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Original Article

Measurement of Sub Foveal Choroidal Thickness in Patients with Hypertension

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ABSTRACT

Objective: To measure sub-foveal choroidal thickness variability in adolescent people with systemic arterial hypertension.
Study Design: Comparative Cross Sectional study.
Place and Duration of Study: Armed Forces Institute of Ophthalmology, Rawalpindi, Pakistan from May to Dec 2023.
Methodology: This study recruited 15 young hypertensive subjects and 15 healthy control persons. Choroidal thickness was estimated using swept source- 3D optical coherence tomography. Choroidal thickness was only checked at the sub foveal site. Mercury sphygmomanometer was used to check systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) was calculated. Statistical analysis between the groups was only applied on left eye values.
Results: A total of 30 individuals were included in the study, 15 in each group. The median systolic blood pressure of the Cases was 140.00 mmHg (148.00-137.00) while in Control Group was 127.00 mmHg (143.00-118.00). Similarly, the median diastolic blood of the Cases was 90.00 mmHg (94.00-87.00) and in Control Group was 84.00 mmHg (92.00-76.00). There was significant difference in the median Intraocular pressure of both the Study Groups [Cases: 105.00 mmHg (110.00-99.00) vs. Control: 96.00 mmHg (102.00-88.00); p=0.004]. The median Sub foveal Choroidal thickness of the Cases was 279.00 mmHg (288.00-269.00) and in Controls was 290.00 mm Hg (299.00-280.00).
Conclusions: The outcomes of this research showed that subfoveal choroidal thickness reduces in people with systemic arterial hypertension. This can be due to arteriolar sclerosis and narrowing due to raised vascular pressure in the choroid.

Keywords: Blood pressure, Choroidal thickness, Systemic arterial hypertension.

How to Cite This Article: *Khan FA, Syed ZU, Khan TA, Tariq U, Jahanzaib M, Naseer MS. Measurement of Sub Foveal Choroidal Thickness in Patients with Hypertension. Pak Armed Forces Med J 2026; 76(2): 192-196. DOI: https://doi.org/10.51253/pafmj.v76i2.11964*

INTRODUCTION

Hypertension, often dubbed as the "silent killer," affects millions worldwide and poses significant risks to cardiovascular health. While its systemic effects are well-documented, its impact on ocular health, particularly on hypertensive retinopathy and choroidal thickness, is increasingly drawing attention.[1] Hypertensive retinopathy, characterized by a spectrum of retinal changes due to elevated blood pressure, serves as a crucial indicator of systemic vascular damage.[2] Concurrently, advancements in imaging technology, such as spectral domain optical coherence tomography (SD-OCT), have enabled non-invasive assessment of choroidal thickness, providing insights into ocular vascular changes associated with hypertension.[3]

Hypertensive retinopathy manifests as a series of retinal microvascular changes resulting from chronic hypertension-induced vascular damage. These changes, including arteriolar narrowing, arteriovenous nicking, retinal hemorrhages, exudates and papilledema offer clinicians valuable insights into the severity and duration of hypertension, as well as the risk of future cardiovascular events.[4] Understanding the pathophysiology of hypertensive retinopathy is crucial, as it not only serves as a window into systemic vascular health but also aids in risk stratification and guiding treatment decisions.[5] With the increasing prevalence of hypertension globally, elucidating the relationship between systemic hypertension and hypertensive retinopathy is imperative for improving both ocular and systemic health outcomes.[6]

In recent years, SD-OCT has emerged as a powerful tool for assessing choroidal thickness, providing detailed visualization and quantification of choroidal vascular changes associated with various ocular and systemic conditions, including hypertension.[7] Swept source (SS)- 3D optical coherence tomography (SS-OCT) (DRI OCT Triton(plus), Topcon) is the latest machine available, and it was used for the measurements in our study. So, the data collected is more precise and accurate because of much higher A scans speed/sec and better axial and lateral resolution. Choroidal thickness alterations have been reported in hypertensive individuals,[7] suggesting a potential link between systemic hypertension and choroidal vascular

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Received: 28 Mar 2024; revision received: 25 Jun 2024; accepted: 26 Jun 2024

changes. Investigating these changes may offer insights into the ocular manifestations of hypertension and its impact on ocular perfusion. Therefore, exploring the association between systemic hypertension and choroidal thickness measured with SS-OCT holds promise for advancing our understanding of ocular vascular changes in hypertensive individuals and may have implications for early detection and management strategies.[8] The aim of this research was to evaluate the variations in thickness of the choroid in young hypertensive patients.

METHODOLOGY

This was a comparative cross-sectional study carried out at Armed Forces Institute of Ophthalmology Rawalpindi, Pakistan over the period of eight months from May 2023 to December 2023. Non-probability convenient sampling technique was used. The sample size was calculated Using Open Epi Software online, keeping prevalence of hypertensive retinopathy as 2%.[8] but we included all patients fulfilling inclusion exclusion (i.e. 15 cases and 15 controls) criteria during the study period, Permission of the hospital ethical review committee was granted (vide letter no 307/308/ERC/AFIO). Informed written consent was obtained from all the participants.

Inclusion Criteria: Individuals in both hypertensive group and control group who had clear ocular lenses and were free from any eye-related or systemic health conditions were included . Individuals of both genders of age 18 to 30 years were included.

Exclusion Criteria: Participants were excluded if they had diabetic retinopathy, macular edema, received any prior retinal treatments (such as retinal photocoagulation, vitrectomy, intravitreal steroids, or antiangiogenic drugs), a history of intraocular surgery, refractive errors exceeding 3 diopters, glaucoma, ocular hypertension, uveitis, other retinal disorders, neurodegenerative diseases (such as Alzheimer's, Parkinson's, or dementia), or any opacity in the eye's media.

Hypertension was determined by blood pressure values greater than 140 mm Hg for systolic pressure and/or 90 mm Hg for diastolic pressure, according to international guidelines.[10] Blood pressure was measured on the right upper arm while the patient was lying down with their arm positioned at heart level. Manual mercury-based sphygmomanometers were utilized, and the average of three readings was taken. Mean arterial pressure (MAP) was calculated using the formula: Mean arterial pressure (MAP) = Diastolic blood pressure (DBP) + 1/3(Systolic blood pressure – Diastolic blood pressure) (SBP-DBP). Ocular examinations were conducted following blood pressure measurements, and none of the participants were taking antihypertensive medications.

The study sample consisted of 15 adolescent patients already having essential hypertension, none of whom had been regularly taking antihypertensive medications. These were young recruits undergoing ophthalmological assessment at the Armed Forces Institute of Ophthalmology in Rawalpindi. To form the control group, 15 healthy individuals of similar age and gender were selected from the attendants accompanying the hypertensive patients (Figure).

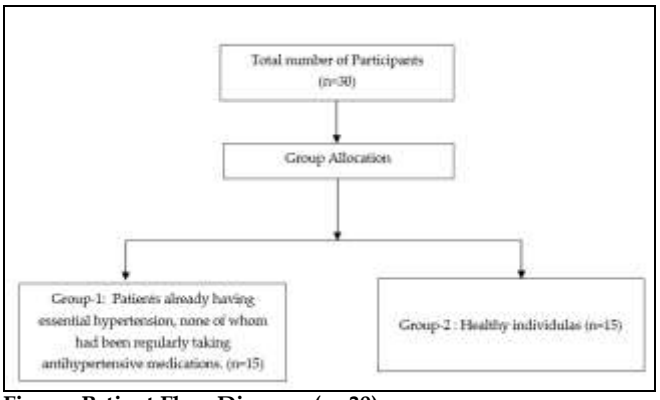

Figure: Patient Flow Diagram (n=30)

Each participant underwent a comprehensive ophthalmic evaluation, which included measurement of intraocular pressure using Goldman applanation tonometry and fundus examination with a Volk Super Field NC 90-D lens. These examinations provided detailed insights into ocular health and allowed for the assessment of any potential differences between the hypertensive group and the healthy controls.

All participants underwent imaging using swept source-3D optical coherence tomography (SS-OCT) with the DRI OCT Triton(plus) device manufactured by Topcon. Prior to imaging, their pupils were dilated with Tropicamide 1%, administered as one drop every 10 minutes for a total of three doses. From each participant, six images were captured, and image with the strongest signal value was chosen for further analysis. To measure choroidal thickness, the Macula Line Raster scan protocol was utilized, allowing for excellent depth penetration with a minimum of 100 B-scans.

Choroidal thickness was defined as the vertical measurement between the hyperreflective outer boundary consisting of the retinal pigment epithelial–Bruch membrane layer, spontaneously identified in the SS-OCT machine, and the sclero-choroidal interface. This measurement was manually performed by a consultant ophthalmologist who was blinded to the study, ensuring impartiality in the assessment process. Importantly, choroidal thickness measurements were exclusively taken at the sub foveal location, providing a standardized approach for evaluation. Statistical analysis was conducted solely on data collected from the left eye of each participant to maintain consistency. The SS-OCT imaging sessions were conducted between 1000 hours and 1400 hours, minimizing potential variations due to diurnal changes in ocular parameters. This meticulous approach aimed to ensure reliable and accurate assessment of choroidal thickness and its potential associations with hypertension in the study population.

Statistical Package for Social Sciences (SPSS) version 26.0 was used for the data analysis. Quantitative data with normal distribution was described as Mean±SD, whereas non-parametric distribution was described as median and interquartile range (after checking the normality). Qualitative variables were expressed as frequency and percentages, Independent sample t-test and Mann-Whitney U were applied to explore the inferential statistics. The *p*-value of ≤0.05 was considered statistically significant.

RESULTS

A total of 30 individuals were included in the study, 15 in each group. The mean age of the participants was 23.63 (±3.68) years, youngest being 18-year-old and eldest being 30-year-old. There were 28(93.30%) males and 2(6.70%) females. Median duration of essential hypertension since the time of diagnosis was 1.50 (IQR 6.00) months. The overall sub foveal choroidal thickness of the study participants was 233.00 (IQR 297.50-273.75) (Table-I).

The median systolic blood pressure of the Cases was 140.00 mmHg (148.00-137.00) while in Control Group was 127.00 mmHg (143.00-118.00). Similarly, the median diastolic blood of the Cases was 90.00 mmHg (94.00-87.00) and in Control Group was 84.00 mmHg (92.00-76.00). There was significant difference in the median Intraocular pressure of both the Study Groups [Cases: 105.00 mmHg (110.00-99.00) vs. Control: 96.00 mmHg (102.00-88.00); *p*=0.004]. The median Subfoveal Choroidal thickness of the Cases was 279.00 mmHg (288.00-269.00) and in Controls was 290.00 mm Hg (299.00-280.00), as shown in the Table-II.

Table-I: Descriptive Statistics of the Study Participants (n=30)

Parameter(s)	Value(s)
Age (Years)(mean±SD)	23.63±3.68 years
Gender n(%)	
Male Female	28(93.30%) 2(6.70%)
Duration of Essential Hypertension median (IQR)	1.50 (IQR 6.00-0.00) months
Systolic Blood Pressure median (IQR)	140.00 (IQR 145.00-125.75) mmHg
Diastolic Blood Pressure median (IQR)	88.50 (IQR 94.00-82.75) mmHg
Arterial Blood Pressure median (IQR)	101.00 (IQR 105.00-95.75) mmHg
Intraocular Pressure (Mean±SD)	15.23 ±2.94 mmHg
Sub foveal Choroidal Thickness median (IQR)	283.00 (IQR 297.50-273.75) µm

Table-II: Comparison of Clinical Parameters between the Study Groups (n=30)

Parameter(s)	Study Groups		*p*-value
	Group-1 Cases (n=15)	Group-2 Controls (n=15)	
Systolic Blood Pressure mmHg median (IQR)	140.00 (148.00-137.00)	127.00(143.00-118.00)	0.071
Diastolic Blood Pressure mmHg median (IQR)	90.00(94.00-87.00)	84.00(92.00-76.00)	0.078
Intraocular Pressure (mean±SD) mmHg	105.00(110.00-99.00)	96.00(102.00-88.00)	0.004
Sub foveal Choroidal Thickness median (IQR)	279.00(288.00-269.00)	290.00(299.00-280.00)	0.089

The mean Intraocular pressure in Cases was 15.13±2.72 mmHg and in Control group was 15.33±3.22 mmHg and the result was not statistically significant (*p*-value: 0.856) as shown in Table-III.

Table-III: Comparison of Intra-Ocular Pressure and Age Between the Study Groups (n=30)

Parameters	Study Groups		*p*-value
	Group-1 Cases (n=15)	Group-2 Controls (n=15)	
Age in years (mean±SD)	23.33±4.04	23.93±3.39	0.663
Intraocular Pressure mmHg (mean±SD)	15.13±2.72	15.33±3.22	0.856

DISCUSSION

The findings of this study suggest that choroidal thickness is reduced in individuals with systemic

arterial hypertension, possibly due to arterial wall stenosis, narrowing of the choroidal vessels, and decreased ocular perfusion pressure resulting from hypertensive vascular compromise. Choroid has a maximal thickness posteriorly, being 0.22mm in central macular region. But the thickness changes, either increases (pachychoroid) or decreases (leptochoroid), due to many ocular disease conditions. Choroid also has the maximum amount of blood flow per unit of any tissue in the body.[11-12] Choroidal arteries run directly into choriocapillaris with very limited branches in between and therefore high pressure is directly conducted to the choriocapillaris.[13] Choroidal vasculature is adapted to blood flow auto regulation in reaction to variations in blood pressure and Intraocular pressure.[14,15]

We established that choroidal thickness was considerably lesser in hypertensive subjects in comparison to control persons. The choriocapillaris is regulated chiefly with the help of sympathetic nervous system.[14,16] This failure in the regulation of blood pressure causes vascular wall stenosis, reduction in the total amount of vascular matter available in the choroid depicted in a measurable decrease in choroidal thickness which was established in our study. Previously, most of the work is done with the help of Spectral domain (SD)-OCT5 which is inferior to SS-OCT.[17] Therefore, the measurements are more accurate and precise and adds to the strengths of our results.

In a latest study, Aşıkgarip *et al.*,[18] also studied choroidal thickness and vascularity changes in hypertensive patients. The Sub foveal, nasal and temporal choroidal thickness were significantly decreased in patients with hypertension and concluded that the remarkable reduction in the structural measurements reveal that choroid is affected in subjects who have not started any treatment for their hypertension.

In another study, Waghamare *et al.*,[19] also concluded that there is reduction in the thickness of choroid in hypertensive persons.

In a study by Simsek *et al.*, End organ damage was studied in patients with hypertension where spectral domain OCT was used to measure Sub foveal choroidal thickness, central macular thickness inner plexiform-ganglion cell complex and peripapillary retinal nerve fiber layer. All parameters were significantly reduced in patients having end organ damage due to hypertension and concluded that it would be helpful to include SD-OCT examination as a part of traditional hypertension retinopathy management for assessing anti-hypertensive treatment, picking up involvement of target organs and end organ damage.[20] Subfoveal and peripapillary choroidal thickness is notably reduced in patients with carotid stenosis which should be considered in people with a thin choroid. Also, surgical interference be carried out in asymptomatic severe carotid stenosis patients who have a thin choroid.[21] Diabetic patients also have a decrease in choroidal thickness.[22] There is no significant relationship in the severity of coronary artery disease and choroidal thinning.[23] Choroidal thickness is also helpful in evaluating the management of macular edema in BRVO patients.[24]

LIMITATIONS OF STUDY

A smaller sample size due to the strict inclusion criteria was the limitation of study. Furthermore, the effect of lifestyle habits and treatment on the change in choroidal thickness was not assessed.

CONCLUSION

The choroidal thickness is reduced in subjects having systemic arterial hypertension. Arterial wall stenosis, narrowing of the choroidal vessels, and reduced ocular perfusion pressure due to hypertensive vascular blockage may be the reasons for thinner choroid in such patients.

Conflict of Interest: None.

Funding Source: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

FAK & ZUS: Conception, study design, drafting the manuscript, approval of the final version to be published.

TAK & UT: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

MJ & MSN: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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