Original Research
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Corneal Measurements in patients with Diabetes Mellitus

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Purpose: To estimate the corneal measurements using Scheimpflug camera in patients with diabetes mellitus.

Methods: Twenty five diabetic patients were prospectively recruited. Two groups were stratified, diabetic group and control group. Central corneal thickness (CCT), keratometry values (Kmean and Kmax), corneal volume (CV), anterior chamber depth (ACD), anterior chamber volume (ACV), Qvalue, frontal and back elevation, and the parameters of corneal variance indices, including minimum radius (Rmin) were measured using Pentacam Scheimpflug camera. Endothelial cell density (ECD) was also recorded. Findings were evaluated and compared between the 2 groups.

Results: Two groups were found to have different Kmax (P = 0.03, one-tailed) and Rmin (P = 0.04, one-tailed) parameters. There was no statistical significant difference between the 2 groups in CCT, Kmean, CV, ACD, ACV, frontal/back elevation, Qvalue, ECD, and parameters of corneal variance indices.

Conclusions: Diabetes mellitus affects keratometry and radius values of the human cornea based on the corneal measurements from Scheimpflug camera.

Keywords: diabetes mellitus, diabetic cornea, corneal measurements, Scheimpflug camera, Scheimpflug measurements.

Introduction

Corneal morphological evaluation is always very crucial in ophthalmologists' clinical practice. In fact, physicians rely on corneal parameters such as central corneal thickness, anterior and posterior corneal curvature, anterior chamber depth or endothelial cells counts to make diagnosis, to follow up or to plan treatments for refractive defects or diseases such as glaucoma, keratoconus, corneal ectasia or cataract [1-6]. Even if last developments have supplied ophthalmologist with very reliable devices, it is always important to pay attention to the limitations of these instruments and to some clinical situations that could bias their precision in corneal power evaluation [7-13].

Hyperglycemia has toxic effects on almost all cells in the body. [14] Ophthalmic complications of hyperglycemia are most remarkable in cornea and retina. Retinal impairment accounts for the majority of visual loss of diabetic patients [14]. Diabetic retinopathy is the most common cause of blindness for people over the age of 50 [1].

Diabetes mellitus has a significant detrimental effect on the morphology, physiology, and clinical appearance of the cornea. The diabetic tear film is composed of a 4-fold higher glucose level than that of normal tears. Changes also manifest in the corneal epithelium, epithelial basement membrane complexes, stroma, and endothelium [15-18]. Studies show that the eyes of patients with diabetes have a greater central corneal thickness (CCT) and that there is a positive correlation between CCT and the degree of diabetic retinopathy[19-21]. Corneal hydration control also appears to be compromised in corneas of diabetic patients [22,23].

The purpose of this study is to analyze corneal morphological parameters

measured with Scheimpflug camera in DM type 2 patients and to compare them with those evaluated in healthy subjects (HS). According to our knowledge, this is one of the first papers about this topic.

Materials and Methods

This is a preliminary prospective study. It enrolled patients from 27 to 79 years of age, who visited the clinic from August 2014 to December 2014. Study population was divided into two groups: first group consisted of diabetes mellitus (type 2) patients and second group was considered as a control group of HS. Patients were excluded from the study if they had a history of corneal pathology or any ocular surgery. None of the diabetic patients had any symptoms of diabetic retinopathy. Both eyes were examined at the same time in both groups. A complete medical history was taken, complete ophthalmic exam and Scheimpflug Camera scan (Pentacam, Oculus, Wetzlar, Germany) were performed. The central corneal thickness (CCT, μm), keratometry values (Kmean and Kmax, D), corneal volume (CV), anterior chamber depth (ACD), anterior chamber volume (ACV), Qvalue, frontal and back elevation, and the parameters of corneal variance indices, such as Index of Surface Variance (ISV), Index of Vertical Asymmetry (IVA), Central keratoconus Index (CKI), Index of Height Asymmetry (IHA) and Index of Height Decentration (IHD), minimum radius (Rmin) were recorded and used for statistical analysis. Endothelial cell density (ECD) was also recorded using a noncontact specular microscope Topcon SP-3000P (Topcon Corp., Tokyo, Japan). Every participant underwent 3 measurements both with Pentacam and with Topcon SP-3000p and average values were taken for statistical analysis.

Every participant was informed about the purpose of the study and had to give informed consent before inclusion. The study was performed in adherence to the tenets of the declaration of Helsinki and Institutional Review Board approval was obtained.

The results were expressed as the mean ± standard deviation (SD). The normality of the data was tested with the Shapiro-Wilk test. The difference between the 2 groups was assessed using an unpaired t test; if the data was not distributed normally, the Mann-Whitney U test was performed instead. All calculations was performed using IBM SPSS statistical software (version 20, SAS Institute, Inc.). The level for statistical significance was set at $P < 0.05$ for one-tailed t-test.

Results

Patient demographic data with some ocular parameters are presented in Table 1. A total of 50 subject eyes were included in the study: 25 eyes were in the diabetic and another 25 eyes were in the non-diabetic group. The mean age of the diabetic patients was 60.80 ± 10.07 year with a range from 28 to 79 years. There were 15 males and 10 females. The mean age of the control population was 51.6 ± 10.78 year with a range from 27 to 73 years. There were 12 males and 13 females.

No statistically significant difference in ECD, CV, ACD, CCT, and ACV was found between two groups ($p > 0.05$ for all parameters, Table 1). From the Pentacam parameters of corneal variance indices only Rmin and Kmax was found to be different between groups ($p < 0.05$, one-tailed t -test, Table 2).

Table 1. Patient characteristics and some ocular parameters for Control and Diabetic groups.

Parameters	Control group	Diabetic group	p value
n	25	25	
M:F	12:13	15:10	
Age, y.o	51.6 ± 10.78 (27 to 73)	60.80 ± 10.07 (28 to 79)	0.372
CCT, μm	532 ± 43.90 (458 to 637)	536 ± 33.69 (470 to 624)	0.261
Kmax, D	44.87 ± 2.09 (40.50 to 49.50)	45.00 ± 1.34 (42.20 to 47.70)	0.032
ECD	2454 ± 288.54 (1842.20 to 3146.80)	2486 ± 419.65 (1398.70 to 3150.60)	0.367*
CV	59.66 ± 4.83 (51.60 to 71.90)	60.39 ± 3.93 (54.90 to 69.40)	0.323
ACD	2.73 ± 0.40 (2.02 to 3.46)	2.58 ± 0.37 (1.69 to 3.22)	0.438
ACV	141.76 ± 39.43 (80.00 to 218.00)	122.84 ± 32.21 (75.00 to 202.00)	0.180

n - number; y.o. - years old; M - male; F - female; Kmax - maximal keratometry; ECD = endothelial cell density; CV - corneal volume; ACD - anterior chamber depth; ACV - anterior chamber volume; asterisk (*) – Mann-Whitney U test.

Discussion

Corneal changes are diagnosed in about 70% of adult patients with diabetes (24, 25). The purpose of this study was to estimate the effect of DM on the corneal measurements. We compared the corneal parameters between patients with DM with those of healthy subjects. The effect of hyperglycemia on refraction was explained with several studies, but the exact cause of refractive change due to unstable diabetes is still under debate. The chronic DM causes the alterations in the lens what lead to the refractive changes in patients [13-18]. However, the exact impact of the cornea to these refractive changes is still unknown. Sonmez et al. evaluated the corneal topographic measurements in patients which were under intensive treatment of acute severe hyperglycemia [26]. It was concluded that knowledge of these changes in corneal topographic parameters is important, especially during the treatment period of acute hyperglycemia, as it may cause an error for refractive and cataract surgery.

Data of this preliminary study suggests that there are some differences in corneal parameters evaluated with Scheimpflug camera between diabetic and non-diabetic patients. According to these results, the eyes in the diabetic patients displayed higher keratometry readings than the eyes of the non-diabetic ones.

Many studies confirmed that diabetes causes abnormalities in morphology and functioning of corneal endothelial cells. Functional disturbances may lead to increased autofluorescence of the cornea and its increased penetrability [27,28].

Table 2. Scheimpflug camera parameters of corneal variance indices for diabetic and control groups of patients.

Parameters	Control group	Diabetic group	p value
Qvalue	-0.19 ± 0.13 (-0.45 to 0.01)	-0.26 ± 0.14 (-0.55 to 0.05)	0.784
ISV	14.28 ± 5.17 (7.00 to 26.00)	18.60 ± 8.87 (9.00 to 51.00)	0.058*
IVA	0.11 ± 0.06 (0.04 to 0.32)	0.15 ± 0.09 (0.05 to 0.46)	0.147*
IHA	2.92 ± 1.79 (0.30 to 6.00)	3.69 ± 3.11 (0.20 to 9.80)	0.741*
IHD	0.01 ± 0.004 (0.003 to 0.02)	0.01 ± 0.01 (0.002 to 0.04)	0.470*
Rmin	7.53 ± 0.35 (6.82 to 8.33)	6.52 ± 0.38 (6.08 to 8.00)	0.01
Qvalue	-0.19 ± 0.13 (-0.45 to 0.01)	-0.26 ± 0.14 (-0.55 to 0.05)	0.784
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IVA	0.11 ± 0.06 (0.04 to 0.32)	0.15 ± 0.09 (0.05 to 0.46)	0.147*

ISV - index of surface variance; IVA - index of vertical asymmetry; IHA - index of height asymmetry; IHD - index of height decentration; Rmin - radius of minimum; asterisk (*) - Mann-Whitney U test.

Morphological changes, recorded by contact specular microscope, may result in a high variability factor of the endothelial cell surface and decreased percentage of hexagonal cells in corneas in patients with diabetes compared to healthy patients [14]. However, our calculations didn't show any significant difference in ECD between diabetic and control groups. This is coincide with results published by Furuse et al. who could not demonstrate the significant changes in mean density of corneal endothelial cells in diabetic subjects of type 2 diabetes mellitus [25].

Although there is no overall concordance in the international literature, Lee et al. found that CCT was significantly increased ($p = 0.001$) in patients who had DM for 10 years (595.9 ± 6 4.2 mm) compared to healthy group (567.8 ± 6 3.8 mm) whereas, other studies concluded that CCT was not increased in DM type 1 or 2 [18, 29, 30].

Results of this study coincide with the those of Inoue et al,31 who reported no significant differences in CCT between 99 subjects with DM type 2 and 97 healthy subjects. In smaller study groups, Keoleian et al. and Ziadi et al. also found no differences in CCT [29, 30].

In 81 subjects with DM type 1, Busted et al. no correlations were found between diabetes duration, blood glucose levels, use of insulin, and CCT, but an association between the level of retinopathy and CCT. [32] In DM patients with proliferative retinopathy, average CCT was 566 μm as compared to 544 μm and 527 μm in subjects with diabetes without retinopathy and healthy subjects, respectively.

No diabetic retinopathy was observed in diabetic group of patients of our study.

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DM causes changes in corneal endothelial cell morphology similar to those induced by aging. [33,34] TThere is a hypothesis that DM causes premature aging of the eye what was determined by age dependence of corneal asphericity in healthy subjects [35].

Therefore in diabetic cornea the asphericity would be affected more than in healthy subjects. In our case, no significant changes were found in the asphericity of the anterior or the posterior corneal surface between groups. According to obtained results, we may consider influence of DM on the radius of the posterior corneal surface. This influence is too small to change the optical power of the diabetic cornea however, it may be clinically significant in patients with not well-compensated DM.

Conclusion

In conclusion, even if data of this study need to be confirmed in further ones with larger population, the observed results has shown a possible influence of diabetes on corneal parameters. Therefore one should exercise careful attention facing diabetic patients, in whom we need precise measurements of corneal curvature.

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