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# Assessment of Juxta Papillary Retinal Fiber Layer in Normal Blood Pressure, Controlled and Uncontrolled Hypertensive Patients

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ORIGINAL ARTICLE

# Assessment of Juxta Papillary Retinal Fiber Layer in Normal Blood Pressure, Controlled and Uncontrolled Hypertensive Patients

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Abstract

*Background:* ***Renal vascular damage resulting from hypertension (HTN) is referred to as hypertensive retinopathy (HR). Generally, symptoms manifest later in the illness. Changes in the vascular wall, arteriovenous nicking, arteriolar constriction, flame-shaped hemorrhages, yellow hard exudates, cotton-wool spots, and optic disk edema are seen in the funduscopic examination.***

*Aim:* ***To investigate alterations in the juxta papillary retinal nerve fiber layer (RNFL) in cases with uncontrolled systemic HTN compared to controlled systemic HTN and normotensive eyes utilizing Spectral Domain Optical Coherence Tomography (SD-OCT).***

*Patients and Methods:* ***A twelve-month cross-sectional trial was conducted on cases with localized defects in RNFL and normal subjects. Sixty eyes were enrolled and divided into three groups: the first group included 20 eyes with uncontrolled systemic HTN patients, the second group included 20 eyes with controlled systemic HTN patients, and the third group included 20 eyes with normal blood pressure (BP).***

*Results:* ***The total macular volume (TMV) showed the most significant diagnostic performance and features in distinguishing uncontrolled HTN from managed HTN. Regarding distinguishing managed HTN from normal BP, the TMV showed the most excellent diagnostic performance and features.***

*Conclusion:* ***Significant reductions in the thickness of RNFL and macula were seen in cases with uncontrolled systemic HTN compared to those with managed systemic HTN and normotensive eyes. This investigation validated the significance of OCT in HR monitoring.***

*Keywords:* Juxta Papillary Retinal Fiber Layer ; Hypertensive Retinopathy ; Spectral Domain Optical Coherence Tomography

## 1. Introduction

HTN is a significant risk factor for further retinal diseases (e.g., diabetic retinopathy, retinal artery or vein occlusion). Hypertension also significantly elevates the likelihood of visual loss. Patients with hypertensive retinopathy (HR) [1] are at a considerable risk of hypertensive damage to other end organs.

Vision deterioration in hypertension individuals often manifests prior to the development of clinical retinopathy; this likely signifies the initial indications of neuronal dysfunction. [2]

One of the crucial structural neurons in the retinal layers, the retinal nerve fiber layer (RNFL), is frequently shown to be compromised during the initial HR pathological stages. Many researchers have documented RNFL abnormalities or thinning in cases with HTN. [3]

There have also been reports of RNFL loss in individuals with HTN without HR but poorly managed blood glucose. RNFL defect may, therefore, be regarded as an additional ocular manifestation of HTN besides HR. Because RNFL loss is permanent and may lead to hypertensive optic nerve (ON) dysfunction, its evaluation is critical.. [4]

Optical coherence tomography (OCT) offers a precise and objective quantitative assessment of the thickness of the RNFL and the ON head with great accuracy and resolution. Many authors have shown clinical decreases in total central retinal or single cellular layer thickness in hypertensive eyes, both with and without HR signs, in comparison to control groups (cases without HR). [5]

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Hypotensive individuals with mild HR have been reported to have a reduction in the inner retinal thickness in the macular area. This may result from first ganglion cell loss in the pericentral regions, followed by RNFL thinning in the peripheral macula. [6]

Spectral Domain Optical Coherence Tomography's (SD-OCT) automatic layering of retinal structures may be a valuable monitoring and diagnostic tool for early HR intraretinal changes. Early diagnosis of RNFL thinning may enable ophthalmologists to reduce vision loss by successfully treating HR and early prevention. [7]

Our objective was to study the juxta papillary RNFL changes in cases with uncontrolled systemic HTN using SD-OCT in comparison to controlled systemic HTN and normotensive eyes.

## 2. Patients and methods

### 2.1.Study Design and Setting

A cross-sectional trial was performed over twelve months duration; cases with localized defects in RNFL and healthy subjects were consecutively recruited in the period from September 1st, 2021, to October 1st, 2022, in the Ophthalmology Department of Memorial Institute of Ophthalmology Hospital and Al-Hussain Hospital, Al-Azhar University. In this trial, 60 eyes were enrolled and divided into three different groups; the first group included 20 eyes with uncontrolled systemic HTN patients, the second group included 20 eyes with controlled systemic HTN patients, and the third group included 20 eyes with normal blood pressure (BP). Eyes that exhibited localized RNFL defects, as identified by clinical evaluation, were included. The control group consisted of ocular disease-free participants who were chosen among those referred for a regular visual acuity assessment and were in good health.

### 2.2.Ethical Consideration

Institutional ethics approval was obtained before the start of the study. Between September 1st, 2021, and October 1st, 2022, all consecutive patients in the Memorial Institute of Ophthalmology Hospital and Al-Hussein Hospital, Al-Azhar University, controlled and uncontrolled HTN and regular patients, were included in the experiment. All individuals included in the experiment were provided with information about the trial's protocols and were duly advised of their right to decline participation or withdraw from the research without the obligation to explain.

Inclusion criteria

140/90 mmHg were considered hypertensive and received anti-hypertensive drugs and cases who did not receive anti-hypertensive drugs. Patients with an average BP value of 80/120 mmHg were measured.

### 2.3.Methods

Identifying and Evaluation

All subjects were subjected to a complete ophthalmologic examination, including History taking (age, occupation, ocular history, past surgical history, past medical history), and admission to the internal medicine outpatient clinic for a comprehensive clinical evaluation, including BP assessment.

2.4.Ophthalmologic Examination: Comprehensive ocular examination of both eyes, which comprises: Best Corrected Visual acuity, intraocular pressure, objective refraction, slit lamp examination, pupil reaction to light, motility examination, fundus examination, color vision (red, green).

2.5.SD-OCT Procedure: Peripapillary RNFL thickness measurements were obtained by Spectralis SD-OCT with Spectralis software, version 4.0 (Heidelberg Engineering, Heidelberg, Germany). Three scans were obtained for each test eye, and the mean was used for the analysis. SD-OCT software calculates the thickness of RNFL for the four quadrants (nasal, temporal, superior, inferior, each 90°) and the average thickness (overall global thickness). The signal strength (range: 0–40 db) of every scan was reviewed, and scans with signal strength of < 15 db were excluded from the analysis. OCT imaging was conducted with the subjects' pupils dilated to get signals of superior quality. In order to acquire pictures with minimum measurement errors, scans with signal strengths below eight were excluded from the investigation. OCT with an optic disc 200 × 200 cube scan procedure along a circle measuring 3.46 mm in diameter encircling the center of the optic disc yielded the average thicknesses of the RNFL in the nasal, temporal, superior, and inferior quadrant peripapillaries.

The same ophthalmologist conducted OCT imaging while maintaining patient anonymity.

### 2.6.Statistical Analysis

IBM SPSS Statistics (Statistical Package for Social Sciences) software version 28.0, IBM Corp., Chicago, USA, 2021, was used for the statistical analysis of the data. Shapiro-Wilk test was used for testing the normality of the quantitative variables, then displayed as mean± standard deviation (SD) in addition to minimum and maximum of the range, and then compared using ANOVA test (three independent groups) and independent t-test (two independent groups). Qualitative variables with small expected numbers were displayed as frequency and percentage and compared using Fisher's Exact test for variables—Bonferroni test was used for post hoc comparisons. Pearson test was used for correlations. The ROC curve was employed to assess the performance of various tests to distinguish across groups. A two-

tailed p-value <0.05 was deemed significant.

The calculation for diagnostic characteristics is as follows:

Specificity = (True negative test / Total negative golden) x 100

Sensitivity = (True positive test / Total positive golden) x 100

Predictive positive value = (True positive test / Total positive test) x 100

Predictive negative value = (True negative test / Total negative test) x 100

Diagnostic accuracy = ([True positive test + True negative test] / Total cases) x 100

## 3. Results

Table 1 showed that: Among Uncontrolled HTN, Controlled HTN and Normal BP groups, age was 55.5±3.2, 56.4±3.0 and 56.7±2.9 respectively. Male sex was 13 (65.0%), 11 (55.0%) and 13 (65.0%) respectively, while duration of HTN was 11.7±3.6 and 10.2±3.5 respectively. No statistical significant variation was reported regarding demographics; age, gender and duration of HTN between the study groups. Among Uncontrolled HTN, Controlled HTN and Normal BP groups, BCVA was 0.8±0.2, 0.8±0.1 and 0.8±0.2 respectively. No statistical significant differences between the study groups regarding BCVA (p-value= 0.933). Among Uncontrolled HTN, Controlled HTN and Normal BP groups, IOP was 16.1±1.4, 15.7±1.9 and 16.0±2.2 respectively. No statistical significant differences between the study groups regarding IOP (p-value=0.782).

*Table 1. Demographics, BCVA (Best Corrected Visual Acuity) (LogMar) and IOP among the studied groups*

| VARIABLES | MEASURES | UNCONTROLLED HYPERTENSION (N=20) | CONTROLLED HYPERTENSION (N=20) | NORMAL BLOOD PRESSURE (N=20) | P-VALUE |
|---|---|---|---|---|---|
| AGE (YEARS) | Mean±SD | 55.5±3.2 | 56.4±3.0 | 56.7±2.9 | ^0.421 |
| | Range | 51.0–62.0 | 52.0–61.0 | 51.0–64.0 | |
| GENDER (N,%) | Male | 13 (65.0%) | 11 (55.0%) | 13 (65.0%) | §0.754 |
| | Female | 7 (35.0%) | 9 (45.0%) | 7 (35.0%) | |
| DURATION OF HYPERTENSION (YEARS) | Mean±SD | 11.7±3.6 | 10.2±3.5 | | #0.189 |
| | Range | 6.0–18.0 | 6.0–17.0 | | |
| BCVA | Mean±SD | 0.8±0.2 | 0.8±0.1 | 0.8±0.2 | ^0.933 |
| | Range | 0.5–1.2 | 0.5–1.0 | 0.7–1.2 | |
| IOP | Mean±SD | 16.1±1.4 | 15.7±1.9 | 16.0±2.2 | ^0.782 |
| | Range | 14.0–19.0 | 13.0–20.0 | 13.0–20.0 | |

^ANOVA test. §Fisher's Exact test. #Independent t-test.

Table 2 showed that: Among Uncontrolled HTN, controlled HTN and Normal BP groups, Superior RFNL was 122.9±12.9, 136.9±16.3 and 152.2±13.5 respectively), inferior RFNL was 116.7±12.8, 130.7±16.5 and 146.1±13.6 respectively, nasal RFNL was 78.6±8.5, 87.9±10.5 and 97.7±8.6 respectively, Temporal RFNL was 70.1±7.4, 78.0±9.0 and 87.0±7.9 respectively, while average RFNL was 97.2±10.4, 108.5±13.0 and 120.7±10.9 respectively. RFNL thickness was highest in normal BP group, followed by controlled HTN group and lowest in uncontrolled HTN group, the variations were significant between all the study groups (p <0.05). Among Uncontrolled HTN, controlled HTN and Normal BP groups, Central macular thickness was 254.1±14.0, 266.0±16.4 and 277.4±13.1 respectively, Average macular thickness was 203.1±13.9, 214.7±16.4 and 226.3±12.9 respectively, while Total macular volume (TMV) was 7.4±0.2, 7.8±0.3 and 8.1±0.3 respectively. TMV and macular thickness were highest in normal BP group, followed by controlled HTN group and lowest in uncontrolled HTN group, the differences were significant between all the study groups (p-value <0.05).

*Table 2. RFNL thickness (µm) and Macular findings among the studied groups*

| | SITE | MEASURES | UNCONTROLLED HYPERTENSION (N=20) | CONTROLLED HYPERTENSION (N=20) | NORMAL BLOOD PRESSURE (N=20) | P-VALUE |
|---|---|---|---|---|---|---|
| RFNL THICKNESS | Superior | Mean±SD | 122.9±12.9a | 136.9±16.3b | 152.2±13.5c | ^<0.001* |
| | | Range | 98.0–148.0 | 100.0–169.0 | 136.0–186.0 | |
| | Inferior | Mean±SD | 116.7±12.8a | 130.7±16.5b | 146.1±13.6c | ^<0.001* |
| | | Range | 92.0–141.0 | 93.0–163.0 | 130.0–180.0 | |
| | Nasal | Mean±SD | 78.6±8.5a | 87.9±10.5b | 97.7±8.6c | ^<0.001* |
| | | Range | 62.0–94.0 | 65.0–108.0 | 87.0–119.0 | |
| | Temporal | Mean±SD | 70.1±7.4a | 78.0±9.0b | 87.0±7.9c | ^<0.001* |
| | | Range | 56.0–86.0 | 57.0–95.0 | 76.0–107.0 | |
| | Average | Mean±SD | 97.2±10.4a | 108.5±13.0b | 120.7±10.9c | ^<0.001* |
| | | Range | 77.0–117.0 | 79.0–134.0 | 107.0–148.0 | |
| MACULAR FINDINGS | Central macular thickness (µm) | Mean±SD | 203.1±13.9a | 214.7±16.4b | 226.3±12.9c | ^<0.001* |
| | | Range | 179.0–229.0 | 189.0–251.0 | 207.0–253.0 | |
| | Average macular thickness (µm) | Mean±SD | 254.1±14.0a | 266.0±16.4b | 277.4±13.1c | ^<0.001* |
| | | Range | 229.0–280.0 | 240.0–301.0 | 257.0–304.0 | |
| | Total macular volume ($mm^3$) | Mean±SD | 7.4±0.2a | 7.8±0.3b | 8.1±0.3c | ^<0.001* |
| | | Range | 6.9–7.8 | 7.1–8.3 | 7.6–8.6 | |

^ANOVA test. Homogenous groups had the same symbol "a, b, c" base on post hoc Bonferroni test. *Significant.

Table 3 showed that: In both of uncontrolled HTN group and controlled HTN group; a significant negative correlations was reported between duration of HTN and each of RFNL thickness, macular volume and macular thickness. No significant correlation between duration of HTN and each of BCVA and IOP.

*Table 3. Correlation between duration of HTN and the studied parameters among the studied groups*

| VARIABLES | MEASURES | DURATION OF HYPERTENSION | |
|---|---|---|---|
| | | Uncontrolled hypertension (n=20) | Controlled hypertension (n=20) |
| BCVA | r | -0.035 | 0.338 |
| | p-value | 0.885 | 0.145 |
| IOP | r | -0.216 | 0.121 |
| | p-value | 0.360 | 0.611 |
| SUPERIOR RFNL | r | -0.765 | -0.663 |
| | p-value | <0.001* | 0.001* |
| INFERIOR RFNL | r | -0.763 | -0.664 |
| | p-value | <0.001* | 0.001* |
| NASAL RFNL | r | -0.763 | -0.681 |
| | p-value | <0.001* | 0.001* |
| TEMPORAL RFNL | r | -0.771 | -0.682 |
| | p-value | <0.001* | 0.001* |
| AVERAGE RFNL | r | -0.774 | -0.674 |
| | p-value | <0.001* | 0.001* |
| CENTRAL MACULAR THICKNESS | r | -0.771 | -0.688 |
| | p-value | <0.001* | 0.001* |
| AVERAGE MACULAR THICKNESS | r | -0.749 | -0.654 |
| | p-value | <0.001* | 0.002* |
| TOTAL MACULAR VOLUME | r | -0.739 | -0.738 |
| | p-value | <0.001* | <0.001* |

r: Correlation coefficient. Pearson correlation test. *Significant.

Table 4 and Figure 1 showed that: Total macular volume statistically had the highest significant diagnostic performance and characteristics in differentiating uncontrolled hypertension from controlled hypertension.

*Table 4. Diagnostic performance and characteristics of the studied parameters in differentiating uncontrolled HTN from controlled HTN*

| VARIABLES | AUC | P-VALUE | CUT POINT | SENSITIVITY | SPECIFICITY | DA | PPV | NPV |
|---|---|---|---|---|---|---|---|---|
| BCVA | 0.516 | 0.860 | 0.8 | 55.0% | 55.0% | 55.0% | 55.0% | 55.0% |
| IOP | 0.415 | 0.358 | 16.5 | 70.0% | 30.0% | 16.0% | 2.9% | 23.5% |
| SUPERIOR RFNL | 0.750 | 0.007* | 130.5 | 70.0% | 70.0% | 70.0% | 70.0% | 70.0% |
| INFERIOR RFNL | 0.755 | 0.006* | 124.5 | 75.0% | 70.0% | 72.5% | 71.4% | 73.7% |
| NASAL RFNL | 0.750 | 0.007* | 82.5 | 65.0% | 70.0% | 67.5% | 68.4% | 66.7% |
| TEMPORAL RFNL | 0.760 | 0.005* | 76.5 | 80.0% | 65.0% | 72.5% | 69.6% | 76.5% |
| AVERAGE RFNL | 0.755 | 0.006* | 103.5 | 70.0% | 70.0% | 70.0% | 70.0% | 70.0% |
| CENTRAL MACULAR THICKNESS | 0.689 | 0.041* | 213.5 | 85.0% | 50.0% | 67.5% | 63.0% | 76.9% |
| AVERAGE MACULAR THICKNESS | 0.698 | 0.033* | 251.5 | 50.0% | 90.0% | 70.0% | 83.3% | 64.3% |
| TOTAL MACULAR VOLUME | 0.855 | <0.001* | 7.6 | 75.0% | 85.0% | 80.0% | 83.3% | 77.3% |

AUC: Area under curve. *Significant. DA: Diagnostic accuracy. NPV: Negative Predictive value. PPV: Positive Predictive value.

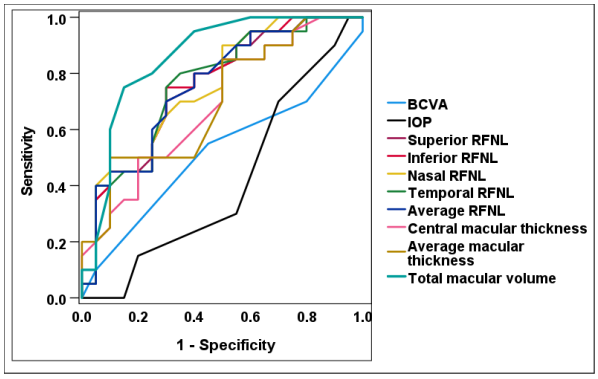


Figure 1. ROC (Receiver Operating Characteristics) curve for the studied parameters in differentiating uncontrolled HTN from controlled HTN.

Table 5 and Figure 2 showed that: Total macular volume statistically had the highest significant diagnostic performance and characteristics in differentiating controlled hypertension from normal blood pressure.

*Table 5. Diagnostic performance and characteristics of the studied parameters in differentiating controlled HTN from normal BP*

| VARIABLES | AUC | P-VALUE | CUT POINT | SENSITIVITY | SPECIFICITY | DA |
|---|---|---|---|---|---|---|
| BCVA | 0.493 | 0.935 | 1.0 | 80.0% | 30.0% | 55.0% |
| IOP | 0.518 | 0.850 | 17.5 | 85.0% | 25.0% | 55.0% |
| SUPERIOR RFNL | 0.785 | 0.002* | 141.0 | 65.0% | 75.0% | 70.0% |
| INFERIOR RFNL | 0.785 | 0.002* | 130.5 | 55.0% | 90.0% | 72.5% |
| NASAL RFNL | 0.771 | 0.003* | 87.5 | 50.0% | 95.0% | 72.5% |
| TEMPORAL RFNL | 0.778 | 0.003* | 78.5 | 55.0% | 90.0% | 72.5% |
| AVERAGE RFNL | 0.776 | 0.003* | 108.5 | 55.0% | 90.0% | 72.5% |
| CENTRAL MACULAR THICKNESS | 0.724 | 0.015* | 209.5 | 50.0% | 90.0% | 70.0% |
| AVERAGE MACULAR THICKNESS | 0.728 | 0.014* | 260.5 | 50.0% | 90.0% | 70.0% |
| TOTAL MACULAR VOLUME | 0.791 | 0.002* | 7.8 | 60.0% | 90.0% | 75.0% |

AUC: Area under curve. *Significant. DA: Diagnostic accuracy. PPV: Positive Predictive value. NPV: Negative Predictive value

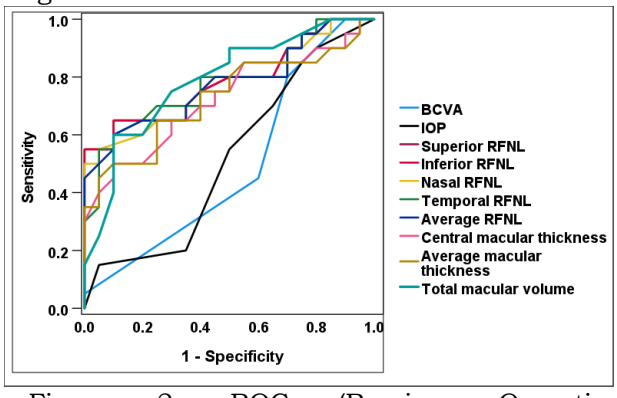


Figure 2. ROC (Receiver Operating Characteristics) curve for the studied parameters in differentiating controlled HTN from normal BP.

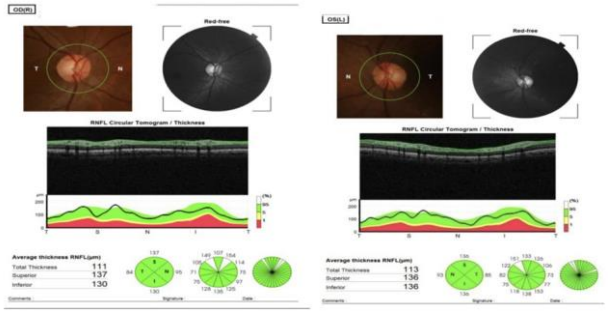

Figure 3. Example of OCT RNFL of both eyes in normal BP.

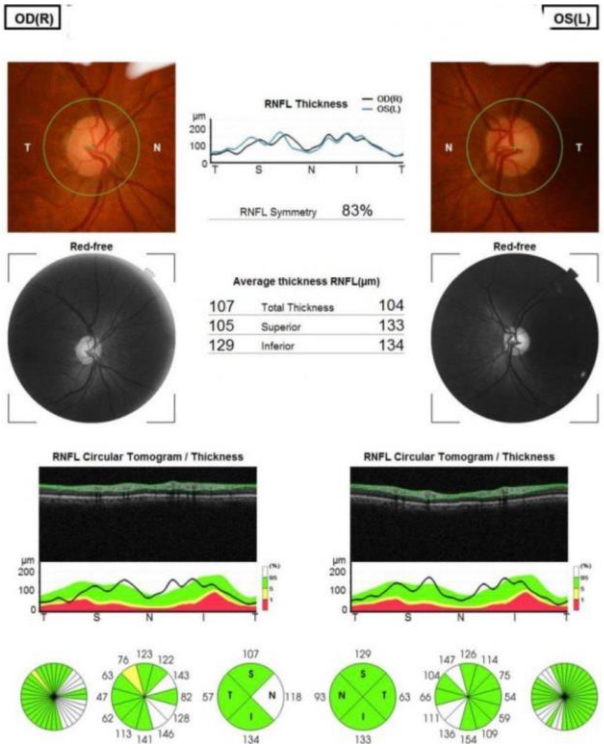


Figure 4. Example of OCT RNFL both eyes in controlled HTN group.

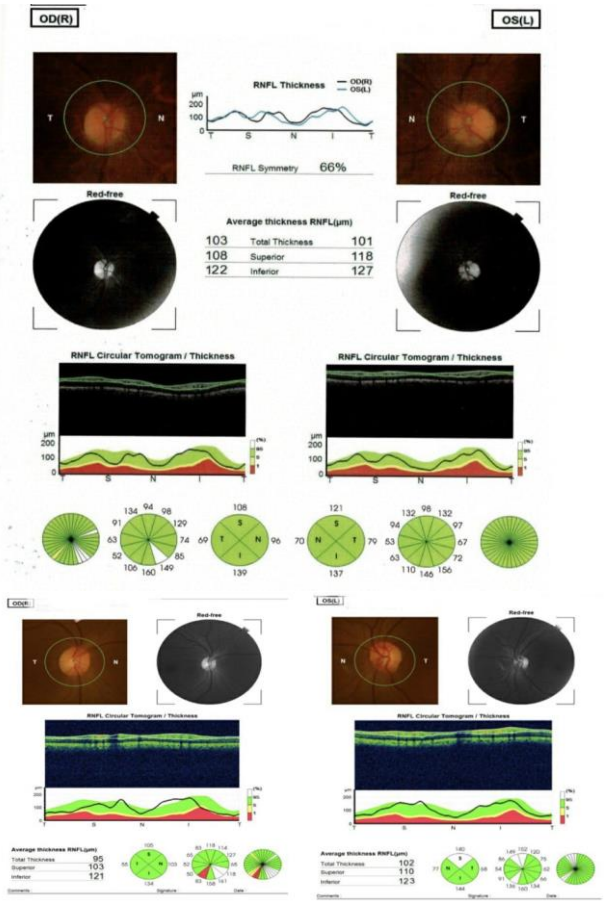


Figure 3. Example of OCT RNFL both eyes in uncontrolled HTN group.

## 4. Discussion

In hypertensive individuals, indications of retinal damage induced by HTN are seen prior to the onset of clinical symptoms and manifestation of damage to the targeted organ. There were statistically significant decreases in both RNFL and macular thickness seen one year after the resolution of the retinal alterations that were apparent during the initial phase of HTN . [8]

Macular and peripapillary RNFL thickness examination using OCT may be a significant clinical practice tool for enhancing the diagnosis, prognosis, and management of systemic HTN . [9]

In our study, the age of the uncontrolled HTN, controlled HTN, and Normal BP groups were 55.5±3.2, 56.4±3.0, and 56.7±2.9, respectively. Male sex was 13 (65.0%), 11 (55.0%), and 13 (65.0%), respectively, while the duration of HTN was 11.7±3.6 and 10.2±3.5, respectively. No significant variation was reported regarding demographics, age, gender, and duration of HTN between the study groups.

In our study, the BCVA of the uncontrolled HTN, controlled HTN, and Normal BP groups were 0.8±0.2, 0.8±0.1, and 0.8±0.2, respectively. No significant variation regarding BCVA between the study groups was reported.

In our study, the IOP of the uncontrolled HTN, controlled HTN, and Normal BP groups were 16.1±1.4, 15.7±1.9, and 16.0±2.2, respectively. No statistically significant differences regarding IOP were reported between the study groups.

This agrees with Lee et al.[10] who reported no significant variation in age between groups B and D ($p = 0.327$) or groups A and C ($p = 0.877$). No significant variation was reported in sex, BCVA, and IOP between the studied groups.

This is in contrast with Henderson et al.[11] who suggested that younger individuals may be more susceptible to Grade III/IV HTNR in the context of hypertensive urgency due to the potential lack of development of chronic compensatory mechanisms.

In our study, among uncontrolled HTN, controlled HTN and Normal BP groups, Superior RFNL was 122.9±12.9, 136.9±16.3 and 152.2±13.5 respectively), inferior RFNL was 116.7±12.8, 130.7±16.5 and 146.1±13.6 respectively, nasal RFNL was 78.6±8.5, 87.9±10.5 and 97.7±8.6 respectively, Temporal RFNL was 70.1±7.4, 78.0±9.0 and 87.0±7.9 respectively, while average RFNL was 97.2±10.4, 108.5±13.0 and 120.7±10.9 respectively. RFNL thickness was highest in the regular BP group, followed by the controlled HTN group, and lowest in the uncontrolled HTN group; the variations were significant between all the study groups ($p < 0.05$).

An investigation similarly documented that patients with HR had significantly reduced CMT and RNFL thickness compared to the standard control group. In ocular illnesses, while determining the thickness of RNFL and central macula, it is crucial to account for the influence of retinal alterations linked to systemic conditions like HTN. [8]

Localized RNFL defects, along with retinal microvascular abnormalities such as generalized and localized arteriolar thinning, reduced arteriolar/venular diameter ratio, and arteriovenous nicking, were found to be associated with various grades of arterial HTN. These findings suggest that localized RNFL defects could be a retinal marker for arterial HTN.[12]

Furthermore, Rezk et al.[13] showed a highly significant reduction in the thickness of peri-papillary temporal, superior, and inferior parts of RNFL and the average total thickness of RNFL ($p < 0.001$ for all), the nasal part thickness of peri-papillary RNFL was significantly reduced in HTN eyes group in comparison to normotensive control eyes ($p < 0.007$ for all).

A recent extensive meta-analysis found that HTN patients had a reduced pRNFL thickness. [14]

Cantor et al.[15] found that Reduced perfusion pressure may induce ischemia in the ON or retinal ganglion cells, leading to glaucomatous injury in individuals with HN. Hence,

microvascular pathology, including increased resistance, rigidity, atherosclerosis, inadequate autoregulation, and HTN-induced ischemia, may account for the primary cause of the decrease in pRNFL. This mechanism is comparable to the proposed explanation for the decrease in pRNFL observed in diabetic cases without retinopathy. [16]

In a cross-sectional study aimed at examining the relationship between the thickness of RNFL and BP in systemic HTN cases, the researchers found a relationship between higher SBP, DBP, and MAP and thinner thicknesses of RNFL. [17]

Prior research has demonstrated a relation between RNFL thinning and decreased blood flow in glaucoma cases. [18]

McGlynn et al.[19] found an association of lower DBP with more progressive RNFL loss (P<0.006, 95% CI 0.1–0.6, OR=0.2 per 10mmHg).

In contrast to the superior, inferior, and nasal subfields, the distance between the optic disc and the temporal subfield regions is greater. The periphery of the calibers of retinal arteries is decreased. One may postulate that systemic HTN might have a more pronounced impact on the narrower retinal arterioles responsible for supplying the temporal subfields, as opposed to the bigger retinal arterioles that feed the nasal subfields. Consequently, temporal subfield ischemia induced by systemic HTN may result in more pronounced retinal cell injury and loss. [20]

In our study, among Uncontrolled HTN, controlled HTN, and Normal BP groups, Central macular thickness was 254.1±14.0, 266.0±16.4 and 277.4±13.1, respectively, and Average macular thickness was 203.1±13.9, 214.7±16.4 and 226.3±12.9 respectively, while TMV was 7.4±0.2, 7.8±0.3 and 8.1±0.3 respectively. TMV and macular thickness were highest in the regular BP group, followed by the controlled HTN group, and lowest in the uncontrolled HTN group; the differences were significant between all the study groups (p<0.05).

This agrees with Rezk et al.[13] who reported that macular thickness (including Central Macular thickness, Average Macular thickness, and TMV) was significantly reduced in the HTN eye group in comparison to normotensive control eyes (p< 0.001 for all). These findings were consistent with the majority of prior researchers.

Except for the fovea, hypertensive cases were discovered to have a considerably reduced macular thickness in most subfields. This arteriolar alteration affected the thickness of the macula. Since the foveal avascular zone, an avascular region (central subfield), is less susceptible to hypertensive vascular alterations, macular thickness exhibited less affection with systemic HTN . [21]

According to some reports, a decrease in the thickness of ganglion cell complexes may serve as a more reliable retinal marker for changes in arterial hypertension compared to macular thickness and RNFL. One of the most significant reductions in RNFL thickness was seen in the inner temporal area. In systemic HTN cases, the temporal subfields are predominantly impacted. No significant correlation was seen between nasal subfields and clinical parameters. [13]

In our study, significant negative correlations were reported between the duration of HTN and each RFNL thickness, macular volume, and macular thickness in both the uncontrolled HTN group and the controlled HTN group. There was no significant correlation between the duration of HTN and each of BCVA and IOP.

Lee et al.[10] Found no significant effect of the duration of HTN on the reduction in pRNFL thickness (P = 0.837). Prior to receiving therapy or a diagnosis of HTN, patients may have potentially presented with the condition for a prolonged duration; hence, the precise duration of HTN may vary.

In our study, TMV was the most statistically significant regarding diagnostic performance and characteristics in differentiating uncontrolled HTN from controlled HTN.

In our study, TMV had the greatest statistical significance in terms of diagnostic performance and characteristics in differentiating controlled HTN from normal BP.

Rezk et al.[13] reported that all three parameters (total RNFL thickness, average macular thickness, and TMV) have high diagnostic accuracy for identifying HTN, with AUC values ranging from 0.864 to 0.976. The total RNFL thickness parameter has the highest diagnostic accuracy, with an AUC of 0.976. The sensitivity, specificity, accuracy, PPV, and NPV values for all three parameters are also high, ranging from 97.5% to 100% for most measures. However, it is essential to note that the cut-off points for each parameter are different, with the total RNFL thickness having a cut-off point of <85, the TMV having a cut-off point of <6.75, and the average macular thickness having a cut-off point of <238.9.

### *4. Conclusion*

Compared to normotensive eyes and patients with managed systemic HTN, individuals with uncontrolled systemic HTN have exhibited significant macular and RNFL thickness reductions. This research validated the significance of OCT in HR monitoring.

## Disclosure

The authors have no financial interest to declare in relation to the content of this article.

## Authorship

All authors have a substantial contribution to the article

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