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Sensitivity of OCT and OCTA metrics in grading of hypertensive retinopathy

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Abstract
Purpose: To investigate the sensitivity of optical coherence tomography (OCT) and optical coherence tomography angiography (OCT-A) metrics in grading hypertensive retinopathy (HTR) compared with the gold standard color fundus photographs grading of HTR.
Methods: This was a prospective cross-sectional controlled study. Forty-five chronic hypertensive individuals with different grades of HTR were included in groups A, B, and C corresponding to HRT grades I, II, and III according to KWB grading, respectively. Also, 15 healthy volunteers with no history of Hypertension were included in this study (Group D). HTR patients. A 6 × 6-mm macula scan and a 4.5 × 4.5-mm optic nerve head OCTA scan were performed in each patient using a DRI Triton OCT machine. Macular and optic nerve head vessel density (VD), central foveal thickness (CFT), subfoveal choroidal thickness (SCT), and foveal avascular zone (FAZ) area were measured.
Results: The mean CFT was lower in grade I HTR patients (245.167± 22.749), while an increase in thickness in grades II & III (252.800 ± 26.702, 432.467 ± 222.914, respectively) compared to normal controls. Mean SCT was lower in grades I & II and higher in grades III than normal controls. The FAZ area was higher in grades I, II, and III HTN (0.386± 0.131, 0.345± 0.122,0.295±0.077) contrasted to normal controls (p<0.05). Vessel density, skeletonized vessel density of deep and superficial capillary plexus decrease in the various hypertensive groups. No substantial variation in choriocapillaris vessel density across the four groups. The peripapillary capillary density showed a decrease in participants grade I, II compared to normal controls.
Conclusions: The vessel density (VD), skeletonized VD of superficial and deep capillary plexus, FAZ area, peripapillary capillary density significantly degraded in hypertensive patients. The superficial and deep vascular densities are independent risk factors for hypertensive retinopathy and may be used to predict hypertensive retinopathy. Additional prospective longitudinal studies are required to sort out the problem.

Keywords: OCT, OCTA, hypertensive retinopathy, hypertension, grading

Introduction
Hypertension is among the most prevalent medical disorders, having an impact on 30 – 45% of the population, and the fourth leading cause of worldwide mortality [1, 2].
Target organ damage may result from hypertension, a major risk indicator underlying cardiovascular and other systemic disorders. In the eye, untreated high blood pressure can lead to retinopathy, optic neuropathy, and choroidal disease. Moreover, hypertension is one of the predisposing factors for occlusion of the major retinal blood vessels, like the central retinal vein and artery [3]. Hypertensive retinopathy (HTR) is a condition in which Due to elevated blood pressure, vessels in the retina are harmed. The duration and extent of HTN are related to the occurrence of retinopathy [4]. There is substantial evidence that HTR predicts hypertension-related target-organ damage, systemic morbidity, and death [5].
There are two pathogenic mechanisms involved in hypertensive retinopathy. Vasoconstriction to auto-regulate perfusion is what causes the early consequences of systemic arterial hypertension [6]. A significant constriction of the retinal arterioles is clinically identified at this stage. thickening of Intima, hyperplasia of the mid-wall, and subsequently hyaline degeneration in the sclerotic stage are caused by persistently high blood pressure. This stage is characterized by more severe arteriovenous nipping or nicking, alterations in the junctions of venule and arterioles, and isolated and systemic regions of arteriolar stenosis. and arterial light reflection changes (i.e., the enlargement and aggravation of central light reflection, or copper wire. Next is the exudation stage includes destruction of blood retinal barrier, smooth muscle, necrosis of endothelial cells, exudation of lipid and blood, and ischemic retinal occurs. Micro aneurysms, hard exudate, hemorrhage and cotton wool spots are some of the retinal alterations that result from these conditions.

At this stage, optic disc edema, a symptom of severely high blood pressure (malignant hypertension), may appear [7].

The most popular method to examine retinal vascular function is still fluorescein angiography, although there are concerns about side effects and documented flaws in imaging deep retinal vasculature [8]. In their study, Bart *et al*. used fluorescein angiography to analyze patients with hypertensive renal failure and reported that HTR is characterized by nonperfusion of retinal capillaries and a coarse retinal capillary bed. In addition, it is common to see tortuous retinal arteriovenous anastomoses or tortuous retinal arterioles [9].

OCT (optical coherence tomography) is a non-invasive, high resolution optical imaging method that produces images by using interference between the signals from the object being studied and a nearby reference signal. A cross-section image of an object, including an image with two dimensions in space (axial and lateral coordinates), may be produced via OCT in real time [10, 11, 12]. Ahn *et al*. employed a combination of fundoscopy and OCT in their investigation, reporting that in patients with severe hypertension, instead of using fundoscopic images, the visual prognosis was related to subretinal fluid (SRF) level, and thickness of the retina and choroids also decreased as a consequence of blood pressure reduction [13].

Using high-resolution volumetric blood flow data, OCT angiography (OCTA), an imaging technology, produces angiographic images in a matter of seconds. By contrasting the decorrelation signals (variations in the backscattered OCT signal's intensity or magnitude) across subsequent OCT B-scans taken at the same cross-section, a blood flow map is created [14]. There are few OCTA studies evaluating microvasculature alterations with systemic hypertension. However, In comparison to the normal control group, the chronic HTN and alleviated HTNR groups demonstrated substantially reduced VD and PD and greater FAZ regions. Furthermore, the chronic HTN and alleviated HTR groups demonstrated a strong association between OCTA and OCT parameters, in contrast to the normal control group. As a result, chronic elevated blood pressure or prior bouts of elevated blood pressure impact the construction and function of the retinal microcirculatory system, which alters the thickness of the retina [15].

The aim of the current study was to investigate the sensitivity of OCT and OCTA metrics in grading hypertensive retinopathy compared with the gold standard color fundus photographs for HTR grading.

Methods

That prospective controlled cross-sectional study has been authorized by the Faculty of Medicine, Tanta University's ethical committee, and was carried out per the Helsinki Declaration principles and its later amendments. All study volunteers provided written informed consent.

Participants

Sixty participants, which includes 45 patients with hypertensive and 15 participants in good health, have been selected between November 2020 and November 2021 at the Soad kafafi Hospital of MUST University. All of the participants ranged in age from 30 to 60 and had been diagnosed as having essential hypertension for at least 5 years along with hypertensive retinopathy. Patients' blood pressure (BP) was under tight control; the average BP during the study was 140/90 mmHg with regular anti-hypertensive medications. We defined hypertension according to World Health Organization WHO-ISH guidelines, as chronic high blood pressure with systolic BP more than 140 mmHg & diastolic BP more than 90 mmHg [16]. The controls (group N) had normal blood pressure. Criteria for exclusion included: other pathologies affecting the optic nerve or the retina, previous Intraocular surgical interventions, patients with media opacity that prevents imaging, existing systemic diseases or conditions that might affect retinal vasculatures such as diabetes, retinal vein occlusion (RVO), Central Retinal Artery Occlusion (CRAO), and branch retinal artery occlusion (BRAO), macular telangiectasia, and intraocular inflammation such as uveitis.

Full medical history and ocular examination were recorded for each patient, such as best corrected visual acuity (BCVA) and uncorrected visual acuity (UCVA), as well as Slit lamp biomicroscopy and slit-lamp fundus examination, Sex, age, blood pressure, and duration of hypertension were all recorded for each patient. Four groups of patients and healthy participants were created, and both eyes of each individual were examined. Groups A, B, and C comprised patients with hypertensive retinopathy grades I, II, and III, respectively, according to KWB grading. Group D comprised 15 healthy volunteers with no history of hypertension.

OCT & OCTA imaging

All study participants were subject to a swept-source (SS)-OCT assessment (DRI Triton, Topcon, Tokyo, Japan), This uses a sweeping light source with a wavelength of 1,050 nm and 100,000 A-scans/second of scanning by a skilled ophthalmic photographer under consistent settings [17]. We used an OCT six-line radial pattern scan focused on the fovea to obtain thickness of the retina at the fovea and thickness of choroid 2 mm from the fovea (temporal, nasal, inferior, and superior). In addition, OCTA 6x6 mm macular can and 4.5 × 4.5-mm ONH scans were used to obtain density of the vessels of superficial capillary plexus DCP, SCP,and CC, and skeletonized density of SCP and DCP using Image J software (https://imagej.net/software/fiji/downloads).

Statistics

The statistical program for social sciences (SPSS, IBM v. 20.0) was utilized for analyzing the data that had been collected.

1. **Descriptive Statistics**: 1. For numerical data that is parametric, we use the mean, standard deviation (SD) and range; for non-parametric data, we use the median and interquartile range (IQR) 2. Frequency and percentage of non-numerical data.
2. **Analytical Statistics:** An analysis of variance (ANOVA) was employed to determine the statistical significance of a parametric variable difference between the means of more than two research groups. 2- The association between two qualitative variables was examined using the chi-square test, but Fisher's Exact Test was utilized when the predicted count was fewer than five in over 20 percent of the cells.

P-value: significance Level: $p>0.05$ = Non-significant (NS),
$p<0.05$ = Significant (S),
$p<0.01$ = Highly significant (HS).

Results

This research comprised 120 eyes from 60 individuals, including 37 females (61.6%) and 25 male (38.4%) in total.

The mean central foveal thickness (CFT) of the control group was 249.03 ± 21.11, which was lower in grade I HTR (245.17± 22.75). In grade II & III groups, the mean CFT was higher than the control group (252.8 ± 26.7, and 432.47 ± 222.91, respectively). A substantial variation existed among group III and the control group concerning CFT.

The mean central choroidal thickness (CT, 258.17± 66.18), superior CT (265.1 ± 62.66), nasal CT (247.3 ± 67.06), temporal CT (257.13 ± 67.35) & inferior CT (268.13± 78.14) in the control group (figure 1), were greater than the mean CT in grades I and II HTR groups. Whereas the mean central CT (339.57± 46.12), superior CT (341.53 ± 48.24), nasal CT (325.27 ± 47.02), temporal CT (343.13± 42.29) & inferior CT (344.23± 46.22) in the grade III HTR group were higher than all other groups (table 1).

Table 1: Comparison group 1 (normal individuals), group 2 (hypertensive patients grade I), group 3 (hypertensive patients grade II) & group 4 (hypertensive patients grade III) as regard thickness of central choroids, superior choroids, nasal choroids, temporal choroids & inferior choroids (µm).

Choroidal thickness (µm)		Diagnosis												ANOVA	
		Normal			Grade I			Grade II			Grade III			F	p-value
Central	Range	145	-	362	147	-	322	58	-	393	247	-	402	30.385	<0.001*
	Mean ±SD	258.167	±	66.177	218.167	±	38.627	211.700	±	75.266	339.567	±	46.115		
Superior	Range	127	-	365	164	-	321	81	-	355	252	-	401	37.488	<0.001*
	Mean ±SD	265.100	±	62.615	227.033	±	39.682	206.667	±	59.099	341.533	±	48.244		
Nasal	Range	117	-	361	114	-	294	85	-	360	229	-	379	22.818	<0.001*
	Mean ±SD	247.300	±	67.055	214.767	±	44.961	216.933	±	72.797	325.267	±	47.022		
Temporal	Range	133	-	373	155	-	297	75	-	396	241	-	386	35.728	<0.001*
	Mean ±SD	257.133	±	67.350	211.200	±	32.835	208.300	±	76.735	343.133	±	42.290		
Inferior	Range	150	-	412	116	-	333	81	-	410	279	-	448	26.500	<0.001*
	Mean ±SD	268.133	±	78.137	222.167	±	46.312	214.700	±	75.157	344.233	±	46.224		

TUKEY'S Test						
	N&I	N&II	N&III	I&II	I&III	II&III
Central	0.045*	0.014*	<0.001*	0.973	<0.001*	<0.001*
Superior	0.032*	<0.001*	<0.001*	0.451	<0.001*	<0.001*
Nasal	0.150	0.199	<0.001*	0.999	<0.001*	<0.001*
Temporal	0.013*	0.007*	<0.001*	0.997	<0.001*	<0.001*
Inferior	0.029*	0.008*	<0.001*	0.968	<0.001*	<0.001*

(*) Statistically significant at $p<0.05$

The mean foveal Avascular zone (FAZ) area in the control group was 0.29 ± 0.1, whereas the mean FAZ area was substantially higher in grade I, II, and III HTR groups (0.39± 0.13, 0.35± 0.12, 0.3± 0.08, respectively) (figure 2).

The mean VD of SCP in the control group was 50.59 ± 1.66, which was lower in grade I, II, and III HTR (45.40 ± 2.62, 46.25 ± 1.96, 45.3 ± 3.9, correspondingly). The mean SVD of SCP in the control group was 28.83± 1.21 SD, while it was lower in grade I, II, and III HTR (24.65 ± 2.34, 24.26 ± 1.48, 23.58 ± 2.89, respectively) (table 2). These variations were statistically significant. The ROC curve for the diagnostic accuracy of measures in discriminating individuals with HTR from the control group, the AUROC of SCP VD was 0.946, The cut-off value of SCP VD was ≤49.19 with a sensitivity of 95.29%, and specificity of 83.33% and the AUROC of SCPSVD was 0.964, the cut-off value of SCPSVD was ≤26.27 with the sensitivity of 84.71% and specificity of 100% (table 4). (figure 3,6)

Table 2: Comparison group 1 (normal individuals), group 2 (hypertensive patients grade I), group 3 (hypertensive patients grade II) & group 4 (hypertensive patients grade III) as regard Superficial capillary plexus (%).

Superficial capillary plexus (%)		Diagnosis												ANOVA	
		Normal			Grade I			Grade II			Grade III			F	p-value
Vessel density	Range	47.04	-	53.14	40.26	-	50.36	42.41	-	49.41	35.81	-	52.85	27.077	<0.001*
	Mean ±SD	50.594	±	1.661	45.407	±	2.619	46.253	±	1.963	45.300	±	3.895		
Skeletonized vessel density	Range	26.52	-	31.03	20.8	-	29.97	21.09	-	27.13	16	-	28.16	39.154	<0.001*
	Mean ±SD	28.831	±	1.209	24.647	±	2.339	24.258	±	1.476	23.580	±	2.893		

TUKEY'S Test						
	N&I	N&II	N&III	I&II	I&III	II&III
Vessel density	<0.001*	<0.001*	<0.001*	0.592	0.999	0.534
Skeletonized vessel density	<0.001*	<0.001*	<0.001*	0.882	0.224	0.614

(*) Statistically significant at $p<0.05$

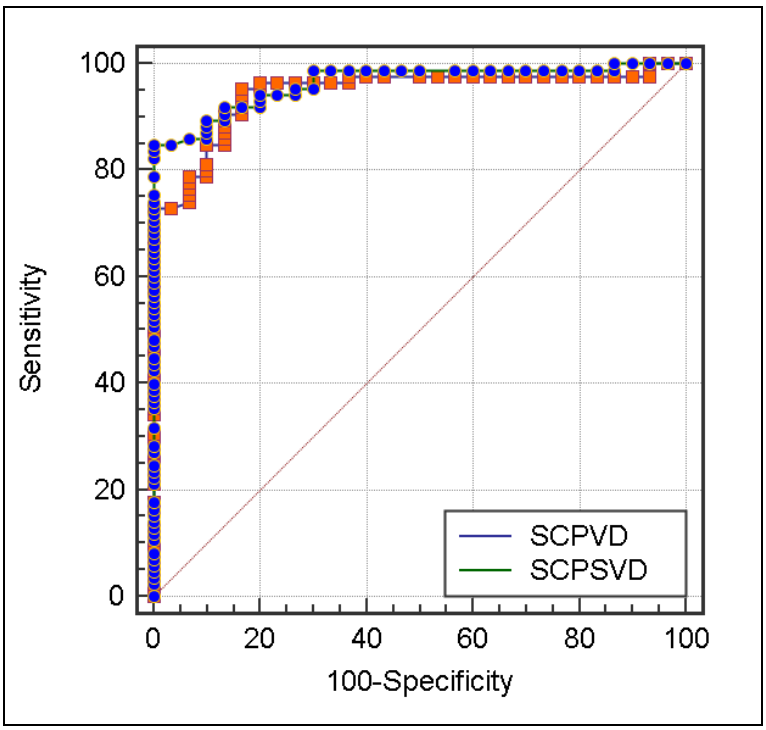

Fig 3: ROC Curve displaying Diagnostic accuracy of superficial capillary plexus vessel density (SCPVD) and superficial capillary plexus skeletonized vessel density (SCPSVD) to differentiate between patients with hypertensive retinopathy and control group.

The mean VD of DCP in the control group was 49.294 ± 3.594 SD, whereas the mean value was lower in grade I, II, III Hypertensive Retinopathy (42.618 ± 3.136, 42.022 ± 3.215, 45.377 ± 9.289), respectively. These differences have statistical significance. The mean values of skeletonized vessel density of deep capillary plexus in the control group were 30.376± 2.090 SD, while it was lower in grade I, II, III Hypertensive Retinopathy (26.356 ± 1.824, 25.818 ± 1.851, 24.978 ± 2.814), correspondingly. The mean values of vessel density of deep capillary plexus in the grade III Hypertensive Retinopathy are higher than the mean value in the grade I, II Hypertensive Retinopathy (table 3).

The ROC curve (figure 4,6) of the diagnostic accuracy of measures in discriminating individuals with HTR from the control group, the AUROC of DCPVD was 0.896, The cut-off value of DCPVD was ≤46.69 with the sensitivity of 92.94% and specificity of 83.33% and the AUROC of DCPSVD was 0.931, the cut-off value of DCPSVD was ≤29.55 with the sensitivity of 100% and specificity of 83.33% (table 4).

Table (3): Comparison group 1 (normal individuals), group 2 (hypertensive patients grade I), group 3 (hypertensive patients grade II) & group 4 (hypertensive patients grade III) as regard Deep capillary plexus (%).

Deep capillary plexus (%)		Diagnosis												ANOVA	
		Normal			Grade I			Grade II			Grade III			F	P-value
Vessel density	Range	37.81	-	53.37	37.13	-	49.24	35.81	-	49.05	37.79	-	74.81	12.070	<0.001*
	Mean ±SD	49.294	±	3.594	42.618	±	3.136	42.022	±	3.215	45.377	±	9.289		
Skeletonized vessel density	Range	23.99	-	32.87	23.21	-	29.55	22.21	-	29.42	19.26	-	28.8	35.960	<0.001*
	Mean ±SD	30.376	±	2.090	26.356	±	1.824	25.818	±	1.851	24.978	±	2.814		

TUKEY'S Test						
	N&I	N&II	N&III	I&II	I&III	II&III
Vessel density	<0.001*	<0.001*	0.033*	0.971	0.214	0.089
Skeletonized vessel density	<0.001*	<0.001*	<0.001*	0.767	0.089	0.475

(*) Statistically significant at $p<0.05$

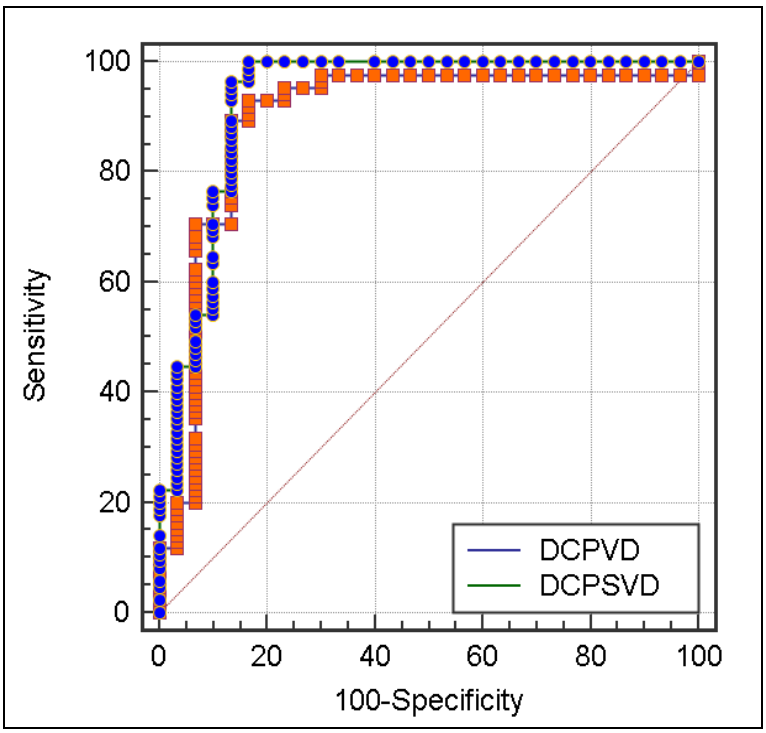

Fig 4: ROC Curve displaying Diagnostic accuracy of deep capillary plexus vessel density (DCPVD) and deep capillary plexus skeletonized vessel density (DCPSVD) to differentiate between patients with hypertensive retinopathy and control group.

The mean values of vessel density of choriocapillaris plexus in the control group were 61.112 ± 0.825 SD, whereas the mean value was lower in grade I, II Hypertensive Retinopathy (60.469 ± 0.961, 60.580 ± 0.940), correspondingly. while the mean values of density of the vessel of choriocapillaris plexus in grade III Hypertensive Retinopathy (61.302 ± 2.563 SD) is greater than the control group.

The mean values of density of the vessel of peripapillary capillary plexus in the control group were 59.927 ± 2.029 SD, whereas the mean value was lower in grade I, II Hypertensive Retinopathy ((54.207 ± 3.068, 54.459 ± 3.074)), respectively. The mean values of skeletonized vessel density of peripapillary capillary plexus in the control group were 28.007 ± 1.865 SD, whereas it was lower in grade I, II HTR (27.301 ± 1.589, 27.804 ± 1.589), respectively. The ROC curve (figure 5) of the diagnostic accuracy of measures in discriminating individuals with HTR from the control group, the AUROC of PCPVD was 0.921, The cut-off value of PCPVD was ≤57.42with the sensitivity of 88.33% and specificity of 100% and the AUROC of PCPSVD was 0.509, the cut-off value of PCPSVD was ≤30.75 with the sensitivity of 100% and specificity of 20% (table 4).

Table 4: ROC Curve displaying Diagnostic accuracy of metrics to differentiate between patients with hypertensive retinopathy and control group.

ROC curve between HTN and No HTN						
	Cut-off	**Sens.**	**Spec.**	**PPV**	**NPV**	**Accuracy**
CFT	>282	30.00	96.67	96.4	31.5	55.7%
CCT	≤349	81.11	3.33	71.6	5.6	50.8%
SCT	≤266	58.89	60.0	81.5	32.7	54.2%
NCT	>309	27.78	86.67	86.2	28.6	51.6%
TCT	≤360	80.00	3.33	71.3	5.3	51%
ICT	≤369	85.56	6.67	73.3	13.3	52.1%
FAZ	>0.213	94.74	33.33	78.3	71.4	66.4%
SCPVD	≤49.19	95.29	83.33	94.2	86.2	94.6%
SCPSVD	≤26.27	84.71	100.0	100.0	69.8	96.4%
DCPVD	≤46.69	92.94	83.33	94.0	80.6	89.6%
DCPSVD	≤29.55	100.0	83.33	94.4	100.0	93.1%
CCVD	≤59.98	23.53	100.0	100.0	31.6	57.6%
PCPVD	≤57.42	88.33	100.0	100.0	81.1	92.1%
PCPSVD	≤30.75	100.0	20.0	71.4	100.0	50.9%
CFT+CCT	>314	17.78	100.0	100.0	28.8	50.8%
SCPVD+SCPSVD+DCPVD+DCPSVD	≤38.02	96.47	86.67	95.3	89.7	96.2%

PPV: Positive Predictive Value, NPV: Negative Predictive Value.

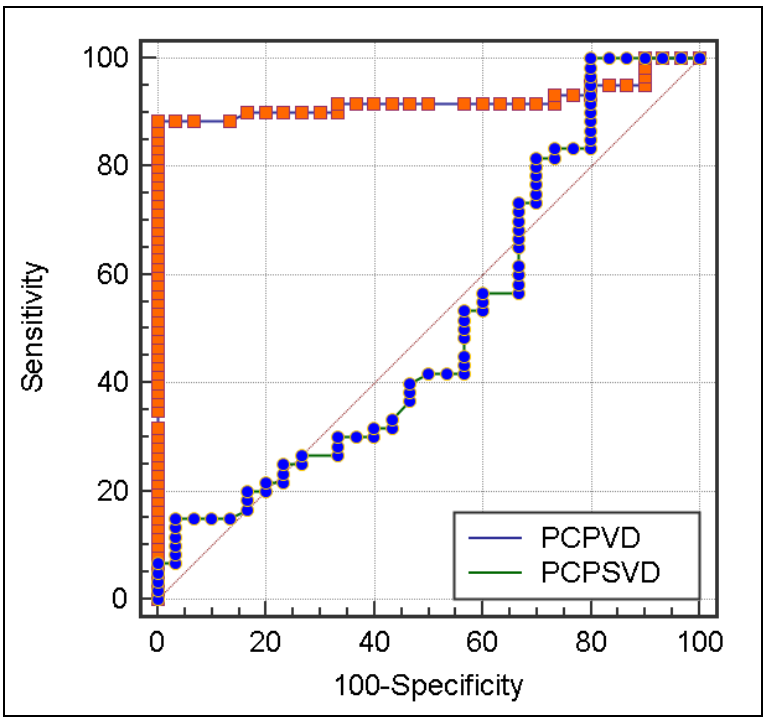

Fig 5: ROC Curve displaying Diagnostic accuracy of peripapillary capillary plexus vessel density (PCPVD) and peripapillary capillary plexus skeletonized vessel density (PCPSVD) to differentiate between patients with hypertensive retinopathy and control group.

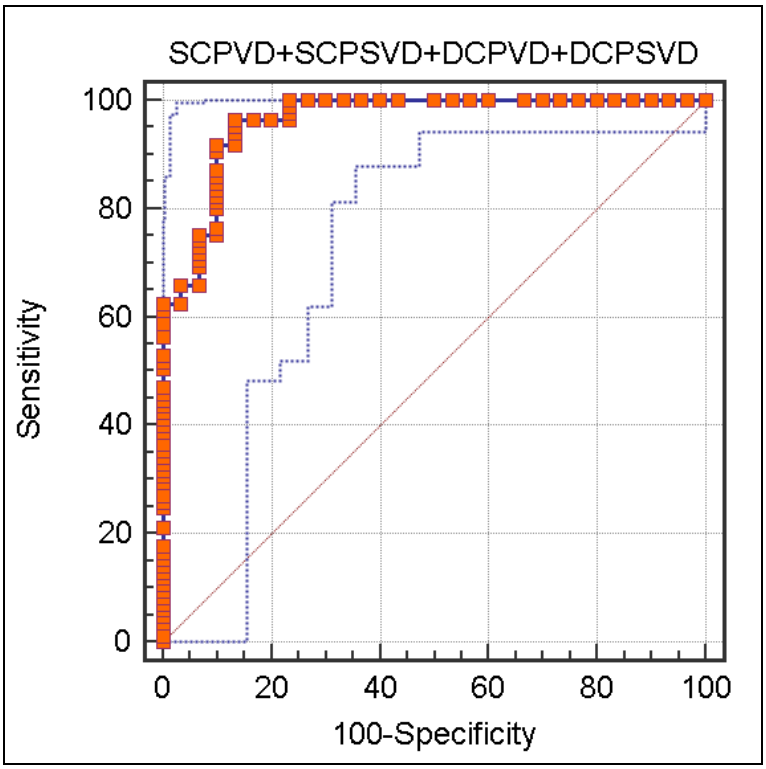

Fig 6: ROC Curve displaying Diagnostic accuracy of SCPVD+SCPSVD+DCPVD+DCPSVD to differentiate between patients with hypertensive retinopathy and control group.

Two readers randomly classified the OCTA pictures from a total of 120 eyes using the hypertension grading system: KWB (Keith-Wagner-barker). The agreement degree for interrater reliability (IRR) was determined using Kappa (standard error) values. Both readers interobserver agreement was matched to a "gold standard" for retinal grading created by a researcher. Kappa has interpreted qualitatively the use of the subsequent criterion: moderate agreement,0.40 -0.60 good agreement, 0.60–0.80; very good agreement, 0.80–1.00. In this study, the kappa value of the grading system and the IRR of KWB (0.56), the accuracy of the first reader to the gold standard is 44.04%, and the accuracy of the second reader is 42.85%.

Discussion

Hypertension is a chief cardiovascular hazard factor, and Vascular trouble has been shown to be predicted by hypertensive retinopathy. Recent advancements in OCT and OCTA have enabled thorough study of anatomy of retina and retinal microcirculation. In the present study, we

performed a quantitative and qualitative assessment of variety of retinal and choroidal parameters in 45 hypertensive subjects and 15 normotensive controls using the OCT & OCTA images.

In our study, two independent readers graded the HTR on OCTA images, and the kappa of the agreement between both readers, interreader reliability (IRR) was 0.56. On the other hand, the accuracy of first reader to gold standard was 44.04%, and the accuracy of second reader was 42.85%. A previous study shows that the kappa value of the KWB grading system was (0.784) [18]. This means that without a proper colour fundus picture, OCTA cannot precisely identify hypertensive retinopathy grading.

Similar to ours, other studies demonstrated lower CMT in HTR eyes than controls, particularly in grade I [19, 20, 21], However, in the present study, CMT was lower in grade I HTR compared to controls, while an increase in the thickness was present in grade II & III HTR. it can be supposed that in grade III HTNR, the CFT at the time of preliminary analysis has been increased due to macular edema; and reduction of retinal thicknesses happened over time.

Mass *et al.* [22] evaluated 112 people with systemic hypertension and 15 healthy people. both groups' average ages were 67 and 51, correspondingly. In hypertension patients, the thickness of the choroids was substantially thinner than in controls. Similarly, lei shao *et al.* demonstrated a thinner subfoveal CT in hypertensive patients, although normal individuals were substantially younger than the hypertensive. However, after adjusting for age and other relevant characteristics, subfoveal CT was not significantly connected with hypertension [23]. In our study, we significantly lower subfoveal CT in grade I & grade II HTR in contrast to controls, whereas there was a substantial increase in grade III HTR patients. Furthermore, there was a strong positive relationship between the SFCT and the degree of HTR in our study and also in several other studies in the literature [24, 25, 26].

According to Lee *et al.*, the superficial FAZ size in hypertensive patients was substantially larger than in control eyes [27]. Similarly, after removing aberrant fundus findings, The FAZ area of hypertension patients for over five years was larger compared to that of the control group, according to Lim *et al.* [28]. On the other hand, Dogan *et al.* [29] found expansion in either the superficial or deep FAZ in malignant HTR over a six-months follow-up. Despite the fact that this study agreed with earlier ones, the FAZ area showed a substantial increase in the individuals with HRT grades I, II, and III compared to the controls.

OCTA could be used to quantitatively assess the retinal capillary network by employing various metrics such as vessel density and skeletonized vessel density metrics. VD was shown to be lower in hypertensive individuals in previous research, which is consistent with our findings [30, 31]. (Dihao *et al.*), found that Hypertensive patients had significantly lower density of vessel in superficial retinal plexus than healthy volunteers [32]. In the various stages of HTR, our research indicated that the density of the vessel, skeletonized vessel density of deep and superficial capillary plexus, tended to decline. The decrease in VD of superficial plexus and the broadening of the FAZ area in the hypertensive groups in the present study, when accompanied with our earlier findings, hypothesized that aberrant retinal microcirculation and retinal atrophy may be related to prolonged hypertension.

After controlling for confounding variables, superficial and deep vessel densities in OCTA parameters were revealed to be highly correlated to HTR risk. This study found that superficial and deep vascular densities are independent risk factor for HTR and may be used to predict hypertensive retinopathy. After correcting for the relevant confounding variables, logistic regression analysis revealed that superficial and deep vessel densities, as well as skeletonized vessel densities, were the parameters most strongly related to hypertensive retinopathy risk (p<0.001).

According to analyses of ROC, the AUC (94.6 percent CI) of density of superficial vessel, the AUC (96.4 percent CI) of superficial skeletonized vessel density, the AUC (89.6 percent CI) of density of deep vessel, and the AUC (93.1 percent CI) of deep skeletonized vessel density were all the highest in a single index, with no substantial variation when compared to the combined index. As a result, in this research, superficial, deep, and skeletonized vessel densities might be among the most accurate and sensitive predictors of the risk of HTR.

Regarding ONH vasculature, The outermost layer of capillaries originating from the central retinal artery are measured by OCTA in the inner disc and peripapillary regions [33] and provide blood to the ONH's superficial RNFL [34]. The study by Yong-Il *et al.* assessed peripapillary vessel density (VD) and perfusion density (PD) were reduced in HTN patients with a 10-year history [35]. In the current study, we found that the peripapillary capillary density showed a decrease in participants with hypertensive retinopathy grade I, II compared to normal controls.

Furthermore, there are many limitations to this research. Firstly, because our present OCTA imaging focuses on blood flow motion contrast to observe the vasculature of the retina, it's possible that vessels with flows below the detection threshold won't be observed [36]. Secondly, we accept that our confined FAZ may have some flow speckles in the background, but this was thought to be a minor artifact of background noise. As a result of our measurement of thickness choroids the usage of the device software the consequences may incorporate mild mistakes and this used to be the first-class scientific technique presently to be had with modern OCT equipment, we attempted to ameliorate this with the aid of using modifying choroidal edges to obtain accurate measurements for the identical image. Because choroidal imaging was not done at a certain time of day, we can't rule out the influence of diurnal fluctuation on CT as previously documented [37].

Conclusions

The vessel density (VD), skeletonized VD of superficial and deep capillary plexus, FAZ area, peripapillary capillary density significantly degraded in hypertensive patients. The superficial and deep vascular densities are independent risk factors for hypertensive retinopathy and may be used to predict hypertensive retinopathy. Additional prospective longitudinal studies are required to sort out the problem.

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Author's Contribution

Not available

Conflict of Interest

Not available

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