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Original Article

RETINAL THICKNESS IN DIABETIC AND NON-DIABETIC PATIENTS USING SPECTRAL DOMAIN OPTICAL COHERENCE TOMOGRAPHY (SD-OCT)

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ABSTRACT:

This study aimed to determine the average retinal thickness with and without diabetes using Spectral Domain Optical Coherence Tomography (SD-OCT). Known diabetic and non-diabetic respondents from Diabetic Eye Clinic & General OPD having no clinical signs of diabetic retinopathy on fundus examination were selected in this study. All the participants gave informed written informed consent. A total of 80 patients (n=156 eyes) were recruited in this study. Average central thickness was 249 µm and 246 µm in diabetic and non-diabetic patients respectively. On quadrant wise evaluation, retinal thickness in diabetic and non-diabetic (Healthy Eye) were: Nasal =310 µm and 324 µm), Temporal =291 µm and 304 µm, Superior =297 µm and 316µm, and Inferior= 292 µm and 314 µm). Retinal thicknesses were greater at nasal and lesser at temporal areas.

In conclusion retinal thickness measured in diabetic patients was found to be less in non-diabetic patients. Age and gender were other related demographic factors that influenced macular thickness measurements.

Keywords: Retinal thickness, Diabetes mellitus, Spectral-domain optical coherence tomography (SD-OCT), Macular thickness, Diabetic eye

INTRODUCTION

Diabetes is a Greek word meaning to siphon, while *Mellitus* is a Latin word meaning honey. The complete term was described by Thomas Willis in 1674. He described the urine of diabetic patients as if it was permeated with honey and sugar. By the mid-1800s, treatments for diabetes were often harsh, including "fad" diets, starvation diets, and other therapies. Among all these treatments, the starvation diet was considered the most successful (1).

In Pakistan, the prevalence of type 2 diabetes, also known as Diabetes Mellitus (DM), has been recorded to be 27%, and it is a progressive chronic disease. Complications of DM arise from hyperglycemia, caused by impairment of insulin metabolism and alterations in biological macromolecules such as carbohydrates, lipids, proteins, and nucleic acids (2). Jagar et al noticed some "yellowish," oval spots on the diabetic human retina in 1939. The condition is known as diabetic retinopathy (DR). The term "diabetic retinopathy" refers to changes in the retina that occur over the course of diabetes. It is one of the leading causes of blindness in the population. Diabetic retinopathy is a silent disease because it is usually recognised by the patient only when the disease reaches a stage where treatment is no longer effective. Therefore, effective treatment for diabetic retinopathy must be administered at the early stages of the disease (3).

Diabetic retinopathy is a common complication of diabetes, in which the retina (a layer of tissue at the back of the eye) becomes progressively damaged. Diabetic retinopathy is the most common microvascular complication of diabetes mellitus. It is a microangiopathy that affects small vessels in the retina, such as arterioles, capillaries, and venules. It is characterized by increased vascular permeability, ocular hemorrhages, lipid exudates, and vascular closure, often mediated by the formation of new blood vessels on the retina (4). The DR can be broadly classified as non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). The stage of the DR can be determined on the presence of specific DR features (5,6).

Optical Coherence Tomography (OCT) is a non-invasive modality that produces cross-sectional or three-dimensional, high-resolution images of the retinal layers and allows quantitative assessment of retinal thickness. OCT has emerged as an important imaging tool in the evaluation and management of retinal diseases. It is based on low-coherence light reflection. The OCT is one of the fundamental diagnostic imaging techniques in the fields of ophthalmology and optometry. Additionally, OCT provides quantitative data on retinal thickness, which is essential for monitoring changes in clinical symptoms of diabetic retinopathy and for use in research settings (7, 8).

Spectral Domain Optical Coherence Tomography (SD-OCT), also known as Fourier Domain OCT, is a relatively new imaging technique based on Fourier transformation to gather depth-resolved data from the spectra of OCT signals. This advanced technology has replaced Time Domain OCT (TD-OCT). Therefore, data are needed to describe normal macular thickness in individuals with or without DM using SD-OCT. The main advantages of SD-OCT over TD-OCT include increased speed of data collection and higher-resolution imaging. The SD-OCT also provides three-dimensional images of the retina, which was not possible with TD-OCT. The TD-OCT uses an interferometer to measure the echo delay time of light reflected and backscattered from various retinal microstructures and samples only one point at a time, making it relatively slow to obtain A-scan and B-mode retinal images (9, 10).

In SD-OCT, light beams returning from the sample and reference paths are combined at the detector, which is a spectrometer that resolves the interference signals throughout the depth of each A-scan without varying the length of the reference path. The SD-OCT provides scans that are 50 times faster than those of TD-OCT (11).

The recent introduction of SD-OCT enables imaging of the macula at a much faster scan rate and with higher resolution. Compared with commercially available TD-OCT, which collects 400 axial measurements per second with an axial resolution of approximately 10 μm. The SD-OCT achieves at least 18,000 axial measurements per second with an axial resolution of 5 μm. The basic working principle of SD-OCT is similar to that of TD-OCT, as both systems measure the echo time delay of backscattered light signals via an interferometer. In TD-OCT, depth information of the retina is collected as a function of time by moving the reference mirror.

The SD-OCT has been modified to perform three-dimensional (3D) OCT. The 3D OCT uses a superluminescent diode laser with a centre wavelength of 840 nm and a bandwidth of 50 nm as the light source. The acquisition rate of 3D OCT is up to 18,000 A-scans per second. The transverse and axial resolutions are 20 μm and 5 μm, respectively. This is achieved through a raster scan composed of 256 × 256 (vertical × horizontal) axial scans, covering a 6 × 6 mm macular region. A built-in correlation-based algorithm is used to cancel axial eye motion artefacts. All images were obtained with an image quality score of at least 60 (12).

Optical Coherence Tomography is a useful tool for quantifying the structural complications of the diabetic retina. OCT provides high-quality examination in patients with DM. It helps measure central macular thickness and central macular volume. There is no such automated and accurate screening system available for diabetic patients to evaluate early central macular changes in the diabetic human retina (13).

According to protocol, central macular thickness is measured using 3D macular scans in SD-OCT. Each macular scan consists of 256 × 256 (vertical × horizontal) axial scans covering a 6 × 6 mm region of the macula. The scan reconstructs a false-color topographic image displayed with numeric averages of thickness measurements for each of the nine regions within the 6 × 6 mm area centered on the fovea. The macula is divided into nine regions: a 3 mm inner ring and a 6 mm outer ring, both centered on the fovea. The inner and outer rings are further divided into four quadrants: nasal, temporal, superior, and inferior. SD-OCT identifies the retinal layers and determines central macular thickness by measuring the distance between the inner limiting membrane (ILM) and the inner boundary of the retinal pigment epithelium (RPE) in all nine regions.

METHODS

This was a hospital-based observational prospective comparative cross sectional study, including 40 diabetic and 40 non-diabetic participants, with an equal distribution of 20 males and 20 females in each group. Purposive sampling was used to select the participants. Type 2 diabetic patients with healthy eyes were included in the study. Participants aged between 20 and 60 years were selected. Both male and female patients were considered. Non-diabetic patients with healthy eyes were also included. Patients with any systemic or ocular problems other than diabetes were excluded. Uncooperative patients were not included. Individuals with type I diabetes or significant diabetic retinopathy were also excluded from the study. After diagnosis by using fundoscopy, retinal photographs and retinal thickness measurements were taken using a SD-OCT machine. The data were recorded on a proforma in the investigation room. Nine standard ETDRS grid regions were used for assessment and analysis.

Ethical Statement:

All participants were provided with a copy of project details sheet with complete description of the study, once they understood and signed a written consent form (English as well as Urdu), they were recruited in the study. Any information obtained in this study that could identify participants was kept confidential and any answers to the questionnaire were kept in a safe place on campus. All participants were given a unique study identification code. Data were de-identified at the time of collection such that only participants' name initial and a study identification

number were used to identify the data for each participant. Any data included in reports, publication, or presented at a meeting were provided in the form of group response or studies identify numbers, such that the participants cannot be identified.

RESULTS

Average central Foveal thickness was (249 ± 19µm) in diabetic patients without DR and (246 ± 16µm) in non-diabetic with healthy eye patients. While Average retinal thickness in different quadrants were (297 ± 21) in Diabetic without DR and (315 ± 13) in non-diabetic. The Average Retinal thickness was decreased in Diabetic subjects when compared to non-diabetic.(Table 1).

On Quadrant wise evaluation, Retinal Thickness in Diabetic and Non-Diabetic (Healthy Eye) were at Nasal (310 ± 17 & 324 ± 14 µm), Temporal (291 ± 31 & 304 ± 14 µm), Superior (297 ± 20 & 316 ± 14µm), and Inferior (292 ± 19 & 314 ± 13µm). Retinal thickness was greater at nasal and lesser at temporal areas. (Table 2)

Foveal Thickness in Diabetes Mellitus subjects Male (260 µm) & Female (237 µm) while the average Retinal Thickness were in Male (312µm) & Female (295 µm). (Table 3).

Table 1: Compression between retinal thickness with Diabetic and Non-Diabetic patients

Thickness	Diabetes	Non-Diabetes
Foveal	249 ± 19µm	246 ± 16µm
Retinal	297 ± 21µm	315 ± 13µm

Table 2: Compression between Retinal Quadrant with Diabetic and Non-Diabetic patients

Region	Diabetes	Non-Diabetes
Nasal	310 ± 17µm	324 ± 14 µm
Temporal	291 ± 31µm	304 ± 14 µm
Superior	297 ± 20µm	316 ± 14µm
Inferior	292 ± 19µm	314 ± 13µm

Table 3: Compression between Retinal thickness with Male and Female

Thickness	Male	Female
Foveal	260 µm	237 µm
Quadrants	305.5 µm	282 µm

DISCUSSION

In this study, we examined retinal thickness in non-diabetic and type-2 diabetic individuals with no signs of DR using SD-OCT. Because diabetic retinopathy is a common complication of diabetes, early diagnosis and proper management can reduce the incidence of vision loss. The OCT studies have consistently demonstrated retinal structural changes and alterations in macular thickness in patients with diabetic retinopathy. However, it is still not clearly established whether changes in macular thickness exist in diabetic individuals without clinical DR. The new OCT devices are reliable tools for easy and repeatable evaluation of the retina because OCT evaluates retinal morphology. Diabetes in humans has been classified into two types: insulin-dependent diabetes mellitus and non-insulin-dependent diabetes mellitus, according to pathogenesis. Although these two types of diabetes differ in pathophysiology and prevalence, type-1 DM generally has an earlier onset and prolonged course, whereas type-2 DM occurs in slightly older individuals. In our research, we included only patients with type-2 DM.

We examined retinal thickness in normal and type-2 diabetic individuals without DR using SD-OCT and analyzed possible factors affecting retinal thickness. Previous studies noted significant differences in central foveal thickness between diabetic patients with and without DR. Our study provides an overall profile of retinal thickness in individuals with diabetes without clinically visible DR. We observed that retinal thickness was generally decreased in diabetes, particularly in the temporal (perifoveal) areas.

One report found that the fovea was significantly thinner in patients with longer disease duration but no or mild DR (14). Another study reported decreased thickness only at the inner plexiform layer (IPL) (15); however, the present study did not demonstrate these features. Another study claimed that subjects with no or mild DR had significantly thinner macular and foveal thickness with longer disease duration (16). Conversely, a few studies found no significant difference in foveal thickness between diabetic and non-diabetic individuals (17,18), which is consistent with our findings.

Two different studies reported significant differences in retinal thickness between diabetic and non-diabetic individuals. One study comparing macular thickness in controls (healthy eyes) and diabetic patients without DR demonstrated greater retinal thickness in males compared with females (19). Another study found greater retinal thickness in males than females among diabetic patients without DR using two different OCT devices (SD-OCT and Stratus OCT) (20). Our study also observed that central foveal and average retinal thickness in different quadrants were greater in males (260 μm and 305.5 μm) than in females (237 μm and 282 μm) in type-2 diabetic subjects without clinical DR using SD-OCT. The present study did not compare data between different OCT machines.

Studies have reported increased retinal thickness in the superior nasal quadrant of the macula in diabetic patients without DR (21). In the present study, we noted differences in retinal thickness across different quadrants in both groups. Retinal thickness in various sectors was significantly thinner in diabetic subjects without DR than in non-diabetic controls. We also found that retinal thickness was greater on the nasal side of the retina and less on the temporal side in both non-diabetic and diabetic subjects without DR. Compared with previous studies, our study included a larger number of subjects and sampled more retinal thickness points. Our inclusion of only eyes without retinopathy may explain the lack of thickness differences between these eyes and control eyes.

CONCLUSION

In conclusion, our study suggests that SD-OCT is capable of detecting subclinical changes in macular thickness in diabetic eyes with no or minimally visible DR when compared with non-diabetic control eyes. Future studies using OCT devices with higher resolution may be able to detect subtle differences in macular thickness in this subset of diabetic eyes.

Conflict of Interest

Authors declare no conflict of interest.

Ethical consideration

The study was approved by local research ethics committee.

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