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Original article

Optical Coherence Tomography Angiography Analysis of the Foveal Avascular Zone in Eyes with Diabetic Retinopathy and Healthy Controls

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Abstract:

Background: Diabetic retinopathy (DR) is one of the most common causes of vision loss in diabetic patients. Fluorescein angiography provides valuable additional information compared to clinical examination or fundus photography, but it has many contraindications. The aim of this study was to analyze the (FAZ) in eyes for both groups using (OCT angiography). **Methods:** This study was a cross sectional case-control study. The study involved (78 eyes) of 40 cases "divided equally into two groups": (38 eyes) of 20 diabetic patients with non-PDR (18 bilateral & 2 unilateral) and (40 eyes) of 20 Healthy non-diabetic subjects. **Results:** The mean FAZ (mm^2) was significantly higher in the Diabetic retinopathy group in comparison to the control group (p value= 0.017). There was a statistically highly significant difference between the two study groups in both the Superficial & Deep vessel density (%) (p value <0.001). The mean Superficial & Deep vessel density (%) were significantly higher in the healthy controls group in comparison to the Diabetic retinopathy group P value <0.001. Insignificant negative correlation was found between BCVA and the FAZ (mm^2). Insignificant positive correlation was present between BCVA and the Superficial & Deep vessel density (%). There was insignificant negative correlation between the FAZ (mm^2) and Superficial & Deep vessel density (%). There was a statistically significant positive correlation between Superficial & Deep vessel density (%) (P value <0.05). **Conclusion:** Using OCTA, there is a significant enlargement of the FAZ area and significant reduction in the superficial and deep vessel density in non-PDR eyes in comparison with healthy nondiabetic eyes.

Keywords: Optical Coherence Tomography Angiography-Foveal Avascular Zone - diabetic retinopathy - healthy controls

Introduction:

Visual impairment due to diabetic retinopathy (DR) is rising worldwide, and diabetic eye disease is now the fifth most common cause of blindness (1). Diabetic retinopathy is a micro angiopathy that causes capillary occlusion, vascular hyper permeability, and neovascularization in the retinal vasculature (2).

The center of the macula is generally capillary-free, this area being named the foveal avascular zone (FAZ). There is a large inter individual variability of FAZ size in the normal subject. It is known that the FAZ enlarges in diabetic retinopathy, and appears to get larger as the stage of retinopathy advances (3).

Fluorescein angiography provides valuable additional information compared to clinical examination or fundus photography. It has many contraindications. It requires venipuncture and intravenous injection of a dye that has a moderate risk of nausea and a rare but well documented risk of anaphylaxis and death. Also, a standard protocol FA acquires images over 10 minutes with repeated exposure to a very bright light source, which can cause significant discomfort for patients (4).

Optical coherence tomography angiography (OCTA) is a new non-invasive modality that generates three-dimensional, depth encoded images of blood flow within the eye by using motion contrast. It is based on rapid OCT scanning of the eye and compares repeat scans acquired at the same position in the retina to look for changes in the scan. It offers an alternative angiographic technique without the drawbacks of FA. Areas of capillary loss obscured by fluorescein leakage on FA were more clearly defined on OCT angiography (5).

OCTA can identify FAZ enlargement and irregularities, as well as areas of capillary dropout. Quantification of the foveal avascular zone (FAZ) area may be useful in detecting and monitoring the progression of retinal vascular diseases such as diabetic retinopathy (6).

Patients and Methods

Study design:

This cross-sectional observational case – control study, was carried out on 40 cases divided equally into two groups:

1. Patients with diabetic retinopathy (20 cases).
2. Healthy non-diabetic subjects (20 cases).

The study was conducted at (Ophthalmology center – Benha University Hospitals) in Benha, Qalyubia, Egypt in the period from February 2021 to September 2021.

The study was approved by the local Research Ethics Committee (Benha Faculty of Medicine Research Ethics Committee) and the principles of declaration of Helsinki were observed. Informed consent was taken from all patients prior to the study.

Research Ethics Committee: Ms 29-1-2021

Patients:

Inclusion criteria:

- Diabetic patients with non-proliferative diabetic retinopathy.
- Healthy non-diabetic controls.

Exclusion criteria:

- Diabetic patients with proliferative diabetic retinopathy.
- Patients with hazy media or/and poor fixation interfering with good quality OCTA images.

- Patients who previously underwent any interventional treatment for diabetic retinopathy (laser retinal photocoagulation or/and intravitreal injection or/and vitrectomy surgery).
- Patients with other forms of retinopathy (hypertensive, sickle cell, thalassemia, radiation, anemia, leukemia … etc.).

Ophthalmic evaluation:

All patients were subjected to:

1. Detailed history taking including age, sex, duration of diabetes -in patients with diabetic retinopathy- and history of any associated ocular and systemic diseases.
2. Best corrected visual acuity testing (BCVA). Snellen visual acuity was converted to Decimal notation visual acuity for the purpose of statistical analysis.
3. Comprehensive examination (anterior and posterior segment examination).
4. Investigations: Dilatation of the pupils using Tropicamide 1% to facilitate imaging was done for all cases.

Optical Coherence Tomography Angiography (OCTA)

OCTA was performed for all subjects using the Optovue RTVue XR Avanti spectral-domain Ophthalmic Optical Coherence Tomography System with AngioVue version 2018.0.0.18 (Optovue, Inc., Fremont, CA, USA).

AngioVue HD imaging was obtained using macular scan size 6×6 mm², automatically centered on the Fovea, 400×400 pixels (two repeats/B-scan), scan time 3 s, axial resolution 5μm and transversal resolution 15μm. Each B-scan was acquired in a rate of 70,000 A-scans per second, using a scan beam centered on 840 nm, with a bandwidth of 50 nm. Acquisitions could be repeated during the examination to obtain the best resolution of images possible.

All the scans were performed for all patients in the same time frame from 10 to 12 am to avoid possible diurnal variations.

All measurements were done using the manufacturer's tools and Analytical Angiovue software.

Within the macular area, OCTA produces segmental images of different 4 zones (Figure 1) (7):

- Superficial capillary plexus (SCP): extending from the ILM to the IPL.
- Deep capillary plexus (DCP): extending from the IPL to the OPL.
- Outer retina: which is normally avascular and extends from the OPL to the Bruch's membrane.
- Chorio-capillaries: a 30 μm thick slab starting 10 μm below the RPE-Bruch's membrane complex.

Slabs and slices are terms that are used to refer to tissue volumes; slabs refer to thick tissue sections such as outer retina, whereas slices refer to thin sections of few microns used to examine fine details (8).

In order to quantify the OCTA findings, we used the newly developed built-in Angio Analytics software to obtain measurements for a series of parameters in the foveal area.

The automated measured OCTA parameters were the FAZ area (mm²), the superficial capillary plexus vessel density (SCP-VD) and the deep capillary plexus vessel density (DCP-VD), in whole area.

FAZ area:

Foveal avascular zone (FAZ) was defined as the area encompassing the central fovea where there are no vessels. The device automatically outlines the boundary of the FAZ along the centermost capillaries and

the FAZ area was measured in square millimeters (mm²), using the non-flow function on the OCTA software (Figure 2).

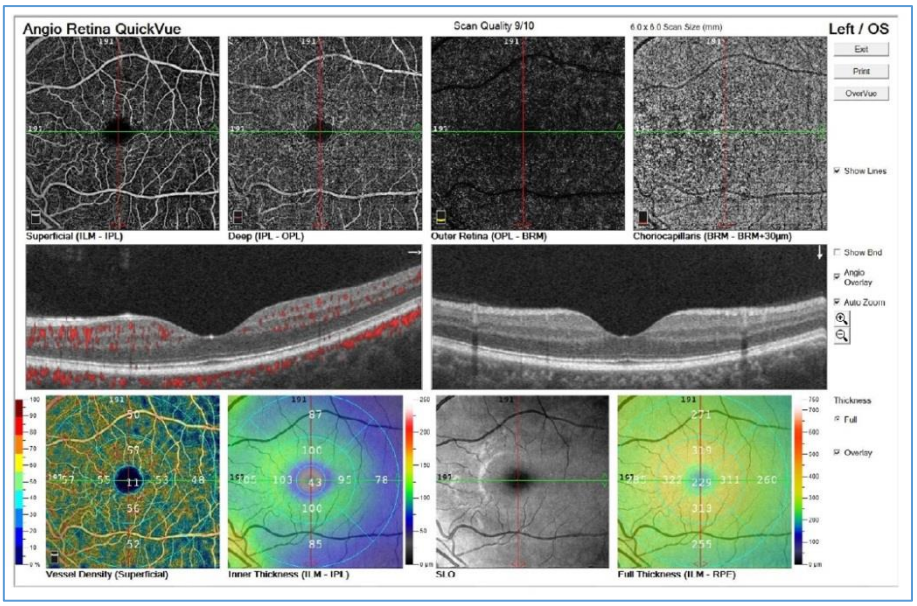

Figure (1): OCTA with en face images shows segmentation of the retina and choroid within the macular area using (Optovue, Inc., Fremont, CA, USA) (9).

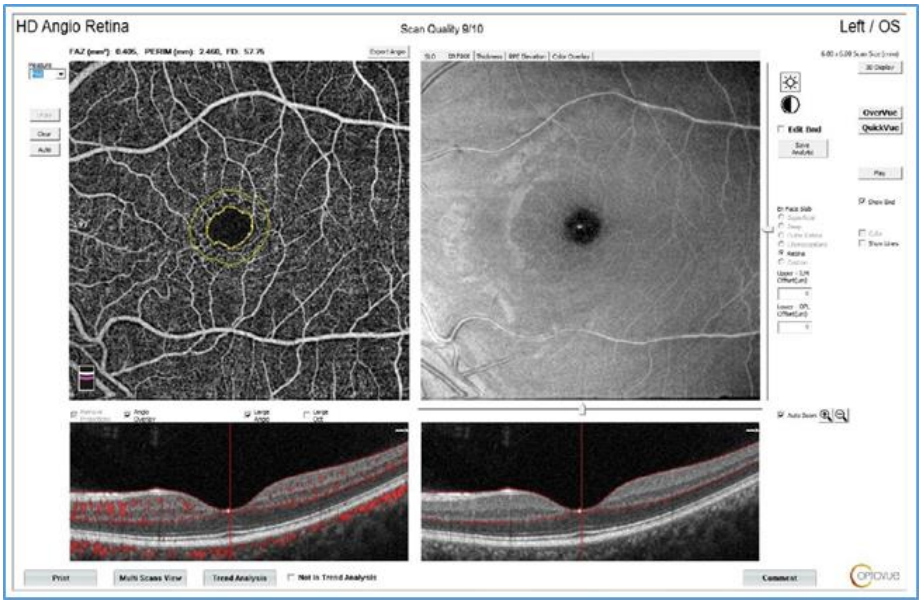

Figure (2): Calculation of FAZ with automated software (Optovue, Inc., Fremont, CA, USA) (9).

(SCP-VD) and the (DCP-VD):

The vessel density was demonstrated as a percentage by taking the ratio of the total vessel area to the total area of analyzed region.

The vessel density was automatically calculated in the whole area in a circular zone of (6 mm) diameter after excluding the FAZ area (Figure 3 , 4).

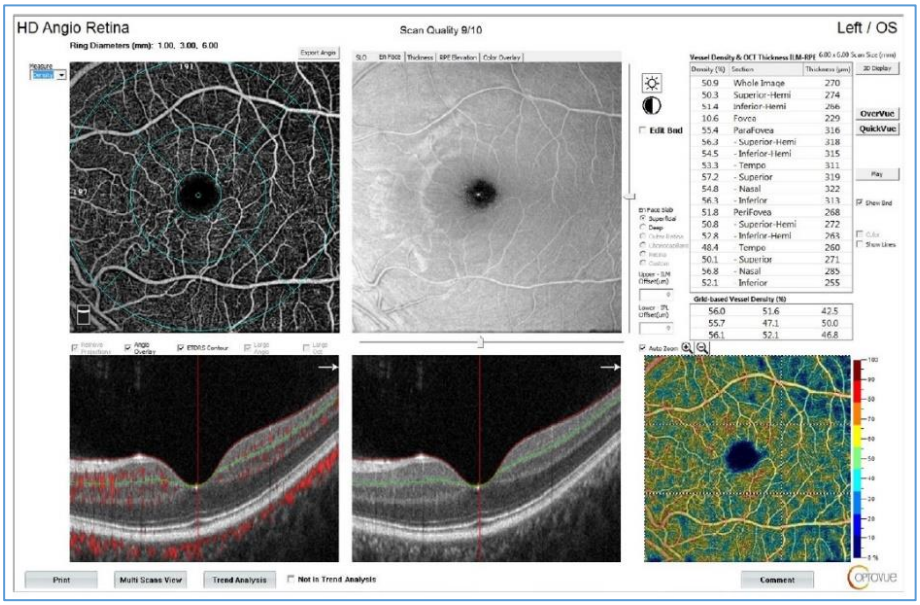

Figure (3): Calculation of superficial capillary plexus vessel density (SCP-VD) values with automated software **(**Optovue, Inc., Fremont, CA, USA) (9).

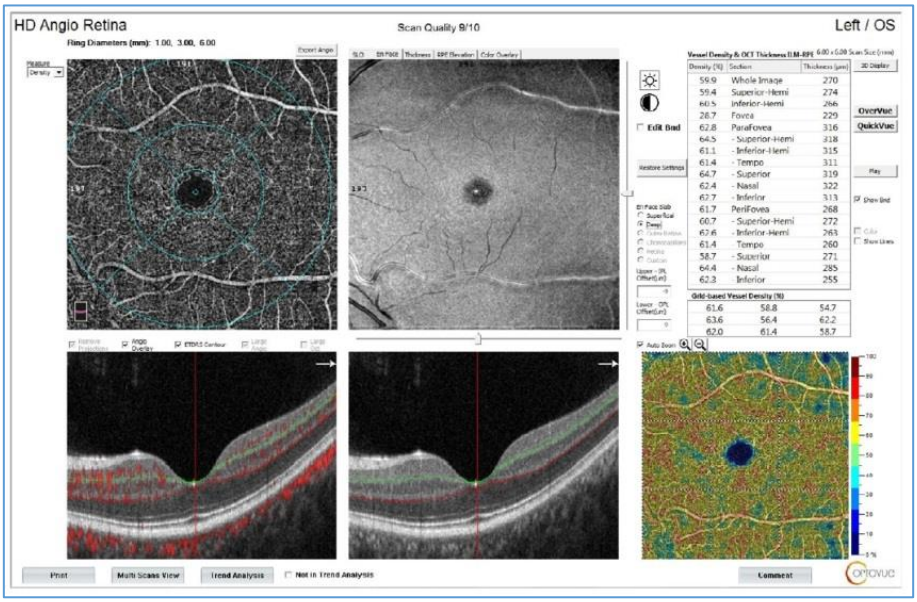

Figure (4): Calculation of deep capillary plexus vessel density (DCP-VD) values with automated software (Optovue, Inc., Fremont, CA, USA) (9).

Statistical analysis:

The collected data were organized, tabulated and statistically analyzed using the computer program SPSS (Statistical package for social science) "version 26" to obtain:

Descriptive data

Descriptive statistics were calculated for the data in the form of:

1. Mean and standard deviation for quantitative data.
2. Frequency and distribution for qualitative data.

Analytical statistics

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests: Student's t-test, Inter-group comparison of categorical data was performed by using chi square test (X^2-value) and fisher exact test (FET) and Correlation coefficient. A P value <0.05 was considered statistically significant (*) while >0.05 statistically insignificant P value <0.01 was considered highly significant (**) in all analyses.

Results:

As shown in table (1), the mean FAZ (mm²) for Diabetic retinopathy cases (38 eyes) was 0.45±0.38 while the mean FAZ (mm²) for the healthy control cases (40 eyes) was 0.29±0.08.

There was a statistically significant difference (P value <0.05) between the two study groups in the mean FAZ (mm²).

The mean FAZ (mm²) was significantly higher in the Diabetic retinopathy group in comparison to the control group.

As shown in table (1), the mean superficial vessel density (%) for Diabetic retinopathy cases (38 eyes) was 42.01±4.36, while the mean superficial vessel density (%) for the healthy control cases (40 eyes) was 48.74±3.22.

And the mean deep vessel density (%) for Diabetic retinopathy cases (38 eyes) was 43.22±5.52 while the mean deep vessel density (%) for the healthy control cases (40 eyes) was 51.47±5.87.

There was a statistically highly significant difference (P value <0.001) between the two study groups in both the Superficial & Deep vessel density (%).

The mean Superficial & Deep vessel density (%) were significantly higher in the healthy controls group in comparison to the Diabetic retinopathy group.

As shown in Table (2), there was insignificant correlation between the BCVA (decimal) and the OCTA FAZ parameters "FAZ (mm²), Superficial & Deep vessel density (%)".

Insignificant negative correlation was found between BCVA and the FAZ (mm²).

Insignificant positive correlation was present between BCVA and the Superficial & Deep vessel density (%).

As regards the FAZ (mm²) Correlation with Superficial & Deep vessel density (%) (Table 2), there was insignificant negative correlation between the FAZ (mm²) and Superficial & Deep vessel density (%).

As regards the Correlation between the superficial & the Deep vessel density (%) (Table 2), there was a statistically significant positive correlation (P value <0.05) between Superficial & Deep vessel density (%).

Table (1): Comparison between BCVA (decimal) and OCTA FAZ Parameters of the two studied groups.

	Diabetic retinopathy group (38)	Healthy Controls group (40)	Statistical test	P value
BCVA (decimal): Mean ±SD	0.39±0.17	0.81±0.22	St t= 9.29	<0.001**
FAZ (mm²): Mean ±SD	0.45±0.38	0.29±0.08	St t= 2.45	0.017*
Superficial vessel density (%): Mean ±SD	42.01±4.36	48.74±3.22	St t= 7.78	<0.001**
Deep vessel density (%): Mean ±SD	43.22±5.52	51.47±5.87	St t= 6.38	<0.001**

* Significant & **highly significant

Table (2): Correlation between the BCVA (Decimal), FAZ (mm²), and superficial & deep vessel density (%) among Diabetic retinopathy group (38 eyes).

	BCVA (Decimal)		FAZ (mm²)		Superficial vessel density (%)		Deep Vessel density (%)	
	Pearson Correlation	P Value	Pearson Correlation	P value	Pearson Correlation	P value	Pearson Correlation	P value
BCVA (Decimal)	1		-0.169	0.311	0.217	0.190	0.150	0.370
FAZ (mm²)	-0.169	0.311	1		-0.263-	0.111	-0.261	0.113
Superficial vessel density (%)	0.217	0.190	-0.263	0.111	1		0.455*	0.004*
Deep vessel density (%)	0.150	0.370	-0.261	0.113	0.455*	0.004*	1	

* Significant

Discussion

Our study found that the mean FAZ (mm²) in non-PDR eyes was 0.45±0.38 while was 0.29±0.08 for the healthy control eyes. And there was a significant enlargement of the FAZ by (OCTA) in non-PDR eyes in comparison with healthy nondiabetic eyes (P=0.017 i.e. (P <0.05), which is consistent with the other previous reports (10-12).

Using fluorescein angiography, Bresnick et al., (10) were the first to show FAZ enlargement in DR. The dimensions of the FAZ were correlated with the extent of the capillary non perfusion.

Later, other subsequent reports have confirmed that FAZ enlargement reflects diabetic retinopathy advancement, which enables FAZ area to be one of the correlated markers for staging diabetic retinopathy (11, 12).

Using OCTA, multiple reports were in agreement with our results and confirmed FAZ enlargement in non-PDR eyes, this includes:

Di et al., (13) which stated that the mean area of FAZ was larger (P=0.02) when

comparing the non-PDR group 0.40±0.11 mm², to the control group, 0.36±0.11 mm² (P=0.02), and Salz et al., (14) which documented that it was larger in the non-PDR group 0.49±0.19 mm² compared to the control group 0.30±0.11 mm² (P <0.05).

Similarly, Lupidi et al., (15) also confirmed that the FAZ was significantly enlarged in both SRL and DRL, when comparing the two groups (P <0.05), In SRL it was 0.42±0.15 and 0.28±0.11 in the non-PDR and the control groups respectively. And in DRL, it was 0.45±0.15 and 0.30±0.10 mm² in both groups respectively.

Kulikov et al., (16) also presented that the FAZ was larger in non-PDR eyes than healthy eyes (P <0.05), 0.41±0.19 and 0.33±0.1, respectively.

On the contrary, Lee et al., (17) did not report significant enlargement of FAZ in non-PDR patients in both SRL & DRL when compared to the healthy control group. The mean FAZ (mm²) in SRL was 0.35±0.11, 0.43 ± 0.65, and 0.33 ± 0.08 in the mild non-PDR, the moderate to severe non-PDR group and the control groups, respectively. And in DRL was 0.90±0.29, 1.17±0.69 and 0.80±0.21 in the same groups, respectively.

In addition to the above-mentioned studies, we found articles investigated the FAZ area in eyes of diabetic patients with "no clinical diabetic retinopathy - NDR" and most of them also documented that FAZ was significantly larger in NDR diabetic eyes as compared to the healthy control group, this includes:

Talisa et al., (18) which stated that the FAZ was larger in the NDR 0.35±0.10 mm² compared to the control group 0.29±0.14 mm² (P=0.04), Takase et al., (19) which presented a significant enlargement in the mean FAZ (mm²) for the NDR group in both SRL & DRL (0.37±0.07 & 0.54±0.13, respectively) when compared to the control group (0.25±0.06 & 0.38±0.11, respectively) (P <0.01) and Di et al., (13) which documented FAZ enlargement in NDR group 0.40±0.16 (P=0.04) compared to the control group 0.36±0.11.

On the other hand, some studies did not report significant enlargement of FAZ in NDR group when compared to the healthy control group, this includes:

Carnevali et al., (20) which found no enlargement in both SRL & DRL. The FAZ in SRL was 0.22±0.10 in the NDR group and 0.25±0.10 in the control group (P=0.34), while in DRL, was 0.75±0.20 and 0.76±0.23 in both groups, respectively (P=0.81), and Lee et al., (17) also did not report significant enlargement of the FAZ in both layers. The mean area of FAZ in DRL was 0.82±0.25 in the NDR group and 0.80±0.21 in the control group. And in SRL, it was 0.35±0.14 mm² in the NDR group and 0.33±0.08 mm² in the control group.

Bresnick et al., (10) stated that the enlargement of the FAZ happens in DR due to the loss of capillaries in the adjacent vessels. And the previous studies have suggested that the mechanism behind the FAZ enlargement in DR is associated with capillary closure (21).

During the early stages of diabetes, there was enhanced expression of ICAM-1 (Intercellular Adhesion Molecule 1) and the obstructed capillary blood vessels were associated with leukocyte aggregation. Since their findings demonstrated that this early retinal capillary closure was transient, the significant FAZ enlargement in NDR study might be reversible (19). These microvascular changes and macular

ischemia are more pronounced in the later stages of DR (22).

According to the studies of (23) and (24) several factors might influence the area of FAZ. Among these, age has been proposed, but they were not able to demonstrate a correlation between them and concluded that the FAZ area had the lowest sensitivity and specificity when compared to the other parameters investigated. This finding may be due to the high inter individual variability in the area of FAZ between age matched groups in both healthy and diabetic patients (25).

Evaluation of the FAZ area by OCTA showed that diabetic eyes exhibited significant FAZ enlargement & impairment of the retinal microcirculation "even before the retinopathy actually develops", so the OCTA is a useful non-invasive screening tool that can be used for the detection of early microcirculatory disturbance in patients with diabetes. Although an OCTA database on the size of the FAZ in "healthy controls" will have to be created to detect the early diabetes–related changes (19).

Our study found that the mean superficial vessel density (%) was 42.01±4.36 & 48.74±3.22 for non-PDR & healthy control eyes, respectively. While the mean deep vessel density (%) was 43.22±5.52 & 51.47±5.87 for both groups, respectively. And both were significantly higher (P <0.001, for both) in the healthy controls group in comparison to the non-PDR group.

Our results were in agreement with multiple reports which confirmed significant decrease in vessel density (%) in non-PDR eyes, this includes:

Samara et al., (26) which stated that the vascular density was significantly lower in all stages of non-PDR at the level of both the superficial and deep retinal layers, compared with controls (all P <0.001). In SRL it was 49.69±3.955 for mild non-PDR group, 49.09±3.907 for moderate-to-severe non-PDR group, and 55.09±2.584 for the control group. And in DRL was 58.09±2.715 for the mild non-PDR group, 55.83±2.990 for the moderate-to-severe non-PDR group, and 61.32±1.939 for the control group.

Lee et al., (17) concluded that the mean vessel density decreased as DR progressed in in non-PDR patients in both SRL (P=0.002) and DRL (P=0.019). In SRL it was 0.399±0.043 in mild non-PDR group, 0.386±0.043 in moderate-to-severe non-PDR group and 0.425±0.028 in the control group. In DRL was 0.240±0.056 in the mild non-PDR group, 0.225±0.054 in the moderate-to-severe non-PDR group and 0.272±0.057 in the control group.

Abdelshafy & Abdelshafy, (27) also confirmed that SCP-VD and DCP-VD showed significant reduction in eyes with DR in comparison to the control group (P <0.001). And the mean vessel density values were shown to decrease in both DCP and SCP as DR progressed. The mean SCP-VD (%) for the non-PDR group was 44.4 while was 53.7 for the healthy control eyes. And the mean DCP-VD (%) was 45.2 for the non-PDR group while was 60.1 for the healthy control eyes.

In addition to the above-mentioned articles, we found articles investigated the superficial and deep vessel density % in eyes of diabetic patients with NDR and most of them also documented decreased vessel density as compared to the healthy control group, this includes:

Dimitrova et al., (28) which presented a significant decrease in the vessel density % for the NDR group in both SRL & DRL (44.35±13.31 & 31.03±16.33,

respectively) when compared to the control group (51.39±13.05 & 41.53±14.08, respectively) (P=0.04 & <0.01, respectively) and Cao et al., (29) that also stated that the average vessel density values in both SCP and DCP decreased in the eyes with NDR compared to normal controls (P <0.001). The average vessel density in SCP was 51.34±4.09 & 55.72±2.43 in NDR & normal controls groups respectively, and in DCP was 57.66±5.73 & 62.10±2.11 in both groups respectively.

However, in other reports, vessel density was significantly reduced only in the deep vascular layer in NDR diabetic patients, this includes:

Carnevali et al., (20) which stated that at SCP, no difference was disclosed in vessel density between the two groups 0.432±0.023 and 0.430±0.020, NDR and control subjects, respectively (P=0.805). While at the DCP, NDR revealed a significantly decreased vessel density compared to control eyes of healthy subjects 0.464±0.016 and 0.477±0.014, respectively (P=0.005), and (30) which documented that the mean deep CD was significantly lower in NDR eyes 52.74±6.3 compared with control eyes 55.45±4.3 (P=0.04). Whereas the mean superficial CD was not significantly different between the groups (P=0.71), it was 44.61±5.9 in NDR eyes and 44.75±4.9 in control eyes.

(OCTA) is a novel, noninvasive method of visualizing the retinal microcirculation in a depth-resolved fashion, allowing the SCP and DCP to be studied separately (31).

OCTA might show very early microvascular changes, which could potentially precede the appearance of micro aneurysms that are currently believed to be the first clinical sign of DR on ophthalmoscopic examination. Moreover, the moderate agreement between SCP and DCP in terms of vascular lesions let us hypothesize that the two plexuses might be simultaneously but not symmetrically involved (32).

In DR, progressive deterioration of perfusion with loss of capillaries is the basis macular ischemia and the various remodeling lesions, which develop in the process (10).

OCTA parameters are altered in patients with diabetes in all retinal vascular layers. Several studies also suggest that OCTA parameter alterations in the deep vascular layer are affected more severely than in the superficial vascular layer in non-PDR (33 , 34).

It was recently shown that, among various OCTA parameters, vessel density in the DPC may have the strongest correlation with functional deficit (34). This is further supported by histological evidence that, in DR, vascular abnormalities are more pronounced in the DCP (35)

Although the mechanism for the preferential involvement of DCP ischemic changes is unknown, one hypothesis suggested that the DPC may contribute more to the metabolic demands of photoreceptor metabolism in eyes with diabetic macular ischemia (36). While one other possible explanation for this was due to relatively lower blood flow in the deep capillary plexus. Histopathological studies also have shown that diabetic micro hemangiomas originate mainly from the deeper capillary network, which indirectly proves that deep tissues are more susceptible to hypoxia, while SCP mitigated hypoxic damage because it was directly connected to the retinal arterioles, which have a higher perfusion pressure and oxygen supply (37).

The ability of OCTA to visualize microvascular changes in diabetic eyes even before their detection clinically may have important implications for the future. OCTA may be able to identify diabetic individuals at risk of developing retinopathy, which may ascertain which individuals need more frequent retinal examinations (38).

Our study results showed that the mean Decimal BCVA was significantly better in the control group (0.81±0.22) in comparison to the non-PDR group (0.39±0.17) (P <0.001).

These results was in agreement with (39) which stated that there was a significant difference regarding the mean (log MAR) BCVA between the groups (P<0.01). It was 0.00±0.01, 0.04±0.03 and 0.18±0.09 in healthy controls, mild and moderate or severe non-PDR groups, respectively. And with Abdelshafy & Abdelshafy, (27) which also documented that the Mean (log MAR) BCVA was significantly higher in the control group (0.05) in comparison to the non-PDR (0.3) (P<0.001).

On the contrary, our results were inconsistent with other studies which stated that there was no significant difference in the mean BCVA between the groups, this includes:

Samara et al., (26) which stated that the mean (log MAR) BCVA was 0.19±0.136 in diabetic eyes and 0.03±0.047 in control eyes, while was 0.15±0.111 in Mild non-PDR eyes and was 0.22±0.141 in Moderate-to-severe non-PDR eyes, Dimitrova et al., (28) which also showed that (log MAR) BCVA was –0.10±0.03 in the non-PDR group & was –0.10±0.03 in the healthy controls (P=0.89) and Suzuki et al., (39) also stated that there were no significant differences found between the groups for BCVA at baseline & latest visit. The mean (log MAR) BCVA at baseline was –0.074±0.125 in the non-PDR group & was –0.058±0.065 in the healthy controls (P= 0.66), while at latest visit was –0.061±0.128 in the non-PDR group & was –0.065±0.073 in the healthy controls (P= 0.83).

There was insignificant negative correlation in our study between the decimal BCVA and the FAZ (mm^2) (P=0.311).

Controversy regarding the correlation between FAZ size and BCVA in DR is still present. Some studies reported a significant correlation between them in non-PDR eyes i.e., "eyes with Larger FAZ areas were correlated with poorer BCVA". This include: (32) (P <0.01 & <0.001) in SCP & DCP respectively and (27) (P <0.001). While other studies did not find an association between them, which is consistent with our results. This include: (40) (P=0.60) and (8) (P= 0.360 & 0.119) in SCP and DCP respectively.

However, the FAZ size may play a limited role in predicting VA in eyes with diabetic retinopathy, as reported by a previous study that observed significant variation in FAZ area (0.071–0.527 mm^2) among normal healthy individuals with a VA of 20/20 (41). Also, inter-individual differences in FAZ area and morphological characters have been observed (42;43). Further research is needed to explicate this correlation.

Insignificant positive correlation was present in our study between BCVA and the Superficial & Deep vessel density (%); (P=0.190 & 0.370, respectively).

Previous studies reported a significant correlation between BCVA and vessel density in both SCP and DCP. This include: (26) (P <0.001, in both) and (27) (P <0.001, in both). While (40) did not

find an association between them, which is consistent with our results.

The Insignificant correlation found in our study between the BCVA and the FAZ, Superficial & Deep vessel densities can be referred to the limited number of patients and presence of other factors that may also influence the BCVA in patients with DR, e.g., grade of DR, presence or absence of diabetic maculopathy, duration of DM, control of DM & other systemic diseases.

Our study found there was insignificant negative correlation between the FAZ (mm^2) and Superficial & Deep vessel density (%); (P= 0.111 & 0.113, respectively).

Similarly, AttaAllah et al., (44) presented insignificant correlation between them in SCP & DCP in non-PDR eyes "with macular edema" (P=0.104 & 0.062, respectively) and in non-PDR eyes "without macular edema" (P=0.599 & 0.133, respectively).

On contrary, Lee et al., (17) reported a strong correlation between them in both superficial & deep layers (P< 0.001). Which was consistent with Salz et al., (14) which stated that the association between DR progression and increased FAZ area may reflect the increased amount of non-perfused areas (14).

Conclusion:

Optical Coherence Tomography Angiography (OCTA) can be used to quantitatively demonstrate alterations in the FAZ area and the vessel density of the different retinal layers in eyes for patients with DR compared to eyes for healthy subjects in a rapid, automated, and noninvasive manner.

Using OCTA, there is a significant enlargement of the FAZ area and significant reduction in the superficial and deep vessel density in non-PDR eyes in comparison with healthy nondiabetic eyes.

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