Comparison of Anterior Segment Parameters Between Phakic and Pseudophakic Eyes of Subjects with Emmetropia and Degenerative Myopia

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ABSTRACT

Purpose: To compare and assess anterior segment measurements including corneal endothelial parameters in phakic and pseudophakic patients with degenerative myopia and emmetropia participants.

Materials and Methods: The individuals were divided into two main groups of Group 1 (control group) and Group 2 (study group).Emmetropic, mild myopic and/or hypermetropic patients were enrolled in Group 1. Degenerative Myopic Patients Were Enrolled in Group 2. Group 1 and 2 were composed of phakic (Group 1A, Group 2A) n pseudophakic (Group 1B, Group 2B) eyes. Corneal endothelial cell density (CD), the coefficient of variation of cell size (CV), hexagonality (HEX) and central corneal thickness (CCT) were of the parameters measured by the specular microscope. Anterior chamber depth (ACD), white to white (WTW) diameter and axial length (AXL) were the parameters measured by optical biometer.

Results: The mean ACD was 3.45±0.55 mm and 3.74±0.61 mm (p=0.005), and the mean AXL was 23.3±0.9 mm and 28.6±5.3 mm (p<0.001) in the control and study group, respectively. Mean BCVA values were worse and mean SE values were higher in degenerative myopic eyes than in emmetropic eyes of both phakic and pseudophakic subjects. Mean ACD was higher in degenerative myopia. Mean K2 was different between Group 1B and Group 2B (p=0.003).

Conclusion: Degenerative myopia has high SE, ACD and AXL values. However, most of the specular microscope measurements did not show a significant difference in degenerative myopia.

Keywords: Degenerative Myopia, Corneal Endothelium, Specular Microscope, Optic Biometry, Emmetropia.

INTRODUCTION

Degenerative or pathological myopia has several properties such as gradual stretching of the eye, scleral/choroidal/retinal and vitreous degeneration, posterior staphyloma and scleral thinning.[1] Collagen fibers are smaller in diameter, and the distance between the fibers are wider.[2] High refractive errors, cataract, glaucoma, detachment of retina, macular degeneration, neovascularization of choroid, and macular retinoschisis are ophthalmic problems among many conditions associated with degenerative myopia.[3] Myopia is prevalent worldwide with an increasing incidence.[4] Myopic eyes with an axial length >26 mm and a spherical equivalent >-6.00 diopters (D) are defined as high myopic eyes.[5]

Corneal endothelium is a sensitive layer and provides transportation between the aqueous humor and the stroma.[6] Corneal health could be analyzed by studying endothelial cells, which can be affected by several factors such as age, ethnicity, systemic diseases (diabetes mellitus), contact lens, ocular surgery, and refractive errors (myopia).[7] Some studies reported that myopic eyes might have an increase in central corneal thickness (CCT), whereas a reduction in endothelial cell density (ECD), polymorphism (reduction of the hexagonal cell percentage), and in polymegathism, which defines the rise of coefficient of variation (CV) in the cell area.[8-9]

Non-contact specular microscopes take fine pictures of endothelial measurements. The fixed-frame method

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for determining ECD allows numerical assessment of cell morphology, including ECD, CV, and percentage of hexagonal cells (HEX). Specular microscope gives us the opportunity to measure the endothelial parameters in a noncontact manner and so corneal ulceration and infectious diseases could be avoided.[10-11]

Optic biometry is commonly used for intraocular lens (IOL) power calculations. Non-contact technique is more accurate and easier than the contact manual biometry measurement techniques and has less chance of corneal abrasions and infections. All these features provide more accurate data to ophthalmologists in choosing the correct IOL and incision location, thereby improving the surgical outcome in phacoemulsification (PHACO) or refractive surgeries.[12-13]

The aim of our study was to evaluate the features of corneal endothelial cells measured by specular microscope and optic biometric parameters in degenerative myopic patients and age-matched emmetropic population including the subgroups and to assess the existence of any correlation between the parameters. By reporting the results of our research, we intended to clarify the importance of specular microscopic and optic biometric measurements in degenerative myopic eyes, thus providing information for the preparation of PHACO or refractive surgeries.

MATERIALS AND METHODS

This cross-sectionally designed study was conducted in accordance with the principles of the Declaration of Helsinki. Medical ethics committee approved the study, and we obtained written informed consent from all participants.

Participants

Overall, 132 eyes of 75 individuals were enrolled in the current study. The participants were divided into two main groups of control (Group 1) and study (Group 2) groups. Group 1 was consisting of emmetropic and mild myopic or hypermetropic eyes. Phakic eyes served as Group 1A, and pseudophakic eyes served as Group 1B in Group 1. Group 2 was composed of degenerative myopic eyes. Phakic eyes served as Group 2A, and pseudophakic eyes served as Group 2B in Group 2. Emmetropic eyes and eyes with spherical equivalent (SE) of <+2.00 and <-2.00 were included in Group 1. Degenerative myopic eyes with an axial length of >26 mm and a SE of >-6.00 diopters (D) were included in Group 2. Patients with glaucoma, inflammatory ocular diseases, any corneal or retinal disorder (other than degenerative myopic retinal changes for Group 2), any previous ocular surgery except for phacoemulsification were excluded.

All patients had a detailed ophthalmic examination. SEs of the participants was measured by an autorefractometer. The BCVA was determined based on the Snellen chart and converted to the logarithm of the minimum angle of resolution (logMAR) units. Besides, the intraocular pressure (IOP) values were measured using non-contact tonometry (NT-530P, Nidek CO., LTD., Gamagori, Japan). The anterior segments were examined with slit-lamp microscopy. Anterior chamber and corneal endothelial parameters were measured in a dim light room before pupil dilatation using optic biometry (AL-Scan, Nidek CO., LTD., Gamagori, Japan) and specular microscope (CEM-530, Nidek CO., LTD., Gamagori, Japan), respectively. The examination of the posterior segment was performed using indirect ophthalmoscopy and a +90-diopter lens after pupil dilatation.

Measurements

The corneal endothelium morphology, including ECD (cell/mm^2), CV (%), HEX (%) and CCT (µm) were analyzed using a non-contact specular microscope (CEM-530, Nidek CO., LTD., Gamagori, Japan). Other parameters measured using specular microscope included number of cells (NUM), average area (AVG, µm^2), standard deviation (SD, µm^2), maximum area (MAX, µm^2) and minimum area (MIN, µm^2).

The patients were asked to fixate the target for morphometric analysis of endothelial measurements. A masked researcher performed the procedure of photographing by taping the pupil and starting the automated alignment. The best one was analyzed among several taken pictures. We accepted an image as the best quality if all of the cell edges and cores in one endothelial display are apart from the peripheral borders of the picture and possessed an adequate number of adjacent cells between 50 and 150.[14] In the present manuscript, the centers of 100 adjacent cells were marked and analyzed by built-in image analysis software.

Patients were carefully aligned for optic biometry measurements. The machine was placed in an optimal space of 45 mm where a certain sight of anterior segment was obtained. The eyes were provided to focus on the red target in the measuring monitor. The equipment has a software property, which helps us for the fine-tune alignment. When this was achieved, an automated measurement starts including axial length (AXL, mm), keratometry (K1, K2, Diopter (D)), anterior chamber depth (ACD, mm), and white-to-white distance (WTW, mm) parameters.[15] After 3 repeated measurements, the mean result was used in statistical analysis.

The comparison of biometry measurements was assessed between control and study groups. We compared biometry

and specular microscope measurements of Group 1A with Group 2A and Group 1B with Group 2B.

Statistical analysis

Statistical analyses were performed using SPSS 15.0 for Windows program. For descriptive analysis; categorical data are presented as number and percentage, and numerical factors are presented as mean, standard deviation, minimum, maximum and median. When the numerical variables provided the normal distribution condition, independent two group comparisons were analyzed with Student's t-test, and independent more than two-group comparisons were assessed with One-Way ANOVA test. When the numerical variables did not provide the normal distribution condition, independent two-group comparisons were analyzed with Mann Whitney U test and independent more than two groups were compared with Kruskal Wallis test. Subgroup analysis in more than two groups was performed by the Mann Whitney U test and interpreted with Bonferroni correction. The relationships between the numerical variables were analyzed by the Pearson Correlation Analysis and the Spearman Correlation Analysis when the parametric test condition was provided or not provided, respectively. The ratios of the categorical variable between the groups were tested by Chi-Square Analysis. Statistical significance was accepted as $p < 0.05$.

RESULTS

Control Group versus Study Group Based on Biometry Measurements

We included 79 eyes of 44 individuals in the control group and 53 eyes of 31 patients in the study group. The mean age in the control and study groups were 54.4±18.9 and 52.3±16.7 years, with an insignificant difference (Table 1).

BCVA was significantly better in the control group compared to the study group with degenerative myopia. Mean SE was near emmetropia in the control group. ACD was higher in the study group ($p=0.005$), whereas WTW was lower in the study group with an insignificant difference ($p=0.235$). AXL was significantly longer in the study group than in the control group ($p<0.001$), which is a characteristic feature of high and/or degenerative myopia. We found no difference in mean K1 and K2 values between control and study groups. No statistical difference was noted in mean IOP measurements between control and study groups (Table 2).

Comparison of Subgroups

There were 40 eyes of 26 individuals in Group 1A and 29 eyes of 18 patients in Group 2A. Thirty-nine eyes of 23 individuals and 24 eyes of 14 patients were included in Group 1B and Group 2B, respectively. Five subjects had one eye in Group 1A and the other eye in Group 1B. Only one patient had one eye in Group 2A and the other eye in Group 2B.

Group 1A and Group 2A had age-matched subjects ($p=0.251$) and included only phakic eyes. Group 1B and Group 2B also had age-matched subjects ($p=0.117$) and included only pseudophakic eyes. So, we were able to compare specular microscopic measurements between emmetropic phakic and degenerative myopic phakic eyes and also between emmetropic pseudophakic and degenerative myopic pseudophakic eyes. The demographic features of the subjects for subgroups are shown in Table 3.

Mean BCVA was significantly better in emmetropic eyes than in degenerative myopic eyes of both phakic and pseudophakic subjects. Mean SE values were higher in degenerative myopic eyes than in emmetropic eyes of both phakic and pseudophakic subjects. Mean ACD was significantly higher in Group 2B than in Group 1B, and there was also a significant difference in mean ACD between Group 1A and Group 2A. We did not observe any significant difference in mean WTW values between the subgroups. As expected, mean AXL values were significantly higher in degenerative myopic subjects. Mean K1 and K2 values were similar in Group 1A and Group 2A, whereas mean K1 and K2 values were different

Table 1: *Demographic features of the subjects for control and study groups.*

		Control Group		Study Group		
		Mean±SD	Min-Max	Mean±SD	Min-Max	p
Age		54.4±18.9	20-89	52.3±16.7	18-82	0.443
		n	%	n	%	p
Gender	Male	26	59.1	15	48.4	0.301
	Female	18	40.9	16	51.6	

SD: Standard deviation, **Min:** Minimum, **Max:** Maximum

Table 2: *Comparison of biometry measurements, BCVA, SE and IOP values between control and study groups.*

	Control Group (n= 79 eyes)		Study Group (n= 53 eyes)		
	Mean± SD	Min-Max	Mean± SD	Min-Max	p
BCVA (logMAR)	0.02±0.03	0.09-0.00	0.58±0.58	0.00-0.05	<0.001*
SE (D)	1.01±0.72	+2.00 - (-)2.00	-14.32±-5.55	-6.25 - (-)31.00	<0.001*
ACD (mm)	3.45±0.55	2.29-4.80	3.74±0.61	2.52-5.33	0.005*
WTW (mm)	11.81±0.40	10.70-12.62	11.70±0.50	9.20-12.62	0.235
AXL (mm)	23.33±0.91	21.10-25.40	28.62±5.30	1.10-38.90	<0.001*
K1 (D)	43.00±1.50	39.90-46.50	43.00±1.80	35.60-47.20	0.883
K2 (D)	43.80±1.50	41.00-47.30	44.20±2.10	35.90-48.80	0.168
IOP	15.92±2.80	10-24	16.21±4.73	10-44	0.528

SD: standard deviation, **Min:** Minimum, Max: Maximum, **BCVA:** Best corrected visual acuity, **SE:** Spherical equivalent, **ACD:** Anterior chamber depth, **WTW:** White to white length, **AXL:** Axial length, **K1/K2:** Keratometric values, **IOP:** Intraocular pressure, ***:** Statistically significant

Table 3: *Demographic features of the subjects for subgroups.*

		Group 1A	Group 2A		Group 1B	Group 2B	
		Mean±SD	*Mean±SD*	*p*	*Mean±SD*	*Mean±SD*	*p*
Age		45.8±17.6	49.2±15.6.	0.251	69.7±8.7	66.±17.6	0.117
		n (%)	*n (%)*	*p*	*n (%)*	*n (%)*	*p*
Gender	Male	16(59.3)	9 (52.9)	0.126	10 (58.8)	6 (42.9)	0.675
	Female	11 (41.7)	8 (47.1)	0.342	7 (41.2)	8 (57.1)	0.836

SD: Standard deviation

between Group 1B and Group 2B (p=0.028 and p=0.003, respectively). No statistical difference was noted in mean IOP values between the subgroups. Although there was a decrease in mean NM and ECD of pseudophakic eyes, there was no significant difference between Group 1A and Group 2A, and between Group 1B and Group 2B. Mean AVG, SD, and CV values were similar in phakic subgroups, whereas significant different was observed in mean AVG, SD and CV values in pseudophakic subgroups (p=0.048, 0.003, 0.015, respectively). No significant difference was noted in mean MAX, MIN, HEX and CCT values between phakic or pseudophakic subgroups (Table 4).

In Group 1A; ACD, WTW, and AXL levels were found to be positively correlated with each other (p<0.001 for all), and there was no statistically significant relationship between ACD, WTW and AXL levels in other groups. In Group 2A; ACD level was found to be positively correlated with ECD (p=0.007) and negatively correlated with AVG (p=0.005) and HEX (p=0.032), and AXL was negatively correlated with NM (p=0.005) and positively correlated with SD (p=0.045). No statistically significant relationship was found in other groups.

DISCUSSION

Myopia is one of the common causes of visual impairment, and although it has been known for more than a century myopia is unpreventable. Further, some of the myopic population falls within the spectrum of high or pathological myopia which can have irreversible visual impact.[16] However, we are still mostly restricted to treating myopia only as a refractive error, with rehabilitative aids or refractive surgery, which does not cure myopia or prevents its progression fully.[17]

In the current study, we assessed biometry and specular microscope measurements in degenerative myopic patients compared to emmetropic participants. We designed this study to provide more information about anterior segment parameters in degenerative myopia and so to have foresight for follow-up of ocular diseases associated with myopia and ocular surgeries, especially refractive surgeries.

Table 4. *Comparison of biometry and specular microscopy measurements, BCVA, SE and IOP values between subgroups.*

	Group 1A	Group 2A	Group 1B	Group 2B	
	Mean±SD	Mean±SD p	Mean±SD	Mean±SD	p
BCVA (logMAR)	0.008±0.060	0.52±0.59 <0.001*	0.04±0.08	0.66±0.57	<0.001*
SE (D)	1.11±0.90	13.56±5.04 <0.001*	0.91±0.47	15.23±6.09	<0.001*
ACD (mm)	3.40±0.45	4.02±0.54 0.002*	3.49±0.64	4.16±0.59	<0.001*
WTW (mm)	11.9±0.4	11.7±0.6 0.375	11.8±0.4	11.7±0.4	0.286
AXL (mm)	23,4±0,7	28.8±2.8 <0.001*	23.2±1.0	28.4±7.2	<0.001*
K1 (D)	43.2±1.4	42.7±2.0 0.334	42.8±1.6	43.4±1.5	0.028*
K2 (D)	44.1±1.5	43,8±2,4 0.706	43.5±1.5	44.7±1.5	0.003*
IOP	16.3±2.8	15.8±2.7 0.569	15.5±2.8	16.6±6.4	0.348
NM (cell)	146.5±47.3	144.1±62.2. 0.998	126.5±42.1	123.6±56.1	0.742
ECD (cell/mm^2)	2556.8±254.1	2524.7±217.1 0.622	2131.4±256.8	2093.2±202.4	0.118
AVG (um^2)	399.9±41.7	398.6±53.5 0.761	475.1±114.2	419.6±65.2	0.048*
SD (um^2)	109.7±18.4	106.8±25.0 0.507	144.3±54.8	111.1±30.9	0.003*
CV (%)	29.1±4.6	28.2±5.2 0.247	33.8±8.0	30.6±5.1	0.015*
MAX (um^2)	1029.8±322.7	1154.6±338.7 0.685	1089.0±301.7	1169.7±673.0	0.612
MIN (um^2)	168.7±132.5	146.3±15.2 0.212	154.4±37.5	149.0±15.9	0.834
HEX (%)	70.6±5.8	69.8±12.8 0.484	66.9±8.9	64.3±7.8	0.517
CCT (um)	554.0±35.8	550.2±50.0 0.738	555.9±43.0	553.9±53.0	0.965

SD: standard deviation, **Min:** Minimum, Max: Maximum, **BCVA:** Best corrected visual acuity, **SE:** Spherical equivalent, **ACD:** Anterior chamber depth, **WTW:** White to white length, **AXL:** Axial length, **K1/K2:** Keratometric values, **IOP:** Intraocular pressure, **NM:** Number of cells, **ECD:** Endothelial cell density, **AVG:** Average area, **CV:** Coefficient of variation, **MAX:** Maximum area, **MIN:** Minimum area, **HEX:** Hexagonality, **CCT:** Central corneal thickness, ***:** Statistically significant

There are several pre-, intra- and post-operative challenges and complications which should be kept in mind in patients with high and degenerative myopia for ocular refractive surgeries. These patients should be told to create awareness. Since AXL is longer than normal, there is the possibility of obtaining incorrect results in the intraocular lens power calculations. So, using different formulas and reliable new technological equipment may be required. Intraoperative ACD might be deep, and that is why it is harder to focus, and patients may feel more pain. So, anterior chamber manipulation may be difficult.[18-19] We found that mean AXL and ACD values were higher in degenerative myopic patients than in emmetropic eyes, which is known in the literature.

Measurements of CCT, keratometry (K1, K2) and WTW parameters are considerable before both cataract and refractive surgery. Proper intraocular lens (IOL, posterior chamber-PC) power calculations, contact lens fitting, and postoperative cornea follow-up are prominent clinical practice areas of the current parameters, and WTW has enhanced concern for PC-IOL positioning.[20-22] A study performed in India over 176 eyes with myopia assessed these eyes in three groups based on the AXL level.[23] The authors reported a significant difference in the mean of CCT and WTW between these three groups with an increase in the mean values by the increase in AXL level. They did not find a difference in mean ACD and K values between the groups. In the Singapore Malay eye study, the CCT also showed significant but small differences between the groups.[24] However, we did not find any difference in mean CCT, keratometry (K1, K2) and WTW values between emmetropic and degenerative myopic eyes.

Corneal endothelium is a very slim layer and innermost sheet of the cornea. It is composed of a single layer of densely packed flattened cells facing the anterior chamber. Many agents could influence corneal endothelial cell morphology including diabetes mellitus (DM), age, race, contact lens, and ocular surgery.[25] To the best of our knowledge, this is the first study in literature comparing the corneal endothelial layer between emmetropic and degenerative myopic eyes, and so this study may be unique in the literature regarding this subject. We compared phakic

emmetropic eyes with phakic degenerative myopic eyes and pseudophakic emmetropic eyes with pseudophakic degenerative myopic eyes to exclude the effect of surgery.

It has been reported that soft contact lenses do not affect ECD, CV, AVG, and HEX, but hard contact lenses decrease ECD.[26] Mean ECD was decreased by age.[27] In a study, the authors showed that ECD decreased in diabetic patients, and CV and AVG increased in diabetic patients regardless of DM severity.[25] There are studies that investigated the effect of ocular surgery, especially refractive surgery on corneal endothelium morphology.[28-30]

We noted that there was not statistically significant difference in mean ECD between phakic emmetropic and degenerative myopic eyes, and between pseudophakic emmetropic and degenerative myopic eyes, though the mean ECD was decreased in pseudophakic eyes. We also did not observe any significant difference in mean HEX and CCT between phakic emmetropic and degenerative myopic eyes and between pseudophakic emmetropic and degenerative myopic eyes. However, a study reported an increase in mean CCT in myopic eyes.[3] Although the mean AVG and CV were similar between phakic eyes of emmetropic and degenerative myopic eyes, they were higher in pseudophakic emmetropic eyes than in pseudophakic myopic eyes. This result may support an impairment of corneal endothelium layer in degenerative myopic patients.

In conclusion, we found that mean AXL, SE, and ACD values were higher in degenerative myopic eyes as proved in the literature. However mean WTW was similar in emmetropic and degenerative myopic eyes, which is controversial in the literature. We did not observe any difference in mean of ECD, HEX, and CCT between emmetropic and degenerative myopic eyes. Mean AVG and CV values were higher in pseudophakic emmetropic eyes than in pseudophakic myopic eyes. Due to some limitations such as retrospective cross-sectional nature, sample size and the possible confounding effect of refractive surgery, new studies considering these limitations are warranted.

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