mean ±SD	51.7 ±4.3	62.6 ±2	<0.001
Nasal quadrant	Mean ±SD	46.8 ±4.7	61.5 ±2.2	<0.001
Temporal quadrant	Mean ±SD	51.8 ±3.6	61.8 ±1.7	<0.001

Independent t-test was used

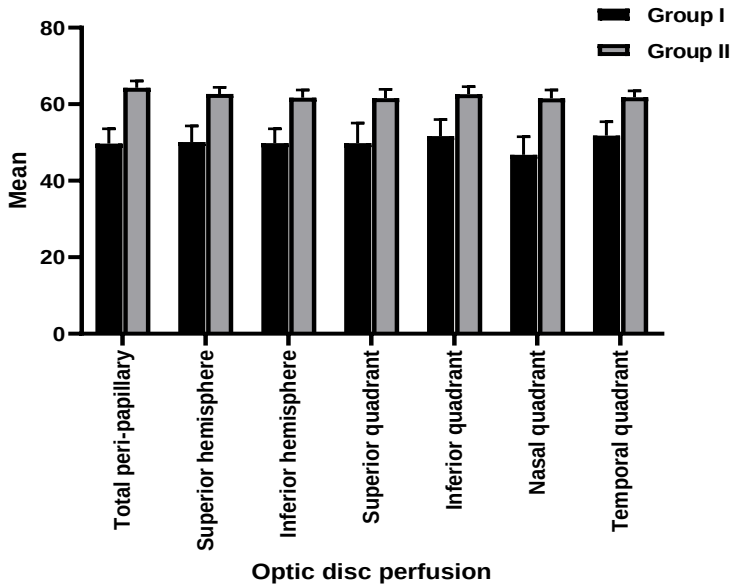

Fig. (1) Optic disc perfusion in the studied groups

❖ ***The retinal nerve fiber layer***

Regarding retinal nerve fiber layer thickness, in total peri-papillary, it was significantly lower in cases (104.2 Um) than controls (140 Um) (P < 0.001). In superior hemi, it was significantly lower in cases (104.1 Um) than controls (143.1 Um) (P < 0.001). In inferior hemi, it was significantly lower in cases (104.5 Um) than controls (140.4 Um) (P <

0.001). In the superior quadrant, it was significantly lower in cases (122.6 Um) than controls (181.2 Um) (P < 0.001). In the inferior quadrant, it was significantly lower in cases (132 Um) than controls (181.6 Um) (P < 0.001). In the nasal quadrant, it was significantly lower in cases (92.9 Um) than controls (132.9 Um) (P < 0.001). In the temporal quadrant, it was significantly lower in cases (70.9 Um) than controls (100.1 Um) (P < 0.001) ***(Table 4 & figure 2).***

Table (4) Retinal nerve fiber layer in the studied groups

		Group I (n = 20)	Group II (n = 20)	P-value
Total Thickness	Mean ±SD	104.2 ±14	140 ±3	<0.001
Superior Hemi	Mean ±SD	104.1 ±14.3	143.1 ±2.2	<0.001
Inferior Hemi	Mean ±SD	104.5 ±14.5	140.4 ±2.9	<0.001
Superior Quadrant	Mean ±SD	122.6 ±22.6	181.2 ±3	<0.001
Inferior Quadrant	Mean ±SD	132 ±21.1	181.6 ±2	<0.001
Nasal Qudrant	Mean ±SD	92.9 ±13.5	132.9 ±2.3	<0.001
Temporal Quadrant	Mean ±SD	70.9 ±12.4	100.1 ±2.6	<0.001

Independent t-test was used

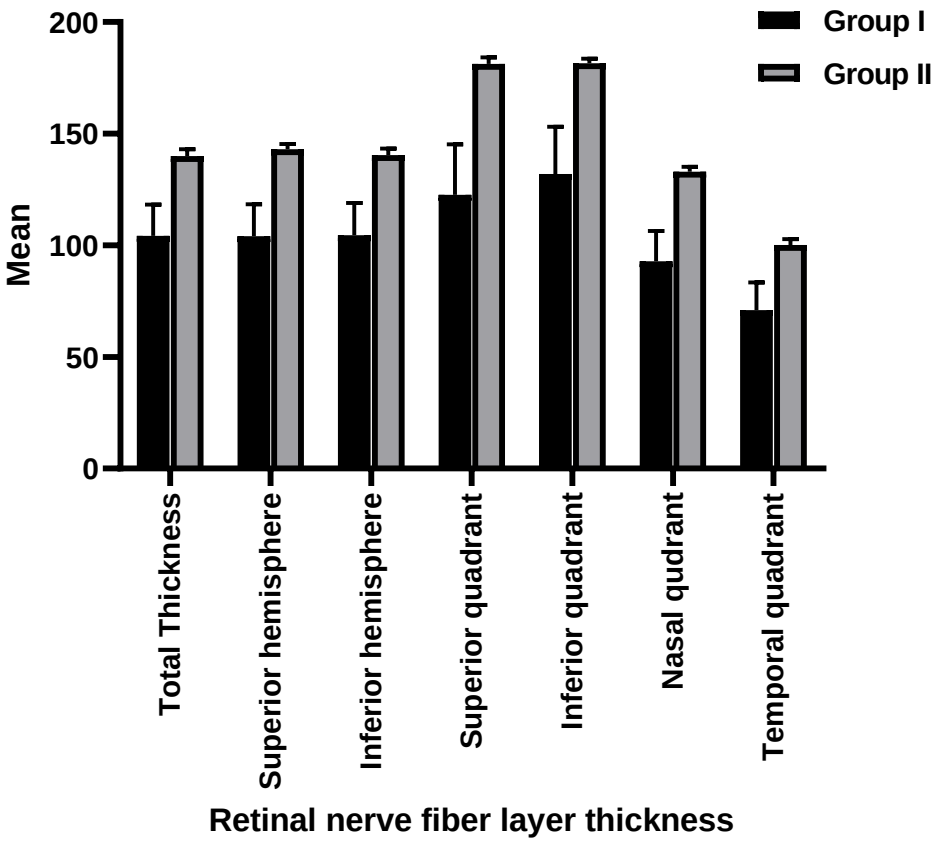

Fig. (2) Retinal nerve fiber layer in the studied groups

❖ ***Correlation between IOP & optic disc perfusion in eyes with ocular hypertension***

There were significant negative correlations between IOP and optic disc perfusion in total peripapilary (r = -0.625 & P = 0.003), superior hemi (r = -0.581 & P = 0.007), inferior hemi (r = -0.644 & P = 0.002), superior quadrant (r = -0.762 & P < 0.001), inferior quadrant (r = -0.697 & P = 0.001), and nasal quadrant (r =-0.520 & P = 0.019) ***(Table 5 & figure 3).***

Table (5) Correlation between IOP and optic disc perfusion

	IOP (mmHg)	
	r	**P**
Total Peripapilary	-.625*	0.003
Superior Hemi	-.581*	0.007
Inferior Hemi	-.644*	0.002
Superior Quadrant	-.762*	<0.001
Inferior Quadrant	-.697*	0.001
Nasal Quadrant	-.520*	0.019
Temporal Quadrant	-0.298	0.201

Pearson's correlation was used r: Correlation coefficient
* Significant

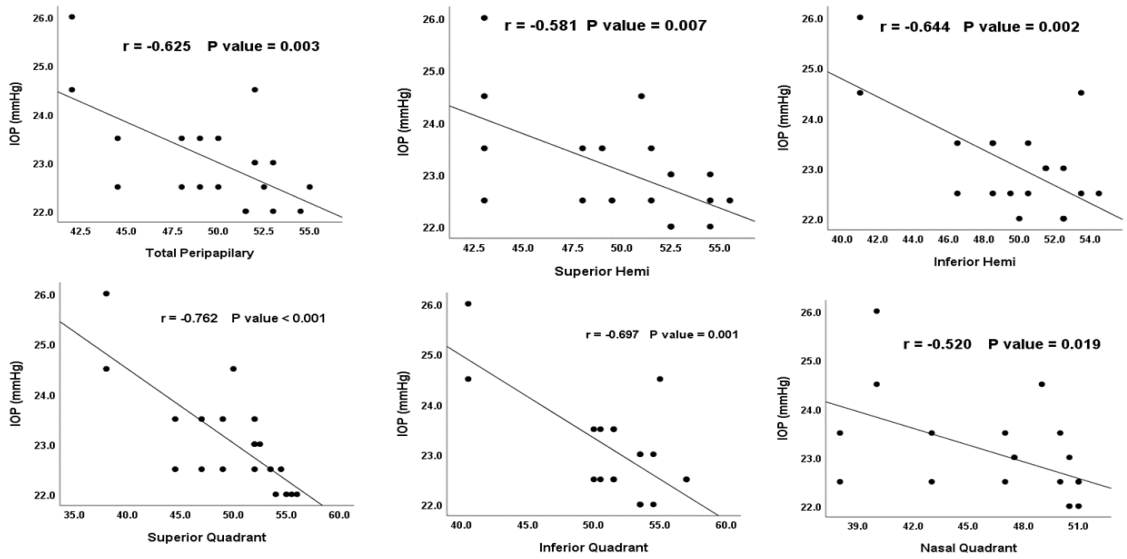

Fig (3) Correlation between IOP and optic disc perfusion

❖ ***Correlation between IOP & retinal nerve fiber thickness in eyes with ocular hypertension***

There were significant negative correlations between IOP and retinal nerve fiber thickness in total peripapilary (r = -0.717 & P < 0.001), superior hemi (r = -0.644 & P = 0.002), inferior hemi (r = -0.745 & P < 0.001), superior quadrant (r = -0.677 & P = 0.001), inferior quadrant (r = -0.757 & P < 0.001), and nasal quadrant (r =-0.596 & P = 0.006) ***(Table 6& figure 4).***

Table (6) Correlation between IOP and retinal nerve fiber layer thickness

	IOP (mmHg)	
	r	**P**
Total Thickness	-.717*	<0.001
Superior Hemi	-.644*	0.002
Inferior Hemi	-.745*	<0.001

Superior Quadrant	-.677*	0.001
Inferior Quadrant	-.757*	<0.001
Nasal Qudrant	-.595*	0.006
Temporal Quadrant	-0.145	0.543

Pearson's correlation was used r: Correlation coefficient
* Significant

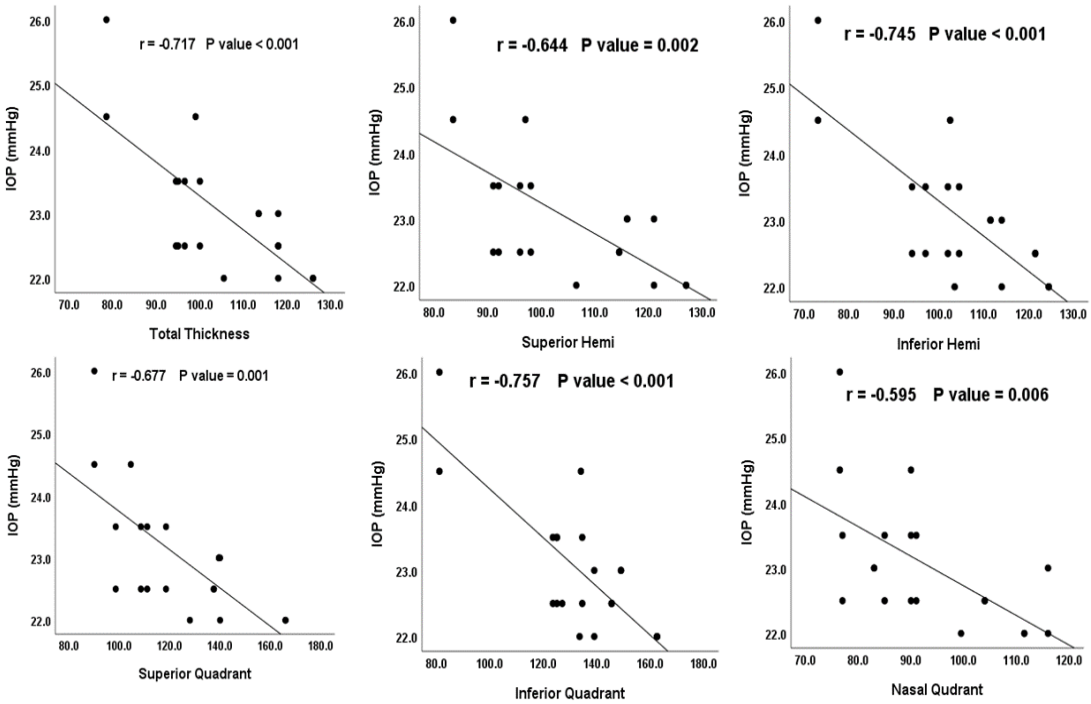

Fig (4) Correlation between IOP and retinal nerve fiber thickness

4. Discussion

There were no statistically significant variations in age or gender between the groups in this investigation.

Previous research demonstrated a statistically significant age difference between hypertensive and control groups, with the former having a mean age of 65.9 and the latter of 58.5. [95% CI, P 0.001]. Both groups consisted of 50% women and 54% women. The hypertension group's mean arterial pressure (MAP) was 9811mmHg, whereas the normotensive group's MAP was 887mmHg (95% CI, P0.001) [7].

Cases had an IOP of 23 mmHg, whereas controls had an IOP of 15.6 mmHg, a statistically significant difference (P 0.001). When comparing cases and controls, we find that BCVA is considerably lower in cases (0.82 decimal) than in controls (0.95 decimal) (P = 0.001).

Although one research found a substantial age and gender gap between the hypertensive group and the control group [7, 8], another study found no such gap between the two groups [9]. There were also no statistically significant differences between the groups in terms of sex, lateralization, intraocular pressure, axial length, best corrected visual acuity, or mean spherical equivalent [11].

In our investigation, we discovered that the total peri-papillary perfusion of the optic disc was considerably lower in cases (49.7%) than in controls (64.3%; P 0.001). Cases had a considerably lower incidence of superior hemisphere involvement (50.1% vs. 62.7%, P 0.001) than controls. Cases had a considerably lower rate in the inferior hemisphere (49.8%) compared to controls (61.7%; P 0.001). It was substantially lower in the superior quadrant in cases (49.8%) compared to controls (61.6%; P 0.001). The percentage of patients with inferior quadrant involvement was 51.7%, which is considerably lower than the control group's 62.6% (P 0.001). It was substantially lower in the nasal quadrant in patients (46.8%) compared to controls (61.5%; P 0.001). Significantly fewer cases (51%) than controls (61%) had it in the temporal quadrant (P 0.001).

In fact, OCTA was employed in a published research comparing Control and OHT participants [12], and the results backed with the findings of another investigation showing no clear changes in vessel density within the superficial vascular plexus (SVPVD). Between Control and OHT, however, IN and T of radial peripapillary capillary vascular density

(RPC-VD) demonstrated statistical significance (P = 0.042 and P = 0.033, respectively) [13].

Our research showed that the thickness of the retinal nerve fibre layer was substantially lower in cases (104.2 Um) than in controls (140 Um) over the whole peri-papillary area (P 0.001). Cases had a superior hemisphere value of 104.1 Um, which was considerably lower than the control group's value of 143.1 Um (P 0.001). Cases had a substantially lower value in the inferior hemisphere (104.5 Um) than controls (140.4 Um) (P 0.001). When comparing cases and controls, the difference between the two values in the upper quadrant was statistically significant (P 0.001), falling from 181.2 Um to 122.6 Um in the former group. It was substantially lower in patients (132 Um) compared to controls (181.6 Um) in the lower visual field. Cases had a substantially reduced value in the nasal quadrant (92.9 Um) compared to controls (132.9 Um) (P 0.001). In the temporal region, the mean value was considerably lower in cases (70.9 Um) compared to controls (100.1 Um) (P 0.001).

Additionally, a prior research demonstrated a 15% average reduction in RNFL thickness in OHT eyes compared with normal eyes. The average thickness of the retinal nerve fibre layer (RNFL) was 72.8 microm (66.4-78.1 microm) in eyes with ocular hypertension, compared to 85.8 microm (80.2-91.7 microm) in normal eyes. In the inferior quadrant, RNFL thickness was 84.8 microm (75.6-94.0 microm) in ocular hypertension eyes compared to 107.6 microm (99.3-115.9) in normal eyes, and 44.1 microm (37.5-51.7 microm) in ocular hypertensive eyes compared to 61.8 microm (53.0-65.6 microm). In glaucomatous eyes, the retinal nerve fibre layer was thinner in all four quadrants and over the whole retina compared to ocular hypertensive eyes and normal eyes [14].

Total peripapilary (r = -0.625, P = 0.003), superior hemi (r = -0.581, P = 0.007), inferior hemi (r = -0.644, P = 0.002), superior quadrant (r = -0.762, P 0.001), inferior quadrant (r = -0.697, P = 0.001), nasal quadrant (r = -0.520, P = 0.019).

Using the linear mixed model, a prior research found that T RPC-VD decreased significantly in OHT participants when the risk factor of IOP more than 21 mmHg was analysed (P = 0.033). While there was no statistically significant association discovered in the IT sector, a general pattern did emerge from the analysis [13]. The reduction in RPC-VD in this research is consistent with the patterns of early glaucomatous alterations, while another study found decreased blood flow in the temporal neuroretinal border of the optic nerve [15].

Treatments that lower intraocular pressure (IOP) have been demonstrated to enhance retinal circulation and minimise the risk of glaucoma in patients with open-angle glaucoma (OHT), according to a prior research. These findings corroborate the impact that elevated intraocular pressure has on blood flow to the eyes. High intraocular pressure also increases the risk of venous collapse, which further reduces blood flow. Although longitudinal data are still need to completely assess this potential, OCTA demonstrates the distinction of capillary VD due to high IOP in OHT participants and might serve as a precise approach to monitor disease progression [16].

Total peripapilary thickness was negatively correlated with IOP (r = -0.717, P 0.001), as were thicknesses in the superior (r = -0.644, P = 0.002) and inferior (r = -0.745, P 0.001) hemifields, the superior (r = -0.677, P = 0.001) and inferior (r = -0.757, P 0.001) quadrants, and the nasal (r =

A similar finding was observed in another investigation, which found that even in individuals with ocular hypertension who had normal visual fields and no abnormalities in RNFL thickness, there was a drop in perfusion to the peripapillary optic disc. The perfusion of the peripapillary optic disc was 53.94 percent in the superior temporal area and 53.9 percent in the inferior temporal area [17].

5. Conclusion

Our results showed that individuals with ocular hypertension had thinner RNFLs in the superior hemisphere, inferior hemisphere, superior hemisphere, inferior hemisphere, superior hemisphere, nasal axis, and temporal axis compared to healthy controls. The AngioVue OCT was used to collect such measurements (Optvue).

Thus, we advise ophthalmologists to use OCTA to quantify vessel density and RNFL thickness in the peripapillary region and to track any changes that may occur in patients with ocular hypertension. Furthermore, they are able to monitor the development of the illness and avert the onset of primary open angle glaucoma.

References

[1] Boey PY and Mansberger SL: Ocular hypertension: an approach to assessment and management. Can J Ophthalmol,vol.49,pp.489–96,2014.

[2] Beiser JA, Brandt JD,CA , Gordon MO ,Heuer DK, Higginbotham EJ, Johnson et al: The Ocular Hypertension Treatment Study: baseline factors that predict the onset of primary open-angle glaucoma. Arch Ophthalmol,vol.120,pp.714–20,2002.

[3] Costa VP, Flammer J, Krieglstein GK, Orgül S, Orzalesi N, Serra LM, et al: The impact of ocular blood flow in glaucoma. Progress in retinal and eye research,vol.21,pp.389-93,2002.

[4] Katsanos A, Quaranta L, Riva I, and Russo A: 24-hour intraocular pressure and ocular perfusion pressure in glaucoma. Surv Ophthalmol.,vol.58,pp.26–41,2013.

[5] Hayreh SS. "Blood Flow in the Optic Nerve Head and Factors That May Influence It." Progress in Retinal and Eye Research ,vol.20 (5),pp.595– 624(2001).

[6] Akil H, Falavarjani KG, Sadda SR, and Sadun AA. "Optical Coherence Tomography Angiography of the Optic Disc; an Overview." Journal of Ophthalmic & Vision Research,vol. 12 (1),pp.98–105,2017.

[7] Sun, C., Ladores, C., Hong, J., Nguyen, D. Q., Chua, J., Ting, D., ... & Tan, A.. Systemic hypertension associated retinal microvascular changes can be detected with optical coherence tomography angiography. Scientific reports,vol.10(1),pp.1-9,2020.

[8] Van Melkebeke, L., Barbosa-Breda, J., Huygens, M., & Stalmans, I. Optical coherence tomography angiography in glaucoma: a review. Ophthalmic research,vol.60(3), ,pp.139-151,2018.

[9] Anjos, R., Ferreira, A., Barkoudah, E., Claggett, B., Abegão Pinto, L., & Miguel, A. Application of optical coherence tomography angiography macular analysis for systemic hypertension. A systematic review and meta-analysis. American journal of hypertension,vol.25,pp.45-60,2021.

[10] Rao, H. L., Srinivasan, T., Pradhan, Z. S., Sreenivasaiah, S., Rao, D. A., Puttaiah, N. K., ... & Weinreb, R. N. Optical coherence tomography angiography and visual field progression in primary angle closure glaucoma. Journal of Glaucoma,vol.30(3),pp. 61-67,2021.

[11] Lee, W. H., Park, J. H., Won, Y., Lee, M. W., Shin, Y. I., Jo, Y. J., & Kim, J. Y. Retinal microvascular change in hypertension as measured by optical coherence tomography angiography. Scientific reports,vol.9(1),pp.1-7,2019.

[12] Yarmohammadi, A., Zangwill, L. M., Diniz-Filho, A., Suh, M. H., Manalastas, P. I., Fatehee, N., ... & Weinreb, R. N. Optical coherence tomography angiography vessel density in healthy, glaucoma suspect, and glaucoma eyes. Investigative ophthalmology & visual science,vol. 57(9),pp451-459,2016.

[13] Bowd, C., Weinreb, R. N., Williams, J. M., & Zangwill, L. M. The retinal nerve fiber layer thickness in ocular hypertensive, normal, and glaucomatous eyes with optical coherence tomography. Archives of ophthalmology,vol.118(1),pp.22-26,2000.

[14] Kerr, J., Nelson, P., & O'Brien, C. A comparison of ocular blood flow in untreated primary open-angle glaucoma and ocular hypertension. American journal of ophthalmology,vol. 126(1),pp.42-51,1998.

[15] Morse, A. R., & Lee, P. P. Comparative effectiveness: insights on treatment options for open-angle glaucoma. Archives of Ophthalmology,vol.130(4),pp.506-507,2012.

[16] Holló, G. Vessel density calculated from OCT angiography in 3 peripapillary sectors in normal, ocular hypertensive, and glaucoma eyes. European journal of ophthalmology,vol.26(3),pp. 42- 45,2016.