Original article

Optical coherence tomography in diabetic macular edema: patterns and related risk factors

Mohammadreza Ahmadpour-Baghdadabad
Masoudreza Manaviat
Ahmad Shojaoddiny-Ardekani
Yazd Diabetes Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

Abstract

Introduction: Diabetic Macular Edema (DME) is an important cause of vision loss in diabetic retinopathy. Optical Coherence Tomography (OCT) is a non-invasive modality that produces high-resolution images of retinal layers. **Objective:** To evaluate the prevalence of DME patterns and their association with risk factors and visual acuity. **Materials and Methods:** In this cross-sectional study, type 2 diabetics with macular edema referred to our center during a ten-month period underwent OCT. Patients with macular edema due to causes other than diabetes and with OCT images of improper quality were excluded from the study. Four distinct patterns were found in the OCT images. A questionnaire including age, sex, duration of diabetes, serum TG and cholesterol, HbA1c, BMI and visual acuity, as well as the findings of OCT images were filled for the subjects. **Results:** Eighty-six eyes from 46 patients were evaluated. The most and the least common patterns were sponge-like retinal swelling (SLRS) and posterior hyaloidal traction (PHT) found in 64.0% and 5.8% of the subjects, respectively. A sub-retinal fluid pattern was more common in males ($p=0.011$) and in patients with serum TG $\geq$ 200mg/dl ($p=0.037$). There were significant associations between central foveal ($r=0.45$, $p<0.001$), nasal ($r=0.35$, $p=0.001$) and temporal ($r=0.32$, $p=0.003$) thicknesses with visual acuity. Moreover, the highest thickness (462.4±119.2µm) and also the worst visual acuity (1.0±0.5logMAR) pertained to the cystoid macular edema (CME) pattern. **Conclusion:** Our study showed that the most common OCT pattern of DME is the sponge-like retinal swelling, while posterior hyaloidal traction has the lowest prevalence. A higher foveal thickness and a lower visual acuity are seen in the CME pattern.

Keywords: optical coherence tomography, diabetic macular edema, OCT pattern, diabetic retinopathy

Introduction

Diabetes mellitus is a disorder with considerable mortality and morbidity and affects 180 million people worldwide (World Health Organization, The World Health Report, 2002); and it is estimated that this number will reach 300 million patients by 2025, with the majority in developing countries (King H et al, 1998). At least some form of retinopathy may be seen in nearly one-fourth of diabetic patients and its incidence significantly increases with the duration of diabetes. This is also true for Diabetic Macular Edema (DME) which affects up to 15% of patients 15 years after diagnosis (Aiello LP et al, 1998). DME is an important cause of vision loss and legal

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Address for correspondence: Ahmad Shojaoddiny-Ardekani Yazd Diabetes Research Center, Shahid Sadoughi University of Medical Sciences, Afshar Alley, Jomhouri Blvd., Yazd, Iran. Postal code: 8917945556
Tel: (+98) 3515223999; Fax: (+98) 3515258354

blindness in patients with diabetic retinopathy (Fong DS et al, 1999). According to the Early Treatment of Diabetic Retinopathy Study (ETDRS report number 7, 1991), Clinically Significant Macular Edema (CSME) is defined as observation of retial thickness or hard exudate accompanied with retinal thickening within 500µm of the center of the macula or if a zone of one-disc area size of retinal thickness is seen within one-disc diameter of the center of the macula.

Traditional methods for evaluating macular edema such as stereoscopic fundus photography and contact and non-contact fundus biomicroscopy are not sensitive enough to determine the details of the involved area. Optical Coherence Tomography (OCT) is a non-invasive modality which produces cross-sectional or three-dimensional, high-resolution images of the retinal layers and quantitative assessment of retinal thickness and other features of macular edema which correlate well with retinal histology as viewed by light microscopy especially by introducing the spectral domain (SD) OCT (Hee MR et al, 1998; Otani T et al, 1999; Yamamoto S et al, 2001; Buabbud JC et al, 2010). OCT has been widely used as a valuable tool for diagnosis and management of DME during the past two decades (Hee MR et al, 1998; Koozekanani D et al, 2000; Browning DJ et al, 2008).

Based on the findings of OCT, various morphologic patterns have been suggested for categorization of DME (Ozdek SC et al, 2005; Kim BY et al, 2006; Soliman W et al, 2007). In this study, we evaluated the prevalence of OCT patterns of DME as well as the association of these patterns with the risk factors of DME based on the OCT findings. We also assessed the relationship between these patterns with visual acuity by measuring the central, nasal and temporal foveal thicknesses as well as detecting the central and total foveal volumes.

Materials and methods

In this cross-sectional study, type 2 diabetic patients with macular edema referred to Yazd Diabetes Research Center (Yazd, Iran) from January 2011 to October 2012 were enrolled. The study was approved by the medical ethics committee of Shahid Sadoughi University of Medical Sciences. After interviewing the subjects and describing the study to them, written consent was taken from all the participants. The OCT scans were done by a highly skilled ocular photographer using SPECTRALIS HRA+OCT (Heidelberg Engineering, Heidelberg, Germany) with 3.9µm axial resolution and 40,000 A-scans/second. Patients with macular edema due to causes other than diabetes were excluded from the study. In addition, cases were excluded if the quality of the OCT images was not good.

According to the structural appearance of OCT imaging and classifications in previous studies (Alkuraya H et al, 2005; Kim BY et al, 2006), we classified these images into four distinct patterns. Sponge-like retinal swelling (SLRS) was defined as an increase in retinal thickening and a reduction in the intra-retinal reflectivity. Cystoid macular edema (CME) was described as cystoid-like spaces surrounded by a highly reflective septa in the macular area. Subretinal Fluid (SRF) was defined as a dome-like dark space under a highly reflective area. Finally, posterior hyaloidal traction (PHT) was described as a highly reflective layer from the inner retinal surface. Some of the patients had more than one pattern. The patients' visual acuities were achieved by Snellen chart and converted to logMAR (logarithm of the minimum angle of resolution).

A questionnaire including age, sex, duration of diabetes, serum TG and cholesterol, HbA1c level and BMI as well as the findings of OCT images was filled for all the subjects.

Statistics: The data was analyzed using SPSS version 18. P-value ≤ 0.05 was considered significant.

Results

Eighty-six eyes from 46 type-2 diabetic patients (20 men and 26 women) with macular edema were evaluated. The mean age of the patients was 61.4±9.6 years with a mean duration of disease of 12.2±6.1 years. Hypertension was found in 20

(43.5%) subjects. The patients were under either oral antidiabetic drugs (n=31, 67.4%), insulin (n=10, 21.7%) or both (n=5, 10.9%). Twenty-two cases (47.8%) had HbA1c levels less than 9% and 24 cases had levels above 9%. Serum cholesterol levels below and above 150 mg/dl was seen in 14 (30.4%) and 32 (69.6%) patients, respectively. A high serum level of triglyceride (TG ≥ 200 mg/dl) was found in 24 (52.2%) and lower levels (TG<200 mg/dl) were found in 22 (47.8%) subjects.

Based on the findings in the OCT images of the retinas, four patterns were identified (Table 1).

Table 1: Prevalence of OCT patterns of DME

Pattern	Number(%)
SLRS	55 (64.0)
SRF	41 (47.7)
CME	24 (27.9)
PHT	5 (5.8)

OCT - Ocular coherence tomography; DME - Diabetic macular edema; SLRS - Sponge-like retinal swelling; SRF - Subretinal fluid; CME - Cystoid macular edema; PHT - Posterior hyaloidal traction.

Our results showed that there is an association between the prevalence of sub-retinal fluid pattern with age ≥ 60 years and HbA1c levels, but they were not statistically significant (p=0.054, 0.086 respectively). Also, this pattern was found in males more than in females (p=0.011). Also, there was a significant relationship between the mean serum levels of TG and the presence of SRF pattern (p=0.037). Similar associations were not found for other patterns and the risk factors.

The mean central foveal thickness and total foveal volume were 361.3±55.4µm and 400.3 ± 108.4mm^3, respectively. The foveal thickness at the nasal and temporal regions was 353.2±55.4µm and 361.3±55.4µm, correspondingly.

Table 2 demonstrates the central foveal thickness, central foveal volume and mean visual acuity according to the patterns of macular edema found in the patients.

Table 2. Results of different parameters according to the OCT patterns of DME.

	SLRS	SRF	CME	PHT
Central foveal thickness (µm)	389.8±104.0	421.2±118.9	462.4±119.2	450.8±86.0
Central foveal volume (mm^3)	0.3±0.1	0.4±0.1	0.4±0.1	0.4±0.1
Visual acuity (logMAR)	0.8±0.5	0.9±0.5	1.0±0.5	0.8±0.5

OCT - Ocular coherence tomography; DME - Diabetic macular edema; SLRS - Sponge-like retinal swelling; SRF - Subretinal fluid; CME - Cystoid macular edema; PHT - Posterior hyaloidal traction; logMAR - logarithm of the minimum angle of resolution.

The data analysis showed significant linear associations between the central foveal (r=0.45, p<0.001), nasal (r=0.35, p=0.001) and temporal (r=0.32, p=0.003) thicknesses with visual acuity; but the associations between the central foveal volume and total foveal volume with visual acuity were not significant.

Discussion

OCT is a non-invasive, rapid and repeatable method for obtaining high resolution cross-sectional images of the retina. In our study, four patterns of macular edema were found, based on the OCT images, and the most prevalent pattern was SLRS (64.0%) while the PHT pattern had the least prevalence (5.8%). In the Alkuraya H et al study (1995), the SLRS pattern was the most common (45.4%), followed by the CME (29.0%), serous retinal detachment (21.8%) and vitreofoveal traction (3.6%) patterns. Similarly, in a survey done by Otani T et al (1999), SLRS was the most frequent pattern found in 88% of the patients.

In our study, the sub-retinal fluid (SRF) pattern had strong associations between male gender (p=0.011) and mean serum TG (p=0.037). Although the p-values for the association of this pattern with HbA1c

(p=0.084) and age ≥ 60 years (p=0.054) were not statistically significant, it seems that they would become significant with a similar study with a greater sample size.

At the time of writing this paper, we found no study which evaluates the relationship between the OCT patterns of macular edema with the risk factors.

Some studies have assessed the association of visual acuity with retinal thickness (Goebel W et al, 2002; Catier et al, 2005; Hussain A et al, 2005). Also, the association between the OCT patterns and visual acuity has been cited in some investigations. Our study showed that the highest thickness (462.4±119.2 μm) and also the worst visual acuity (1.0±0.5 logMAR) pertain to the CME pattern. In the Alkuraya H et al (1995) study, serous retinal detachment and vitreofoveal traction patterns were accompanied by a higher central retinal thickness and a worse visual acuity. In the Yamamoto S et al (2001) study, the CME pattern was associated with a lower visual acuity. Also, in another study (Kim et al, 2006), the CME and PHT without tractional retinal detachment were related to a worse visual acuity.

Conclusion

Our study showed that the most common OCT pattern of DME is SLRS, while PHT has the lowest prevalence. Moreover, this study showed that a higher foveal thickness is associated with a lower visual acuity and the worst visual acuity was seen in patients with the CME pattern. There was a significant association between the SRF pattern and some risk factors.

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