Original Article

The Effect of Contact Lens Induced Myopia and Hyperopia on Retinal Thickness and Volume Measured by Optical Coherence Tomography

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Abstract

Purpose: To determine the effect of induced myopia and hyperopia in emmetropic eyes using soft contact lenses on retinal parameters, measured by optical coherence tomography.

Patients and Methods: In this quasi-experimental self-controlled study 57 emmetropic participants, 18 - 42 years of age, were studied. Each subject underwent a complete ophthalmic examinations including, measurement of best corrected visual acuity, intraocular pressure, dry and cycloplegic refractions, and axial length. Optical coherence tomography scans to measure foveal thickness, parafoveal thickness and perifoveal thickness were performed while different refraction powers were induced in each eye by wearing soft contact lenses of five different diopter (- 10.00, - 5.00, plano, + 5.00, + 10.00).

Results: Fifty seven normal emmetropic participants with a mean age of 25.78 ± 6.50 years participated in the present study. Average foveal thickness was 246.02 ± 22.03 μm, 245.47 ± 22.78 μm, 246.47 ± 24.38 μm, 246.42 ± 22.96 μm, and 246.18 ± 22.46 μm in high-induced-myopic (CL: + 10.00 D), mild-induced-myopic (CL: + 5.00 D), emmetropic (CL: Plano), mild-induced-hyperopic (CL: - 5.00 D), and high-induced-hyperopic (CL: - 10.00 D) groups, respectively. Average parafoveal thickness was 329.21 ± 16.31 μm, 329.24 ± 16.36 μm, 328.86 ± 16.46 μm, 328.92 ± 16.57 μm, and 328.80 ± 16.76 μm in high-induced-myopic, mild-induced-myopic, emmetropic, mild-induced-hyperopic, and high-induced-hyperopic groups, respectively. Corresponding numbers for perifoveal thickness was 312.25 ± 14.39 μm, 311.84 ± 14.91 μm, 312.46 ± 16.55 μm, 311.57 ± 14.88 μm, and 311.77 ± 14.96 μm.

Conclusion: Contact lens induced myopia and hyperopia had no significant effect on foveal thickness, parafoveal thickness and perifoveal thickness readings in Fourier domain optical coherence tomography.

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Introduction

Recently; optical coherence tomography (OCT) has been used to measure retinal nerve fiber layer and macular thickness [1]. The instrument provides objective noninvasive imaging of ocular structures and is widely used in ophthalmology to obtain high quality cross sectional images of the retina [2]. With the advent of OCT technology a significant improvement took place in understanding the pathophysiology of retinal eye diseases and it allowed the clinicians to examine these conditions more accurately. Quantitative analysis of retinal morphology using OCT can be used as a control for treatment response and its special features cause it to be widely used to assess retinal diseases like macular hole, macular edema, retinal epithelial membrane and vitreomacular traction [3]. Macular thickness evaluation is important in many eye diseases. Optical coherence tomography enables the accurate determination of small changes in retinal thickness and quantitative assessment of the effectiveness of different treatment strategies [4]. The RTVue-100 OCT is one of the new commercially available Fourier-domain OCT instruments. Its axial resolution is about 5 micrometers and its scan speed is about 26000 A scan per second [5].

Many factors affect the OCT measurements like glaucoma, dry eye, type of instrument used, race, and refractive errors [6-10]. Although some studies reported that refractive errors might affect this instrument's measuring, but it is not clear if these findings show real changes or are caused by sources affecting the accuracy of the OCT measurements [11]. Theoretically, the OCT optical system is known to be affected by a magnification factor which may affect any measurement on retinal plane [12,13].

The aim of the present study was to determine the effect of different induced refractive errors using a soft contact lens on reading of retinal parameters using an OCT system.

Patients and Methods

In a quasi-experimental self-controlled study 57 normal emmetropic participants, 18 - 42 years of age, entered the study. The study followed the principles of the Declaration of Helsinki and was approved by the local ethics committee. All subjects were given a complete explanation about the procedure and gave their informed consent before entering the study.

The sample size according to the instrument normative data base was 114 eyes. Inclusion criteria were being older than 18 and younger than 42 years, IOP less than 21 mmHg, BCVA 20/20 and equivalent refractive error of less than 0.50 diopter. The exclusion criteria included any vitreoretinal diseases and retinal nerve fiber layer problems, history of systemic disease such as hypertension and diabetes, ocular media opacities, history of any eye surgery, history of intolerance to local anesthesia, contraindication to pupil dilations or any evidence of glaucoma. Each participant underwent a complete ophthalmic evaluation including refraction and BCVA measurements and IOP measurement (using Goldman applanation tonometry). Eye axial length was measured by A-scan ultrasonography (Sonomed; California, USA). The pupils were dilated using Cyclopentolate 1% eye drops twice within 5 minutes; and after 45 minutes fundus examination was performed using a + 78 D lens; then refraction was performed again to ensure the accommodation will not affect findings. To investigate the effect of contact lens on images; retinal pictures with and without Plano contact lenses were taken. In the next step subjects wore + 5.00, + 10.00, - 5.00, and - 10.00 D soft contact lenses. Participants were allowed to relatively feel comfort with soft contact lenses without tearing and while they wore each contact lens, images were taken for the fovea, parafovea and perifovea measurements (Using

RTVue OCT, Optovue; USA, algorithm version: A5, 1, 0, 90). All measurements were performed by an experienced optometrist. The accuracy of landmarks was approved.

For each subject a file was prepared and the retinal parameters, that software automatically measured, were extracted. Because of the effect of signal strength only scans with signal strength of above 50 were accepted. Findings were analyzed using SPSS software. The Kolmogorov Smirnov test showed that all of the variables had a normal distribution. Descriptive variables were calculated and expressed in tables and for variable comparisons repeated measure ANOVA was used.

Results

This study included 114 eyes of 57 normal emmetropic 18 - 42 years old subjects. The mean age of participants was 25.78 ± 6.50 years, including 30 males (52.63 %) and 27 females (47.36 %).

The mean spherical equivalent refractive error and axial length were - 0.27 ± 0.20 Diopter and 23.31 ± 0.56 mm respectively. The mean intraocular pressure was 14.53 ± 1.94 mmHg. Due to small ranges for refractive errors (- 0.50 D to + 0.50 D), axial length (22.78 mm to 23.81 mm) and normal IOP their impact on OCT readings will be inconsiderable.

Paired t-test demonstrated statistically insignificant differences for average foveal, parafoveal and perifoveal thickness measurements (P = 0.052, 0.492, 0.369 respectively) (Table 1). Also no statistically significant difference was observed in average foveal, parafoveal and perifoveal volumes (P = 0.516, 0.328, 0.162 respectively) (Table 2). These parameters with and without Plano contact lens are presented in table 3 and 4. Also repeated measures ANOVA with Greenhouse-Geissler correction demonstrated statistically insignificant differences for the average values of the measured parameters in different induced refractive errors by soft contact lenses. The average foveal thicknesses were 246.02 ± 22.03, 245.47 ± 22.78, 246.47 ± 24.38, 246.42 ± 22.96 and 246.18 ± 22.46 micrometer in high induced-myopic, mild induced-myopic, emmetropic (contact lens: Plano), mild induced-hyperopic, and high induced-hyperopic groups, respectively (P = 0.607). Corresponding numbers for average parafovea thickness measurements were 329.21 ± 16.31, 329.24 ± 16.36, 328.86 ± 16.46, 328.92 ± 16.57 and 328.80±16.76 micrometer (P = 0.643). Also corresponding numbers for average perifovea thickness measurements were 312.25 ± 14.39, 311.84 ± 14.91, 312.46 ± 16.55, 311.57 ± 14.88 and 311.77 ± 14.96 micrometer (P = 0.578). P values for fovea, parafovea and perifovea volumes were 0.884, 0.420 and 0.632 respectively and the differences were not statistically significant.

Table 1: The effect of different contact lens powers on retinal thickness readings.

Measurement	Contact lens power: + 5.00 diopter	Contact lens power: + 10.00 diopter	Contact lens power: plano	Contact lens power: - 5.00 diopter	Contact lens power: - 10.00 diopter	P value
Foveal Thickness (micrometer)	245.47 ± 22.78	246.02 ± 22.03	246.47 ± 24.38	246.42 ± 22.96	246.18 ± 22.46	0.607
Parafoveal Thickness (micrometer)	329.24 ± 16.36	329.21 ± 16.31	328.86 ± 16.46	328.92 ± 16.57	328.80 ± 16.76	0.643
Perifoveal Thickness (micrometer)	311.84 ± 14.91	312.25 ± 14.39	312.46 ± 16.55	311.57 ± 14.88	311.77 ± 14.96	0.578

Table 2: The effect of different contact lens powers on retinal volume.

Measurement	Contact lens power: + 5.00 diopter	Contact lens power: + 10.00 diopter	Contact lens power: plano	Contact lens power: - 5.00 diopter	Contact lens power: - 10.00 diopter	P value
Foveal Volume (mm^3)	0.192 ± 0.017	0.193 ± 0.017	0.193 ± 0.019	0.193 ± 0.017	0.193 ± 0.017	0.884
Parafoveal Volume (mm^3)	2.067 ± 0.101	2.069 ± 0.102	2.078 ± 0.124	2.067 ± 0.105	2.065 ± 0.105	0.420
Perifoveal Volume (mm^3)	3.918 ± 0.186	3.914 ± 0.209	3.927 ± 0.205	3.917 ± 0.188	3.917 ± 0.187	0.632

To investigate the effect of soft contact lens wearing by itself on the measurements, retinal parameters were compared with and without Plano soft contact lenses and none of the studied parameters were affected by induced refractive errors.

Table 3: The effect of Plano contact lens wearing on retinal thickness.

Measurement	Without plano soft contact lens	With plano soft contact lens	P Value
Foveal Thickness (micrometer)	245.77 ± 23.29	246.47 ± 24.38	0.052
Parafoveal Thickness (micrometer)	328.68 ± 16.19	328.86 ± 16.46	0.492
Perifoveal Thickness (micrometer)	311.74 ± 14.29	312.46 ± 16.55	0.369

Table 4: The effect of Plano contact lens wearing on retinal volume.

Measurement	Without plano soft contact lens	With plano soft contact lens	P Value
Foveal Volume (mm^3)	0.193 ± 0.019	0.193 ± 0.019	0.516
Parafoveal Volume (mm^3)	2.065 ± 0.102	2.078 ± 0.124	0.328
Perifoveal Volume (mm^3)	3.916 ± 0.182	3.927 ± 0.205	0.162

Discussion

The actual transverse distance or d, at the retina of the eye being scanned is related to the distance or d0 for the standard eye by following equation: $d = d0 / (1 + dM)$, whereby dM is the difference in magnification between the eye being scanned and the standard eye. This magnification difference is affected by the power change due to a change in the axial length as well as the refractive properties of the cornea and lens.

Optical power variation affects transverse magnification factor and it changes the OCT circular scan path; the larger diameter of the scan circle in myopic eyes results in a larger distance from the center of measurement point [13].

In this study, foveal thickness, while cases wore soft contact lenses to induce refractive high myopia, moderate myopia, emmetropia, moderate hyperopia and high hyperopia were measured. We found that different induced refractive errors had no significant effect on the foveal thickness and volume ($P = 0.61$, $P = 0.88$ respectively). Mrugacz et al [14]. in their study using OCT 2000, version A 4.01, examined myopic eyes and they found a mean foveal thickness reading of 231 microns in high myopia, 218 microns in mild myopia and 178 microns in low myopia. Lim et al. [15] measured the mean retinal thickness with OCT (Carl Zeiss Meditec, version 4.1). The mean foveal thickness was 141.1 ± 19.1 micrometer and it was positively associated with ocular axial length and refractive error equivalent sphere [15]. Sato et al. [16] using Spectralis OCT measured the fovea (within 1 mm area). In their study thickness of the fovea was negatively associated with refractive error and positively with eye axial length; also similar relationships were found for the foveal volume [16]. Wu et al. [17] using OCT-3 fast macular thickness map protocol (Carl Zeiss Meditec, Model 3000, B 3.0) found that in high myopia group the mean retinal thickness in fovea was greater than the non-myopic group. In addition, in individuals with high myopia, macular volume was dramatically smaller than non-myopic eyes [17]. In our study parafoveal thickness and volume were not statistically different (P = 0.64, P = 0.42). In Lim et al. study [15], using OCT (Carl Zeiss, Meditec, version 4.1) the mean parafovel thickness was 278.4 ± 13 micrometer and it was negatively associated with eye axial length. Song et al. [4] using Cirrus HD OCT (version 3.0) and macular cube 512 × 128 protocol concluded the refractive error had no significant influence in partial correlation analysis. In their study the axial length correlated negatively with the average outer macular thickness, overall average macular thickness, and macular volume [4]. Madrid-Costa et al. using Cirrus HD OCT found no significant difference in the mean macular thickness or macular thickness of studied areas with and without multifocal contact lenses [18].

Also in the present study perifovea thickness and volume were not statistically different (P = 0.58, P = 0.63). Cheng et al. using stratus OCT (Carl Zeiss Meditec, model 3000, version 4.0) concluded that the fovea and foveola in myopic eyes were thicker than non-myopic eyes and other parts of the myopic macula was significantly thinner than the non-myopic eyes [19].

Feng et al. [20] using time domain stratus OCT-3, version 4 concluded that the total macular volume changed significantly between preoperative and postoperative measurements and no statistical differences were found between preoperative and postoperative mean foveal thickness. In their study the variation in total macular volume correlated significantly with the change in spherical equivalent refraction. They could not find the exact mechanism for this change [20].

Another study showed mild macular edema was common in the first month following LASIK, especially in high myopia, and that was correlated with high refractive diopters and laser treatment time [21]. Wakitani et al. using Humphrey OCT 2000 (Zeiss Humphrey system) stated that when pathological myopia was removed, eye axial length did not influence macular thickness [22]. Results in another study using the same OCT did not show a relationship between eye axial lengths and mean retinal thickness [23]. However, these two studies analyzed only a small central macular area within 2 mm and 3 mm diameters with four linear scans [22, 23]. In another study using overlapping OCT (Stratus OCT 3.0), images of the retina were acquired along the 45° meridian and covered the central 32° of the retina. The study showed the peripheral retinal thickness in high and mild myopia was dramatically thinner than normal eyes, but fovea was thicker in myopic patients compared to emmetrope individuals [24]. Lam et al. [25] using Stratus OCT fast macular thickness map protocol, showed a negative correlation between outer and overall macular thicknesses and axial length. But the authors did not perform partial correlation analysis to discover the individual effects of refractive error.

Many studies have indicated that retinal thickness in the macular central region of one and three millimeters increases when myopia is present; but when studying the total macular thickness (total 6 millimeters), the amount of change was not clinically significant. In fact increasing the axial length of the eye (myopia) causes physical stretching of the retina and it reduces the thickness of the peripheral retina and increases the central retinal thickness. The eye axial length decreasing causes the opposite results. When calculating the macular thickness in the myopic eye, while we accumulate the increase in the central macular thickness with the decrease in the peripheral macular thickness, they neutralize each other effects; and this mechanism will be opposite in the hyperopia. The question is how inducing refractive error via soft contact lenses did not alter OCT measures. We know the refractive error is strongly dependent on the axial length; also previous studies have shown that RNFL thickness values do not change after excimer laser surgery to correct myopia [26,27]. One possible explanation is that as previous studies [22] have indicated the difference in magnification between the eye being scanned and the standard eye (dM) is strongly correlated to axial factor rather than optical power: dM = 0.018 D axial + 0.002 D refraction. So the effect of optical power alone is not strong enough to produce considerable changes in retinal measurements.

Conclusion

Contact lens induced myopia and hyperopia had no significant effect on foveal thickness, parafoveal thickness and perifoveal thickness readings in Fourier domain optical coherence tomography.

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Footnotes and Financial Disclosures

Conflict of Interest:

The authors declare no conflict of interest with the subject matter of the present manuscript.