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Research Article

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Correlation between Corneal Elevation Topography and Perimetric Changes in Patients with Primary Open Angle Glaucoma

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Abstract

Aim: *The aim of this study is to assess Scheimpflug topographic elevation maps in patients with POAG and correlate the results with their perimetric changes.*

Methods: *This was an analytical observational cross-sectional study. The study included 130 eyes of 70 subjects which were divided into 78 eyes of 44 patients diagnosed with POAG and 52 eyes of 26 control subjects. Measurement of IOP, visual field examination in patients with POAG using Humphrey Field Analyzer (2003 Carl Zeiss Meditec), Germany were done. Subjects were scanned using TMS-5 topographer (Topographic Modeling System, version 5. Tomey Corp. Nagoya, Japan) to measure central corneal thickness, mean anterior keratometry, maximum anterior and posterior topographic elevation maps in the central 3, 5, and 7 mm.*

Results: *78 patients with POAG classified according to visual field deterioration using Hodapp-Anderson-Parrish grading scale into mild glaucoma 33 eyes, moderate glaucoma 19 eyes, severe glaucoma 26 eyes, and 52 eyes control were included in the study. The mean age of the patients with POAG was 57.82 ± 7.78 years; 22 eyes (50%) were male and 22 eyes (50%) were female. The average age of control subjects was 56.62 ± 8.48 years; 12 eyes (46.2%) were male and 14 eyes (53.8%) were female, average CCT was 530.3 ± 23.58 µm, average mean anterior keratometry (MAK) was 42.97 ± 1.42 D, average maximum anterior elevation (MAE) in 3,5 and 7mm zone was 5.31 ± 2.28, 12.10 ± 6.94 and 44.04 ± 21.99 µm respectively and average maximum posterior elevation (MPE) in 3,5 and 7mm zone was 8.46 ± 2.10, 19.90 ± 9.39 and 62.72 ± 28.82 µm respectively in patients with POAG, whereas average CCT was 543.0 ± 31.02µm, average MAK was 43.11 ± 1.73 D, average MAE in 3,5 and 7mm zone was 4.52 ± 1.97, 5.90 ± 2.71 and 27.19 ± 8.55 µm respectively.*

Conclusion: *Evaluation of corneal elevation topography by scheimpflug imaging showed forward shifting of the anterior and posterior corneal surfaces in POAG.*

Keywords: Primary open-angle glaucoma, Corneal topography, Scheimpflug imaging

Introduction

Glaucoma is one of the leading causes of visual morbidity and blindness worldwide [1]. It is the second leading cause of induced vision loss worldwide after cataracts [2]. This disease is characterized by progressive damage of the optic nerve and is associated with visual field loss over time [3].

Primary open-angle glaucoma is typically a chronic multifactorial optic neuropathy characterized by progressive retinal ganglion cell loss and visual field defects [4]. Between 35 and 58 million people were estimated to have POAG worldwide in 2015. The prevalence of POAG is expected to increase up to between 53 and 65.5 million affected individuals by 2020, owing to the ageing world population [5].

The relationship between the cornea and POAG has been extensively reviewed, mainly related to central corneal thickness (CCT). CCT can influence the accuracy of the gold-standard applanation tonometry [6]. Most importantly, a thin cornea has also been recognized as an independent risk factor for progression of ocular hypertension to POAG, as a prognostic factor for the progression of POAG and as risk factor for the development of POAG [7,8]. Corneal topography in POAG is a recent perspective on this topic. Recent studies showed that patients with POAG have a significant forward shifting of the posterior and anterior corneal surface compared with healthy controls [9].

The relationship between corneal topography and IOP had already been studied in other contexts. In patients with vernal keratoconjunctivitis and steroid-induced glaucoma, the reduction of IOP after treatment was associated with a decrease in the maximum Sim K and in the mean posterior corneal elevation [10]. The aim of the present study is to evaluate Scheimpflug topographic elevation maps in primary open angle glaucoma patients and correlate the results with their visual field deterioration.

Methods

Study Population

This is an analytical observational cross-sectional study conducted at Mansoura ophthalmic center, Mansoura University. This study protocol was approved by Mansoura medical research ethics committee, faculty of medicine, Mansoura University (code number: MS/17.03.56) and Informed consent was obtained from each participant in the study after assuring confidentiality.

Inclusion criteria included for control eyes; no history or evidence of ocular disease, surgery or laser. No family history of glaucoma, Intraocular pressure of 21 mmHg or less by Goldmann applanation tonometry, normal optic nerve head appearance based on clinical stereoscopic examination. Normal visual field. Patients with primary open-angle glaucoma with criteria including an age above 40 years, best corrected visual acuity ≥ 6/60, refractive error within ± 6.0 diopters equivalent sphere and within ± 3.0 diopters astigmatism, or less than 2.0 diopter anisometropia, open anterior chamber angle on gonioscopy, glaucomatous changes on the Humphrey 24-2 visual field test, evidence of glaucomatous optic nerve head damage.

Exclusion criteria were previous intraocular surgery or laser therapy, possible consistently unreliable visual fields (defined as a false negative > 33%, false positive > 33% and fixation losses > 20%) were excluded from the study, possible neurological field loss were also excluded, angle closure glaucoma and secondary glaucoma, evidence of vitreoretinal disease or diabetic retinopathy, opacities of the optic media such as cataract, contraindication of pupil dilatation.

Ocular Examination

Ophthalmic examination including measurement of the BCVA using Snellen chart, intraocular pressure measurement using Goldmann applanation tonometer, assessment of the anterior segment of the eye using slit lamp biomicroscopy, pupillary dilatation was performed with mydriacyl 1% eye drops, fundus examination using a Volk lens 90 diopter, assessment of anterior chamber angle using gonioscopy (three mirror Goldmann goniolens).

Visual Field Testing

The patients underwent Central 24-2 full threshold automated static perimetry by Humphrey (2003 Carl Zeiss Meditec), Germany. And reliable visual field (VF) test results (fixation loss ≤20%, false-positive rate ≤15% and false-negative rate ≤33%) were used. VF defects were classified as glaucomatous by either an abnormal report on the Glaucoma Hemifield Test or a pattern standard deviation (PSD) of <5% of the normal reference (confirmed by two consecutive tests) and if the defects were clinically determined to be characteristic or compatible with glaucoma by the clinician.

Scheimpflug Imaging Examination

TMS-5 topographer (Topographic Modeling System, version 5. Tomey Corp. Nagoya, Japan) for measurement of (central corneal thickness, mean anterior keratometry, maximum anterior and posterior topographic elevation maps in the 3, 5, and 7 mm central corneal zones). It uses rotating Scheimpflug imaging technique to capture a 3D image from the anterior segment of the eye. During its measurements, extraneous eye movements are detected by a second pupil camera and corrected simultaneously.

Technique of Scheimpflug scanning was done as follows; examined subject demographic data was entered into the data base then the subject chin was adjusted on the chin rest after instillation of topical lubricant eye drops in the lower conjunctival fornix to counter dryness for better results. The examined subject was oriented to focus on the light in front of the eye and was asked to open his eye as wide as possible, For the device to start it must be put in standby mode with the joy stick pulled backwards then the joy stick was moved until the examined eye was in focus then the device automatically took the shots. The TMS-5 takes two shots in two modes (ring topography mode using placido cone) and (slit mode using scheimpflug camera).

Statistical Analysis

Data were analyzed using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were presented as mean ± SD (standard deviation) for parametric data and median (min-max) for non-parametric data. The two groups were compared with Student t test for parametric data and Mann Whitney test for non-parametric data. Pearson (parametric) and Spearman (non-parametric) correlation were used to correlate continuous data. The results was considered non-significant when the probability of error is more than 5% ($p > 0.05$) while significant when the probability of error is less than 5% ($p \leq 0.05$).

Results

Total of 130 eyes of 70 subjects including 78 eyes with POAG which were classified according to disease severity into mild glaucoma 33 eyes, moderate glaucoma 19 eyes, severe glaucoma 26 eyes were included in this study.

The mean age of the patients with POAG was 57.82 ± 7.78years; 22 eyes (50%) were male and 22 eyes (50%) were female. The average age of control subjects was 56.62 ± 8.48 years; 12 eyes (46.2%) were male and 14 eyes (53.8%) were female, average CCT was 530.3 ± 23.58 µm, average mean anterior keratometry (MAK) was 42.97 ± 1.42 D, average maximum anterior elevation (MAE) in 3,5 and 7mm zone was 5.31 ± 2.28, 12.10 ± 6.94 and 44.04 ± 21.99 µm respectively and average maximum posterior elevation (MPE) in 3,5 and 7mm zone was 8.46 ± 2.10, 19.90 ± 9.39 and 62.72 ± 28.82 µm respectively in patients with POAG.

Average CCT was 543.0 ± 31.02μm, average mean MAK was 43.11 ± 1.73 D, average maximum MAE in 3,5 and 7mm zone was 4.52 ± 1.97, 5.90 ± 2.71 and 27.19 ± 8.55 μm respectively and average MPE in 3,5 and 7mm zone was 7.92 ± 2.27, 12.0 ± 4.71 and 37.79 ± 11.70 μm respectively in control subject. A statistically significant difference of maximum anterior and posterior corneal elevation in 5 and 7mm zones was detected between the study groups with p value (p<0.001).

The present study showed a forward shifting of the anterior corneal surfaces in POAG which was more evident in the central 5 and 7mm zones and more statistically significant in moderate and severe POAG. Anterior elevation maps showed that mean MAE in 5mm zone was (12.10 ± 6.94 μm) in patient group and (5.90 ± 2.71 μm) in control group (P <0.001), while mean MAE in 7mm zone was (44.04 ± 21.99 μm) in POAG group and (27.19 ± 8.55 μm) in control group (P <0.001) as shown in Table 1.

Table 1: Comparison between two studied groups according to maximum anterior elevation

MAE (μm)	**POAG (n=78)**	**Control (n=52)**	**U**	**P**
3mm				
Min. – Max.	1.0 – 12.0	2.0 – 9.0	1591.0*	0.036*
Mean ± SD.	5.31 ± 2.28	4.52 ± 1.97		
Median (IQR)	5.0 (4.0 – 7.0)	4.0 (3.0 – 6.0)		
5mm				
Min. – Max.	2.0 – 34.0	1.0 – 13.0	851.50*	<0.001*
Mean ± SD.	12.10 ± 6.94	5.90 ± 2.71		
Median (IQR)	11.0 (6.0 – 17.0)	6.0 (4.0 – 7.0)		
7mm				
Min. – Max.	14.0 – 100.0	13.0 – 49.0	1078.0*	<0.001*
Mean ± SD.	44.04 ± 21.99	27.19 ± 8.55		
Median (IQR)	37.50 (26.0 – 61.0)	26.0 (22.0 – 31.0)		

- U: Mann Whitney test
- p: p value for comparing between the two studied groups
- *: Statistically significant at p ≤ 0.05

Mean MAE in 5mm zone of (13.95 ± 5.52 μm) in moderate sub-group , (16.50 ± 7.71 μm) in severe sub-group and (5.90 ± 2.71 μm) in control group (P <0.001), also it showed a mean MAE in 7mm zone of (51.16 ± 18.32 μm) in moderate sub-group, (55.81 ± 25.94 μm) in severe sub-group and (27.19 ± 8.55 μm) in control group (P <0.001). For all pairwise comparison as shown in Table 2, (Figure 1).

Table 2: Comparison between POAG sub-groups and control group according to maximum anterior elevation

MAE (μm)	**POAG (n = 78)**			**Control (n = 52)**	**H**	**P**
	Mild (n = 33)	**Moderate (n = 19)**	**Severe (n = 26)**			
3mm						
Min. – Max.	1.0 – 8.0	2.0 – 11.0	3.0 – 12.0	2.0 – 9.0	27.151*	<0.001*
Mean ± SD.	4.0 ± 1.70	5.42 ± 2.01	6.88 ± 2.12	4.52 ± 1.97		
Median (IQR)	4.0 (3.0 – 5.0)	5.0 (4.0 – 6.0)	7.0 (6.0 – 8.0)	4.0 (3.0 – 6.0)		
P*	**0.381**	**0.101**	**<0.001***			
P**	p_1=0.027*,p_2<0.001*,p_3=0.042*					
5mm						
Min. – Max.	2.0 – 16.0	4.0 – 24.0	3.0 – 34.0	1.0 – 13.0	55.245*	<0.001*
Mean ± SD.	7.58 ± 3.66	13.95 ± 5.52	16.50 ± 7.71	5.90 ± 2.71		
Median (IQR)	6.0 (6.0 – 9.0)	14.0 (10.50–18.0)	15.50 (11.0–22.0)	6.0 (4.0 – 7.0)		
P*	**0.101**	**<0.001***	**<0.001***			
P**	p_1<0.001*,p_2<0.001*,p_3=0.556					
7mm						
Min. – Max.	14.0 – 53.0	20.0 – 78.0	14.0 – 100.0	13.0 – 49.0	38.112*	<0.001*
Mean ± SD.	30.67 ± 11.04	51.16 ± 18.32	55.81 ± 25.94	27.19 ± 8.55		
Median (IQR)	31.0 (22.0 – 36.0)	52.0 (38.0–65.50)	61.0 (32.0 – 79.0)	26.0 (22.0 – 31.0)		
P*	**0.257**	<0.001*	<0.001*			
P**	p_1=0.001*,p_2<0.001*,p_3=0.966					

- H: H for Kruskal Wallis test, Pairwise comparison between each group using Post Hoc Test (Dunn's for multiple comparisons test)
- p: p value for comparing between the studied groups
- p*: p value for comparing between control and each other subgroup
- p_{1**}: p value for comparing between mild and moderate
- p_2**: p value for comparing between mild and severe
- p_3**: p value for comparing between moderate and severe
- *: Statistically significant at $p \leq 0.05$

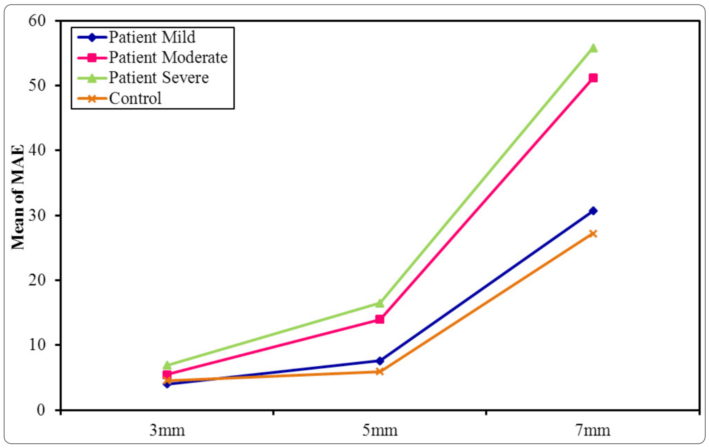

Figure 1: Comparison between the different studied groups according to maximum anterior elevation

The present study showed a forward shifting of the posterior corneal surfaces in patients with POAG which was more evident in the central 5 and 7 mm zones and also was more significant in moderate and severe patients sub-groups Results from anterior elevation maps showed that mean MPE in 5mm zone was (19.90 ± 9.39 µm) in patient group and (12.0 ± 4.71 µm) in control group (P <0.001), while mean MPE in 7mm zone was (62.72 ± 28.82 µm) in patient group and (37.79 ± 11.70 µm) in control group (P <0.001) as shown in Table 3.

Table 3: Comparison between the two studied groups according to maximum posterior elevation

MPE (µm)	**Patient (n=78)**	**Control (n=52)**	**U**	**p**
3mm				
Min. – Max.	4.0 – 14.0	3.0 – 11.0	1855.0	0.406
Mean ± SD.	8.46 ± 2.10	7.92 ± 2.27		
Median (IQR)	8.0 (7.0 – 10.0)	8.0 (6.0 – 10.0)		
5mm				
Min. – Max.	2.0 – 43.0	3.0 – 25.0	949.50*	<0.001*
Mean ± SD.	19.90 ± 9.39	12.0 ± 4.71		
Median (IQR)	18.50 (12.0 – 27.0)	12.0 (8.50 – 14.50)		
7mm				
Min. – Max.	18.0 – 127.0	15.0 – 67.0	913.50*	<0.001*
Mean ± SD.	62.72 ± 28.82	37.79 ± 11.70		
Median (IQR)	51.50(39.0 – 89.0)	35.50 (29.0 – 47.0)		

- U: Mann Whitney test
- p: p value for comparing between the two studied groups
- *: Statistically significant at $p \leq 0.05$

Mean MPE in 5mm zone of (23.37 ± 6.26 µm) in moderate sub-group, (27.23 ± 8.36 µm) in severe sub-group and (12.0 ± 4.71 µm) in control group (P <0.001), also it showed a mean MPE in 7mm zone of (75.21 ± 23.48 µm) in moderate sub-group, (80.50 ± 30.23 µm) in severe sub-group and (37.79 ± 11.70 µm) in control group (P <0.001) for all pairwise comparison as shown in Table 4, (Figure 2).

Table 4: Comparison between patient sub-groups and control according to maximum posterior elevation

MPE (μm)	Patient (n = 78)			Control (n = 52)	H	p
	Mild (n = 33)	Moderate (n = 19)	Severe (n = 26)			
3mm						
Min. – Max.	4.0 – 12.0	5.0 – 13.0	5.0 – 14.0	3.0 – 11.0	3.811	0.283
Mean ± SD.	7.97 ± 1.81	8.47 ± 2.14	9.08 ± 2.31	7.92 ± 2.27		
Median (IQR)	8.0 (7.0 – 9.0)	8.0 (7.0 – 10.0)	9.50 (7.0 – 10.25)	8.0 (6.0 – 10.0)		
5mm						
Min. – Max.	2.0 – 26.0	15.0 – 35.0	12.0 – 43.0	3.0 – 25.0	71.466*	<0.001*
Mean ± SD.	12.12 ± 4.74	23.37 ± 6.26	27.23 ± 8.36	12.0 ± 4.71		
Median (IQR)	11.0 (9.0 – 15.0)	23.0 (18.50 – 28.5)	26.0 (21.0 – 35.0)	12.0 (8.50 – 14.50)		
P_*	**0.877**	**<0.001***	**<0.001***			
P**	$p_1<0.001^*, p_2<0.001^*, p_3=0.512$					
7mm						
Min. – Max.	18.0 – 69.0	39.0 – 125.0	28.0 – 127.0	15.0 – 67.0	57.838*	<0.001*
Mean ± SD.	41.52 ± 12.69	75.21 ± 23.48	80.50 ± 30.23	37.79 ± 11.70		
Median (IQR)	38.0(34.0 – 48.0)	73.0(54.0 – 90.50)	84.50(49.0 – 109.0)	35.50(29.0 – 47.0)		
P_*	**0.307**	**<0.001***	**<0.001***			
P**	$p_1<0.001^*, p_2<0.001^*, p_3=0.949$					

- ❖ H: H for Kruskal Wallis test, Pair wise comparison between each group using Post Hoc Test (Dunn's for multiple comparisons test)
- ❖ p: p value for comparing between the studied groups
- ❖ p*: p value for comparing between Control and each other subgroup
- ❖ p_1**: p value for comparing between Mild and Moderate
- ❖ p_2**: p value for comparing between Mild and Severe
- ❖ p_3**: p value for comparing between Moderate and Severe
- ❖ *: Statistically significant at $p \leq 0.05$

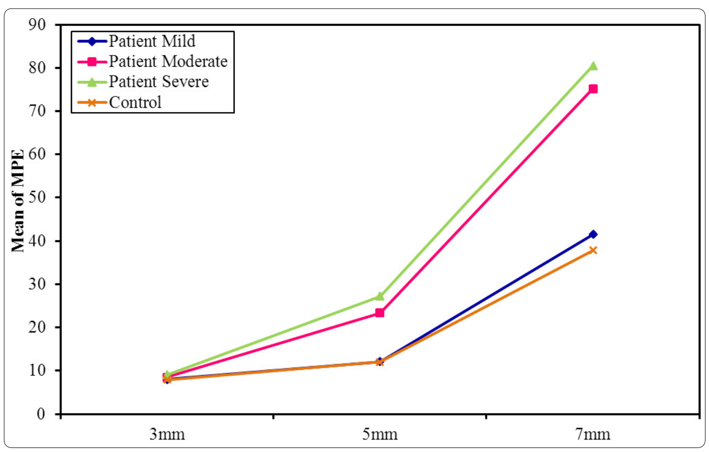

Figure 2: Comparison between the different studied groups according to maximum posterior elevation

Discussion

This study aimed to evaluate changes in corneal topography in POAG patients, such as central corneal thickness, mean anterior keratometry, maximum anterior elevation and maximum posterior elevation in 3,5 and 7 mm zones using Scheimpflug imaging and correlating the results with the severity of glaucoma grading according to visual field changes.

In the present study central corneal thickness measurements showed slight decrease in POAG group in comparison with control group with a mean CCT of (530.3 ± 23.58 μm) in patient group and (543.0 ± 31.02 μm) in control group (p = 0.014), while isolated severe POAG results showed more significant decrease in CCT with a mean CCT of (521.3 ± 25.95 μm) which was highly significant (p = 0.005). These results were comparable to the results which had been reported by Gil, et al. who carried his study to describe and compare anterior and posterior topographic elevation maps in primary open angle glaucoma patients with functional damage staging and in healthy controls and evaluated CCT using pentacam HR and reported a mean CCT of (541.13±36.98 μm) in patient group and (548.67±34.56 μm) in control group (P=0.12) [9].

The present study results were also comparable to the results reported by Tian, et al. who evaluated corneal tomography and biomechanical properties of the cornea in eyes with primary open-angle glaucoma (POAG) and normal control eyes using Pentacam (Oculus) and CorVis ST and reported a mean CCT of (547.69 ± 36.95μm) in patient group and (546.65 ± 28.02μm) in control group (P = 0.878) [11].

Similar to our study, Arranz-Marquez, et al. aimed at comparing anterior and posterior corneal curvature between eyes with POAG and healthy controls and evaluated CCT using ultrasonic pachymetry (DGH 1000; Technology Inc., Exton, PA) and reported a mean CCT of (547.88 ± 37.95 μm) in patient group and (548.89±35.89μm) in control group (P = 0.87) [12].

Saenz-Frances, et al. whose study design was to identify possible differences between healthy subjects and patients with primary open-angle glaucoma (POAG) in keratometry, central corneal thickness, overall corneal thickness, mean thickness of a circular zone centered at the corneal apex of 1-mm radius (zone I), and mean thickness of several concentric rings also centered at the apex of 1-mm width and measured central corneal thickness (CCT) using ultrasound pachymetry (Dicon P55; Paradigm Medical Industries Inc., Salt Lake City, UT) [13]. And reported a mean CCT of (546.68 ± 37.42 μm) in patient group and (555.08 ± 31.09μm) in control group (P = 0.171).

Another study was conducted by Yagci, et al. who had measured CCT in POAG, pseudoexfoliative glaucoma, ocular hypertension, and healthy controls using regularly calibrated ultrasonic pachymeter (Sonomed, Sonoscan, model 4000 AP) and reported a mean CCT of (539.92±21.50μm) in POAG group and (533.96±29.25μm) in control group (P > 0.05) [14]. Ventura, et al. had evaluated CCT in patients with primary open angle glaucoma, normal tension glaucoma, pseudoexfoliation glaucoma, ocular hypertension and healthy control using an optical low coherence reflectometry and reported a mean CCT of (515±35μm) in POAG group and (524±25μm) in control group (P >0.05) [15].

Copt, et al. also had measured CCT in primary open angle glaucoma, normal tension glaucoma, ocular hypertension, and healthy controls using ultrasonic pachymetry (DGH-1000, DGH Technology Inc, Frazer, Pa) and reported a mean CCT of (543±35μm) in POAG group and (552±35μm) in control group (P >0.05) [16].

In the present study mean anterior keratometry (MAK) measurements showed insignificant difference between patient group and control group with a mean MAK of (42.97 ± 1.42 D) in patient group and (43.11 ± 1.73 D) in control group which was statistically insignificant (P = 0.625). This was in agreement with Gil, et al. who evaluated MAK using pentacam HR and reported that the mean anterior keratometry was similar in both groups with a tendency for higher values in the control group with a mean MAK of (43.83 ± 0.15D) in patient group and (44.17 ± 0.14D) in control group (P = 0.10) [9]. These results were also comparable to the results which had been of Tian, et al. who reported a mean MAK of (43.62 ± 1.52D) in patient group and (43.96 ± 1.51D) in control group (P = 0.269) [12].

Arranz-Marquez, et al. evaluated MAK using orbscan II and reported a mean MAK of (44.16 ± 1.74 D) in patient group and (43.87 ± 1.54 D) in control group (P=0.3) [11]. While Saenz-Frances, et al. measured power in the steepest (Ks) and flattest axis (Kf) using (Pentacam; Oculus, Lynwood, WA) and reported a mean Ks of (44.95 ± 1.54 D) in patient group and (44.65 ± 1.73 D) in control group (P = 0.307) and reported a mean Kf of (43.72 ± 1.62 D) in patient group and (43.17 ± 3.80 D) in control group (P = 0.290) [13]. Another study was conducted by Morad, et al. who evaluated Corneal curvature in patients with primary open-angle glaucoma, patients with normal tension glaucoma and age-matched healthy controls using a keratometer and reported a mean MAK of (43.66 ± 1.68D) in POAG group and (44.36 ± 1.13D) in control group (P >0.05) [17].

In the present study maximum anterior elevation and maximum posterior elevation in 3, 5 and 7mm zones were measured and used as a parameter to evaluate anterior and posterior corneal elevation, and results showed a forward shifting of the anterior and posterior corneal surfaces in patients with POAG which was more evident in the central 5 and 7 mm zones.

Results from anterior elevation maps showed that mean MAE in 5mm zone was (12.10 ± 6.94 μm) in patient group and (5.90 ± 2.71 μm) in control group (P <0.001), while mean MAE in 7mm zone was (44.04 ± 21.99 μm) in patient group and (27.19 ± 8.55 μm) in control group (P <0.001), Also posterior elevation maps showed that mean MPE in 5mm zone was (19.90 ± 9.39 μm) in patient group and (12.0 ± 4.71 μm) in control group (P <0.001), while mean MPE in 7mm zone was (62.72 ± 28.82 μm) in patient group and (37.79 ± 11.70 μm) in control group (P <0.001).

In addition, the forward shifting of the anterior and posterior corneal surfaces was also more significant in moderate and severe patients sub-groups, which further suggests the influence of increased IOP on elevation topography.

Results of MAE in POAG sub-groups showed a mean MAE in 5mm zone of (13.95 ± 5.52 μm) in moderate sub-group , (16.50 ± 7.71 μm) in severe sub-group and (5.90 ± 2.71 μm) in control group (P <0.001), also it showed a mean MAE in 7mm zone of (51.16 ± 18.32 μm) in moderate sub-group, (55.81 ± 25.94 μm) in severe sub-group and (27.19 ± 8.55 μm) in control group (P <0.001).

While results of MPE in POAG sub-groups showed a mean MPE in 5mm zone of (23.37 ± 6.26 μm) in moderate sub-group , (27.23 ± 8.36 μm) in severe sub-group and (12.0 ± 4.71 μm) in control group (P <0.001), also it showed a mean MPE in 7mm zone of (75.21 ± 23.48 μm) in moderate sub-group, (80.50 ± 30.23 μm) in severe sub-group and (37.79 ± 11.70 μm) in control group (P <0.001).

This was in agreement with Gil, et al. who evaluated MAE and MPE in 3, 5 and 7mm zones using pentacam HR and reported that MAE and MAP measurement in the two main groups was as follow: 3mm zone: showed a mean MAE of (5.26 ± 4.66 μm) in patient group and (4.37 ± 2.65 μm) in control group (P = 0.096), while it showed a mean MPE of (11.50 ± 6.80 μm) in patient group and (10.94 ± 5.64 μm) in control group (P = 0.510) [9]. 5mm zone: showed a mean MAE of (8.21 ± 8.63 μm) in patient group and (5.80 ± 3.62 μm) in control group with high statistical significance (P = 0.009), while it showed a mean MPE of (16.17 ± 8.72 μm) in patient group and (13.92 ± 6.03 μm) in control group (P = 0.029). 7mm zone: showed a mean MAE of (17.32 ± 20.78 μm) in patient group and (9.61 ± 5.64 μm) in control group with high statistical significance (P < 0.001), while it showed a mean MPE of (38.81 ± 19.78 μm) in patient group and (26.38 ± 12.73 μm) in control group (P < 0.001).

These results were also comparable to the results of Arranz-Marquez, et al. who reported that when elevation data from both corneal surfaces were compared in the patient group and control group a statistically significant difference was found (P = 0.001) in both MAE and MPE, with a mean MPE of (52 ± 47 µm) in patient group and (33 ± 11 µm) in control group and a mean MAE of (16 ± 11 µm) in patient group and (18 ± 6 µm) in control group [11].

Conclusion

Evaluation of corneal elevation topography by scheimpflug imaging showed forward shifting of the anterior and posterior corneal surfaces in POAG patients. Scheimpflug imaging could be a useful tool for evaluating corneal elevation topography with the advantages of objectivity, good quantitative measurements, ease of handling, obtained with a rapid, non-contact method. Further studies may ascertain the potential for this link to be used as a tool for monitoring POAG patients

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