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Subfoveal Choroidal Thickness in Diabetic Patients without Retinopathy versus Normal Individuals Using Optical Coherence Tomography

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ABSTRACT

Background: Diabetes mellitus (DM) is a prevalent systemic ailment. The incidence of this condition varies from 8.3% to 11.6% among different ethnic groups in the general population. **Objective:** The objective is to compare the subfoveal choroidal thickness between diabetic patients without retinopathy and healthy individuals, utilizing Optical Coherence Tomography (OCT) as the primary diagnostic tool.

Individuals and Methods: This study was conducted on 40 individuals who attended the Ophthalmology outpatient Clinic at Al-Zahraa University Hospital.

Results: The mean age of the cases ranged between 18 and 53 year (mean ± SD was 37.65 ± 6.91 years. Twenty-five were females (62.5%) and 15 were males (37.5%). The mean subfoveal choroidal thickness (SFCT) in healthy individual was 272±13.79 (μm), while in diabetic patients without retinopathy it was 269±12.1 (μm). In our study there was non-statistically significant difference in right, left and average SFCT found between the patients group and the normal group (p-values were 0.428, 0.805 and 0.529 (μm) respectively).

Conclusion: Diabetes mellitus is a microvascular systemic disease, so it affects choroidal circulation lately with development of diabetic retinopathy. Diabetic patients without retinopathy had no significant changes in the subfoveal choroidal thickness. Spectral domain optical coherence tomography with enhanced depth imaging is an objective, fast, reliable, high sensitive, and a non-invasive technique used for measurement of subfoveal choroidal thickness.

Keywords: Diabetes mellitus, optical coherence tomography.

INTRODUCTION

Diabetes mellitus, a widespread condition, impacts an estimated 8.3% to 11.6% of people across diverse ethnic backgrounds [(1)]. Diabetes mellitus (DM) is a persistent medical condition that impacts 415 million individuals globally, and it is projected to increase in prevalence to around 642 million by the year 2040 [(2)]. It is defined by long-term high blood sugar levels and a disrupted balance among cells, potentially resulting in malfunction of many organs. Diabetes mellitus (DM) leads to the development and buildup of advanced glycosylation end products (AGEs) due to high blood sugar levels. These AGEs are closely linked to many clinical consequences of DM [(3)].

The choroidal layer in the eye, responsible for supplying blood to the outer portion of the retina, could have a significant role in the onset of diabetic retinopathy (DR). The primary alterations observed in the choroid are predominantly seen in the choriocapillaris layer, and these changes can extend to the larger vessels found in the choroid's outer layers [(4)].

Diabetic choroidopathy is the term used to describe choroidal abnormalities in individuals with diabetes. Lutty (2017) outlined the risk factors linked to diabetic choroidopathy, which include severe diabetic retinopathy, inadequate management of blood sugar levels, and the specific treatment plan being followed [(5)].

Recent research into neo-vascular age-related macular degeneration and diabetes suggests that the choroid thickness could be a useful marker for assessing the efficacy of antiangiogenic medications [(6)]. Therefore, evaluating choroidal alterations can aid in making more informed therapy decisions and enhancing treatment monitoring [(7)].

Initial studies on the pathology of diabetic choroids have shown various changes, including twisted blood vessels, the loss of choriocapillaris, drusenoid deposits on Bruch's membrane, microaneurysms, and choroidal neovascularization. Additionally, both the choroidal vascularity index (CVI) and subfoveal choroidal thickness (SFCT) are dynamic factors influenced by diabetic macular edema (DME) [(8)].

The choroidal layer provides oxygen and nutrients to the outermost layer of the retina. Any alteration or harm to this tissue's thinning can impact the retina above it, resulting in hypoxia and contributing to the emergence of diabetic retinopathy, lesions, or the advancement of pre-existing retinal disease. It remains uncertain if the reduction in choroidal thickness is a precursor to diabetic retinopathy (DR) lesions or if these lesions contribute to the thinning of the choroid. Therefore, deepening our knowledge of the pathological processes involved in DR, especially those affecting the choroid, is crucial. This understanding could aid doctors in better grasping how the disease evolves and in refining DR treatment through tailored approaches [(7)].

Choroidal blood flow deficit may occur as an initial pathological alteration in diabetic retinopathy (DR). The luminal to choroidal area ratio (L/C ratio) can serve as a predictive indicator for the development of diabetic retinopathy (DR) before to its clinical manifestation. The primary occurrence in diabetes, even

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in the absence of diabetic retinopathy (DR), is the development of ischemic alterations in the choroidal vasculature [9].

The Heidelberg Spectralis, Cirus HD-OCT, and spectral domain (SD)-OCT equipment have been used to effectively examine and evaluate choroidal thickness in both normal and pathological conditions, as indicated by recent findings. Optical coherence tomography (OCT) is a non-invasive imaging method used to obtain detailed, high-resolution cross-sectional images of the retina. EDI SD-OCT has been recently introduced. The EDI program collects an image of the choroid near the zero-delay line to optimize sensitivity at the outer boundary of the choroid [10].

OCT is beneficial for seeing and measuring the choroid in living organisms, as it avoids the interference from the outer retina in fundus photography and scanning laser ophthalmoscopy, as well as the limited resolution of ocular ultrasonography [11]. OCT provides visualization and quantification of the choroid. Research has demonstrated that the thickness of the choroid is influenced by both age and the length of the eye's axial axis [12].

AIM OF THE WORK

The objective of this study is to assess and contrast the subfoveal choroidal thickness in diabetic patients without retinopathy and persons with normal ocular health, utilizing the Optical Coherence Tomography (OCT) technique.

INDIVIDUALS AND METHODS

The study was conducted on 40 individuals who attended the Ophthalmology outpatient Clinic at Al-Zahraa University Hospital between November, 2022 and September , 2023.

- **Study design:** Cross sectional descriptive comparative study.
- **Study site:** The Ophthalmology Department of Al-Zahraa University Hospital.

Inclusion criteria:

Age between (18-50) years. They were divided into 2 groups:

- ***Group 1:*** Healthy individuals (non-diabetic or hypertensive).
- ***Group 2:*** Patients with history of diabetes mellitus of any type without retinopathy.

Exclusion criteria: Un-controlled systemic hypertension, age-related macular degeneration or choroidal neovascularization, patients with previous ocular surgery, patients with previous ocular trauma, previous treatment for diabetic retinopathy either injection, laser, or surgery, taut posterior hyaloid or vitreomacular traction, diabetic patients with retinopathy and pregnancy.

The study was conducted on 80 eyes of 40 individuals divided into 2 Groups:

- ***Group 1:*** 40 eyes of 20 age matched healthy individuals.
- ***Group 2:*** 40 eyes of 20 diabetic patients without retinopathy.

- **Methods:** Patients underwent a thorough evaluation that included their medical history, physical examinations, and various diagnostic tests.
- ***History:*** Personal information encompasses details like an individual's name, age, gender, place of residence, contact number, and profession. This also includes criteria for inclusion and exclusion in a study or evaluation. Additionally, a comprehensive medical history is gathered, focusing on any eye-related diseases, injuries, and surgeries the individual may have had, as well as the duration of their Diabetes Mellitus.

Examination: Visual acuity assessment by Landolt's C type chart, both unaided (UCVA) and aided (BCVA). Results were converted into the Log MAR scale. Anterior segment examination using: slit-lamp. Fundus examination using: slit-lamp biomicroscopy and indirect ophthalmoscopy.

Investigations: Enhanced Depth Imaging Spectral Domain Optical Coherence Tomography (EDI-SD-OCT).

Figure (1): Optical coherence tomography.

In our work, we conducted a thorough examination of the eyes, which involved using spectral-domain optical coherence tomography (OCT) with enhanced depth imaging to quantify subfoveal choroidal thickness (SFCT) in both healthy individuals and diabetic patients without retinopathy.

Ethical consideration:

Prior to completing the interviews, all participants in the study signed a well-informed written consent. The patient possessed the prerogative to engage or discontinue their involvement in the study at any given moment. The patient was entitled to receive comprehensive information regarding the study. The researchers ensured that all patients' information and identities in the study were strictly maintained as confidential and accessible only to them. The study was

approved by the Ethics Board of Al-Azhar University.

Statistical Analysis

The collected data were systematically analyzed, coded, and entered into IBM's Statistical Package for Social Science (SPSS), version 23. For parametric analysis, quantitative data were presented as means, standard deviations, and ranges.

Qualitative data were represented using counts and percentages. Group comparisons involving qualitative data utilized the Chi-square test. The Independent t-test was applied for comparing two groups with quantitative data showing a parametric distribution. To assess the correlation between two quantitative variables within the same group, Spearman correlation coefficients were used.

A 95% confidence level was set, with a 5% margin of error deemed acceptable. The p-value significance was categorized as follows: P-value > 0.05 indicates a lack of statistical significance; P < 0.05 suggests statistical significance; and P < 0.01 indicates a high level of statistical significance.

RESULTS

This study is a cross sectional descriptive comparative study. It was held at the Ophthalmology Department of Al-Zahraa University Hospital between November , 2022 and September , 2023. It was conducted on 40 individuals who were divided into 2 groups: ***Group 1:*** Healthy individuals (non-diabetic or hypertensive), and ***Group 2:*** Patients with a history of diabetes mellitus of any type without retinopathy.

Table (1) shows a comparison between the health and the patients groups regarding demographic data and characteristics of the studied subjects. The comparison between the healthy group and the patient group showed no significant statistical difference in terms of sex distribution, with a p-value of 0.744. However, there was a statistically significant difference in the ages of the groups, with the patient group being older than the healthy group, as indicated by a p-value of less than 0.001.

Table (1): Demographic data and characteristics between the healthy and patients groups

		Normal group No. = 20	Patients group No. = 20	Test	P	Sig.
Sex	Female Male	12 (60.0%) 8 (40.0%)	13 (65.0%) 7 (35.0%)	0.107*	0.744	NS
Age (Years)	Mean ± SD Range	30.55 ± 8.15 18 – 51	44.75 ± 5.67 33 – 53	-6.397•	0.000	HS
DM (Months)	Median (IQR) Range	– –	18 (12 – 24) 4 – 36	–	–	–

Table (2) shows a comparison between the healthy and the patients groups regarding the history of the studied individuals.

Table (2): Clinical history between the normal and the patients group

		Normal group No. = 20	Patients group No. = 20	Test	P	Sig.
Anterior segment	NAD	20 (100.0%)	20 (100.0%)	NA	NA	NA
Fundus examination	Free	20 (100.0%)	20 (100.0%)	NA	NA	NA

NA: Not applicable

As regards the BCVA in right and left eyes calculated by Log MAR, there was statistically significant increase in the right, the left and the average BCVA in the patients group than the healthy group (p-value < 0.001, 0.001 and <0.001) (Table 3).

Table (3): BCVA between the healthy group and the patients group

		Normal group No. = 20	Patients group No. = 20	Test	P	Sig.
RT.VA	Mean ± SD Range	0.00 ± 0.00 0 – 0	0.13 ± 0.10 0 – 0.301	-5.533•	0.000	HS
LT.VA	Mean ± SD Range	0.00 ± 0.00 0 – 0	0.09 ± 0.11 0 – 0.301	-3.728•	0.001	HS
VA average	Mean ± SD Range	0.00 ± 0.00 0 – 0	0.11 ± 0.10 0 – 0.24	-5.101•	0.000	HS

As regards the right, the left and the average SFCT in the patients group and the healthy group, there were non-statistically significant differences (p-values were 0.428, 0.805 and 0.529; respectively) (Figure 4).

Table (4): SFCT between the healthy group and the patients group

		Normal group No. = 20	Patients group No. = 20	Test	P	Sig.
RT.SFCT (µm)	Mean ± SD Range	275.05 ± 15.68 250 – 300	271.05 ± 15.88 240 – 299	0.802•	0.428	NS
LT.SFCT (µm)	Mean ± SD Range	270.05 ± 17.11 240 – 300	268.80 ± 14.54 223 – 287	0.249•	0.805	NS
SFCT (µm) average	Mean ± SD Range	272.55 ± 13.79 246 – 296	269.93 ± 12.31 241.5 – 289	0.635•	0.529	NS

Figure (5) shows a correlation between the right, the left and the average SFCT with the age and the DM duration among the studied patients. There were statistically significant negative correlations between left SCT and duration of DM (r -0.455 and p-value 0.044), while there were non-statistically significant correlations between the other studied parameters.

Table (5): Correlation of right, left and average SFCT with age and DM duration among the studied patients.

	RT.SFCT (Mm)		LT.SFCT (Mm)		SFCT (Mm) average	
	r	P-value	R	P-value	r	P-value
Age (Year)	-0.354	0.125	0.026	0.914	-0.258	0.273
DM (Months)	0.195	0.411	**-0.455***	**0.044**	-0.048	0.842

Figure (5) shows a correlation between the right, the left and the average BCVA with SFCT the right, the left and the average among the studied patients.

Table (6): Correlation of the right, the left and the average BCVA with SFCT right, left and average among the studied patients.

	RT.VA		LT.VA		VA average	
	R	P-value	r	P-value	r	P-value
RT.SFCT (µm)	-0.251	0.285	-0.205	0.385	-0.24	0.308
LT.SFCT (µm)	-0.332	0.153	-0.355	0.125	-0.392	0.088
SFCT (Mm) average	-0.355	0.125	-0.342	0.139	-0.375	0.103

Table (7) shows that there were non-statistically significant relations between the sex of the studied patients and their right, left and average SFCT measurements (p-value were 0.940, 0.628 and 0.813 respectively).

Table (7): Relation between the gender of the studied patients and the right, the left and the average SFCT among the studied patients

		Sex		Test value	P-value	Sig.
		Female	Male			
RT.SFCT (µm)	Mean ± SD Range	270.85 ± 16.65 240 – 294	271.43 ± 15.6 252 – 299	-0.076•	0.940	NS
LT.SFCT (µm)	Mean ± SD Range	270 ± 10.12 243 – 286	266.57 ± 21.35 223 – 287	0.493•	0.628	NS
SFCT (µm) average	Mean ± SD Range	270.42 ± 11.78 241.5 – 284	269 ± 14.15 245 – 289	0.240•	0.813	NS

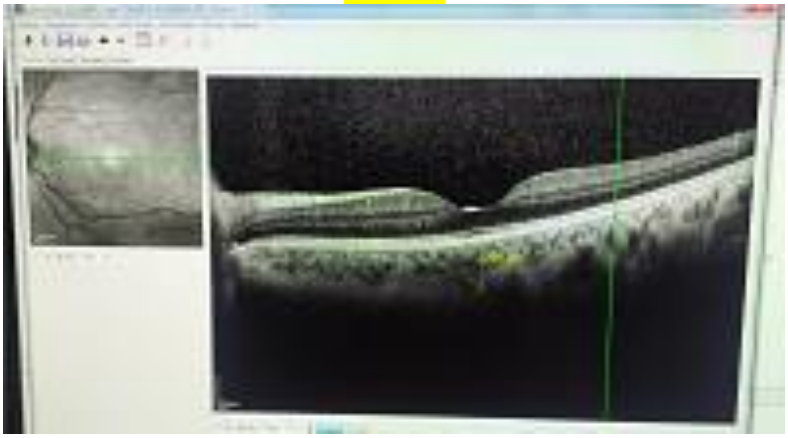
Examples of diabetic cases

CASE 2

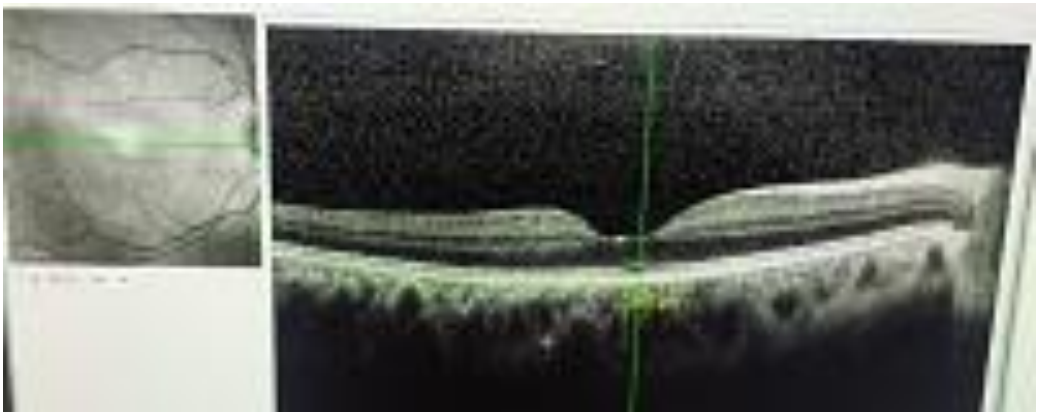
RT SFCT 261(µm)

Lt SFCT 264 (µm)

CASE 9



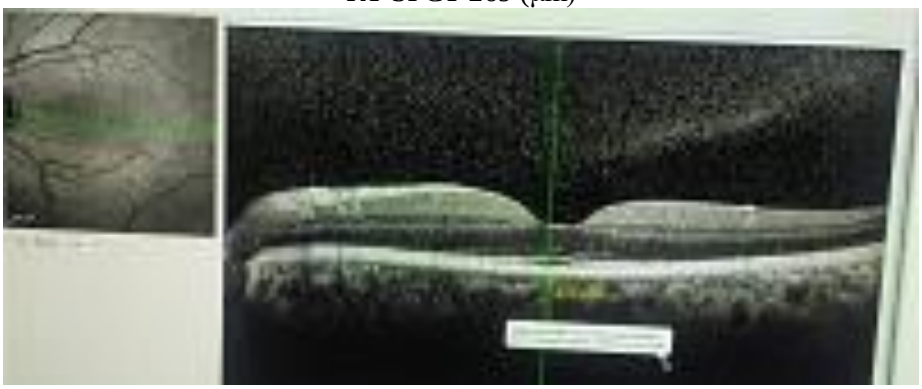
LT SFCT 268 (µm).



RT SFCT 293 (µm)
Examples of normal cases

CASE 7:

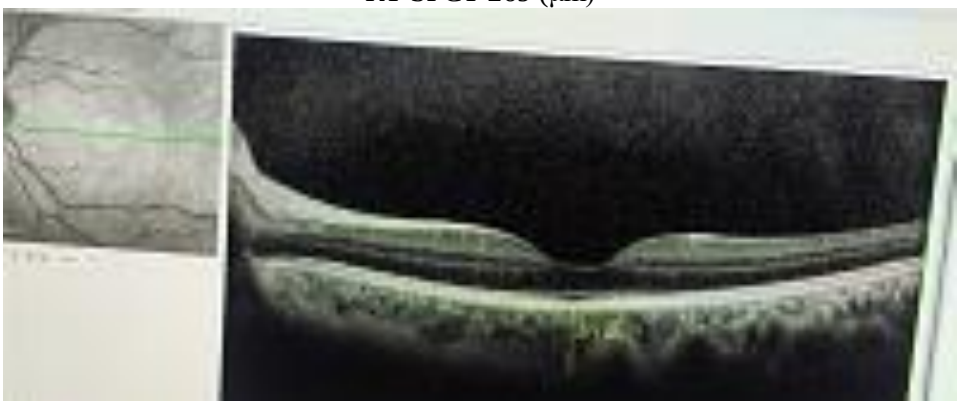
RT SFCT 269 (µm)



Lt SFCT 277 (µm)

CASE 13

RT SFCT 269 (µm)



LT SFCT 271 (µm)

DISCUSSION

This cross sectional descriptive comparative study included 40 individuals, 25 females (62.5%) and 15 males (37.5%). Their ages ranged between 18 and 53 years (Mean ± SD was 37.65 ± 6.91 years).

The mean SFCT in the healthy individual was 272±13.79 (μm), while it was 269±12.1 (μm) in the diabetic patients without retinopathy.

There were non-statistically significant differences in the right, the left and the average SFCT found between the patients group and healthy group (p-values were 0.428, 0.805 and 0.529; respectively).

Our study supports the findings of ***Ambiya et al.'s (2018)*** research. Their study included 100 eyes from diabetic patients without diabetic retinopathy (group D), 100 with diabetic retinopathy (group R), and 100 healthy individuals (group N). The assessment involved gathering demographic information, diabetes duration, comprehensive eye examinations, capturing images of the eye's fundus with or without the use of fundus fluorescein angiography dye, and employing spectral domain optical coherence tomography with enhanced depth imaging to measure the subfoveal choroidal thickness (SFCT). Their findings indicated no significant difference in SFCT between groups and D (308.48 ± 30.06 μm; P = 0.60) and N (310.65 ± 37.34 μm). However, SFCT was significantly reduced in group R (296.52 ± 21.41 μm; P < 0.01) [(13)]. Furthermore, our research is consistent with the outcomes of the 2013 study by ***Lee and colleagues***. This study involved 203 eyes from diabetic patients and 48 eyes from non-diabetic subjects. The researchers utilized enhanced-depth imaging optical coherence tomography to assess the thickness of the choroid at the foveal area. Their findings showed that there was no notable statistical disparity in the thickness of the choroid between the diabetic eyes without alterations and those of the control group [(14)]. Our results similarly match the conclusions of ***Xu et al.'s 2013*** study. They reported no marked disparity in the average subfoveal choroidal thickness (SFCT) when comparing diabetic individuals to non-diabetic ones (266±108 μm vs. 261±103 μm; P = 0.43). Likewise, they found no significant variance in SFCT between diabetic patients with retinopathy and those without this condition (249±86 μm vs. 262±104 μm; P = 0.56) [(15)].

Our study corroborates the findings of ***Sayin et al. (2014)***, who determined that an average subfoveal choroidal thickness (SFCT) in diabetic patients' eyes of 375.3 ± 66.5 μm, compared to 356.4 ± 52.0 μm in the control group. The research found no significant correlation between SFCT and various factors, including fasting glucose levels, HbA1c, age, or diabetes duration. It concluded no significant difference in SFCT between diabetic patients without retinopathy and the healthy individuals in the control group [(16)].

Our research findings are in agreement with those reported by Eroğul and Eroğul in 2019. In their study, diabetic patients without diabetic retinopathy exhibited a subfoveal choroidal thickness (SFCT) 348.7 μm in the left eye and 311.6 μm in the right eye. By comparison, the control group showed SFCTs of 368.9 μm in the left eye and 377.1 μm in the right eye. However, when comparing the choroidal thickness between diabetic patients without retinopathy and the control group, even though the control group had a higher SFCT, the difference was not statistically significant, with a p-value of 0.214 [(17)].

Also our study came in agreement with those done by ***Obadă et al. (2022).*** They reported that SFCT in group 1(healthy subjects) was 260.19 ± 113.18 (μ) and in group 2(diabetics without DR) was 258.40 ± 85.43 (μ). There were no significant differences between the two groups with respect to SF-CT ($p > 0.05$) [(18)].

In line with the findings of Abadía et al. (2019), our study also supports their conclusions. They showed that the average subfoveal choroidal thickness (SFCT) in healthy individuals was 229.97 ± 79.9 μm, compared to 192.67 ± 74.3 μm in patients with Type 2 Diabetes (P = 0.013). Furthermore, they found no significant differences in the consistency of choroidal measurements within a single session between healthy individuals and patients with Type 2 Diabetes (T2D) [(19)].

While our study generally aligns with the findings of several other researchers, it differs from the results presented by Endo et al. in 2020. Their study highlighted a statistically significant reduction in the subfoveal choroidal thickness (SFCT) in diabetic eyes without retinopathy compared to those of healthy control subjects, with the difference being significant (P < .005). This contrast in findings highlights the complexity and variability in the impact of diabetes on ocular health [(20)].

Our work contradicts the findings of Sudhalkar et al. (2015) in the same context. They observed that normal eyes had a higher subfoveal choroidal thickness (SFCT) compared to individuals with diabetes but without retinopathy. The study found that those with diabetes but without retinopathy had choroids that were considerably thinner (261.71 ± 51.8 microns) than the normal eyes (281.7 ± 47.7 microns) (P = 0.032) [(21)].

Also our study disagrees with those done by ***Rifada et al. (2023)*** who showed that SFCT in diabetic patients without retinopathy was significantly thinner (266.68 ± 51.76 microns) when compared to the control group (283.07 ± 69.98; p = 0.042) [(22)].

Our study presents findings that differ from those reported by Oliveira-Ferreira et al. (2020). In their research, it was shown that the mean subfoveal choroidal thickness (CT) in diabetic patients was 251.08 ± 69.31 μm, in contrast to 246.03 ± 59.41 μm in non-diabetic individuals. Their study concluded that the mean subfoveal CT was higher in diabetic patients compared to non-diabetic patients. However, our research does not align with these observations.

CONCLUSION

Diabetes mellitus, being a microvascular systemic disease, typically impacts choroidal circulation at a later stage, coinciding with the development of diabetic retinopathy. Spectral domain optical coherence tomography with enhanced depth imaging serves as an objective, rapid, reliable, highly sensitive, and non-invasive technique for measuring subfoveal choroidal thickness. This technology is crucial for assessing changes in the choroidal layer associated with diabetes.

Diabetic patients who did not have retinopathy did not have any notable alterations in the thickness of the choroid located beneath the fovea. There was an insignificant difference in subfoveal choroidal thickness (SFCT) between the group of patients and the group of healthy individuals.

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- **Conflict Of Interest:** None.

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