

Effect of pathological myopia on biomechanical properties: a study by ocular response analyzer

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Abstract

• **AIM:** To evaluate the ocular response analyzer (ORA) measurements of patients with pathological myopia in comparison with those of emmetropic control subjects, and to investigate the correlation between these ORA measurements and spherical equivalent (SE).

• **METHODS:** Measurements of 53 eyes of 53 subjects with pathological myopia (SE > -6.00 D) were compared with those of 60 eyes of 60 emmetropic controls. Corneal hysteresis (CH), corneal resistance factor (CRF), noncontact tonometer intraocular pressure (IOPg), and corneal-compensated IOP (IOPcc) were obtained for each subject. The refractive error value was determined as SE *via* a cycloplegic refraction test.

• **RESULTS:** The mean age was 54.1±18.9y (ranging from 5 to 88) in the pathological myopic group and 56.2±19.0y (ranging from 6 to 89) in the control group. There were no significant differences between the groups concerning age and sex. CH and CRF were significantly lower in the pathological myopic group than in the control group ($P < 0.001$, $P = 0.005$, respectively). IOPcc and IOPg were significantly higher in the pathological myopic group than in the control group ($P < 0.001$, $P = 0.009$, respectively). There were significantly positive correlations between CH and SE ($r = 0.565$, $P < 0.001$) and between CRF and SE ($r = 0.364$, $P = 0.007$). There were significantly negative correlations between IOPcc and SE ($r = -0.432$, $P = 0.001$) and between IOPg and SE ($r = -0.401$, $P = 0.003$).

• **CONCLUSION:** The present study displayed that pathological myopia affected biomechanical properties measured by ORA. The results of corneal biomechanical

properties measured by ORA may need to be appreciated by taking refraction into account. Further, pathological myopia might be related with the increased IOP.

• **KEYWORDS:** ocular response analyzer; corneal hysteresis; corneal resistance factor; intraocular pressure; pathological myopia

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INTRODUCTION

Recently, with the introduction of ocular response analyzer (ORA) (Reichert Ophthalmic Instruments, Depew, NY, USA), direct clinical measurement of the biomechanical properties of the cornea has become possible^[1]. The ORA provides 2 parameters, corneal hysteresis (CH) and corneal resistance factor (CRF), which reflect the biomechanical properties of the cornea. CH is a parameter to assess the corneal tissue properties that results from viscous damping^[1]. CRF is an empirically measured parameter that reflects the overall resistance of the cornea. In addition, ORA is used to measure noncontact tonometer intraocular pressure (IOPg) and corneal-compensated IOP (IOPcc). IOPcc is a pressure measurement based on data supplied by the CH.

Myopia is the most common ocular disease in the world^[2]. Its extreme form, pathological myopia, is characterized by an axial length typically higher than 25.50 or 26.50 mm, a corresponding refractive error of at least -5.0 diopters (D), and accompanied characteristic pathological changes^[3]. Posterior pole abnormalities including tilted optic disk, lacquer cracks, choroidal neovascularization, macular atrophy, posterior staphyloma, temporal peripapillary atrophic crescent, and hemorrhages are associated with pathological myopia^[4,5].

On the other hand, changes of the anterior segment in pathological myopia are still under debate. Previous studies evaluating corneal biomechanical properties of myopic patients are controversial. Song *et al*^[6] demonstrated lower CH in patients with longer axial length. However, Lim *et al*^[7] showed no correlation between CH and the axial length. In addition, although Jiang *et al*^[2] revealed a positive correlation between CRF and SE, Shen *et al*^[8] displayed no

Table 1 Clinical characteristics of the groups

Characteristic			$\bar{x} \pm s$
	Pathological myopic group (n=53)	Emmetropic control group (n=60)	P
SE (diopter)	-11.5±3.0 (-6.0 to -17.0)	0.1±0.3 (-0.50 to +0.50)	<0.001 ^a
CH (mm Hg)	9.0±2.4	11.0±2.9	<0.001 ^a
CRF (mm Hg)	9.7±2.8	11.0±2.9	0.005 ^a
IOPg (mm Hg)	18.2±4.0	16.3±3.3	0.009 ^a
IOPcc (mm Hg)	18.2±3.9	15.5±3.6	<0.001 ^a

CH: Corneal hysteresis; CRF: Corneal resistance factor; IOPcc: Corneal-compensated intraocular pressure; IOPg: Noncontact tonometer intraocular pressure; SE: Spherical equivalent. ^aStatistically significant.

correlation. Similarly, the relation between myopia and IOP is controversial^[9].

Accordingly, in the present study, we aimed to evaluate the ORA measurements (CH, CRF, IOPg, and IOPcc) of patients with pathological myopia in comparison with those of emmetropic control subjects, and to investigate the correlation between these ORA measurements and spherical equivalent (SE).

SUBJECTS AND METHODS

The study was a retrospective medical records evaluation comparing the ORA measurements including CH, CRF, IOPg, and IOPcc of 53 eyes of 53 Turkish subjects with pathological myopia with those of 60 eyes of 60 Turkish emmetropic controls. Pathological myopia was defined as a refractive error higher than -6.00 D and accompanied characteristic pathologic changes. Subjects who had SE ≤+0.50 and ≥-0.50 D were enrolled in the control group. Each subject underwent ocular examinations including assessment of visual acuity, slit-lamp examination and funduscopy. Subjects with ocular pathology other than refractive error, and myopia-associated chorioretinal changes (*i.e.* strabismus, amblyopia, glaucoma, uveitis) were excluded from the study. Subjects with anisometropia and astigmatism >2 D were also excluded. This study followed the tenets of the Declaration of Helsinki and it was approved by Local Ethics Committee.

The refractive error value was determined as SE *via* a cycloplegic refraction test. Cycloplegia was induced with administration of one drop of 1% cyclopentolate every 5min for three times. Cycloplegic refraction was measured with an autorefractometer (KR-8900 Topcon Co., Tokyo, Japan) at least 30min after the last drop. Three consecutive measurements were obtained and the average value was used for analyses.

ORA (Reichert Ophthalmic Instruments, Depew, NY, USA, version:2.04) was used as a noncontact tonometer to measure biomechanical properties. The details of its method have been described elsewhere ^[10]. Four variables including CH, CRF, IOPg, and IOPcc were obtained for each subject. Two consecutive measurements were obtained and the mean was used for analyses.

Statistical Analysis Statistical analysis was performed using SPSS version 16.0. Sex was compared using Chi-square test. The distribution of all variables has been checked with

Kolmogorov-Smirnov test. Student's *t*-test was used to compare the groups. Pearson correlation coefficients were calculated to evaluate correlations. Statistical significance was set at *P*<0.05.

RESULTS

The mean age was 54.1±18.9y (ranging from 5 to 88) in the pathological myopic group and 56.2±19.0y (ranging from 6 to 89) in the control group. There were 27 females and 26 males in the pathological myopic group and 33 females and 27 males in the control group. There were no significant differences between the groups concerning age and sex. There were no significant differences between the female and male patients concerning CH, CRF, IOPg, and IOPcc in each group.

The clinical data of the subjects are given in Table 1. CH and CRF were significantly lower in the pathological myopic group than in the control group (*P*<0.001, *P*=0.005, respectively). IOPcc and IOPg were significantly higher in the pathological myopic group than in the control group (*P*<0.001, *P*=0.009, respectively).

Figure 1 shows correlations between corneal biomechanical properties and SE in the pathological myopic subjects. Correlation analyses among pathological myopic subjects showed that there were significantly positive correlations between CH and SE (*r*=0.565, *P*<0.001) and between CRF and SE (*r*=0.364, *P*=0.007). On the other hand, there were significantly negative correlations between IOPcc and SE (*r*=-0.432, *P*=0.001) and between IOPg and SE (*r*=-0.401, *P*=0.003). Although there was a moderate positive correlation between CRF and IOPg (*r*=0.327, *P*<0.001), there was a very weak negative correlation between CRF and IOPcc (*r*=-0.195, *P*=0.037). In addition, there was a significantly negative correlation between CH and IOPcc (*r*=-0.563, *P*<0.001). There were no correlations between the measured ORA parameters and the age in each group.

DISCUSSION

The present study demonstrated that patients with pathological myopia had lower CH and CRF but higher IOPcc and IOPg than emmetropic control subjects according to measurements performed by ORA. Further, CH and CRF were positively correlated with SE while IOPcc and IOPg were negatively correlated with SE in patients with pathological myopia.

Elongation of the eye, deeper anterior chamber, thinner retina

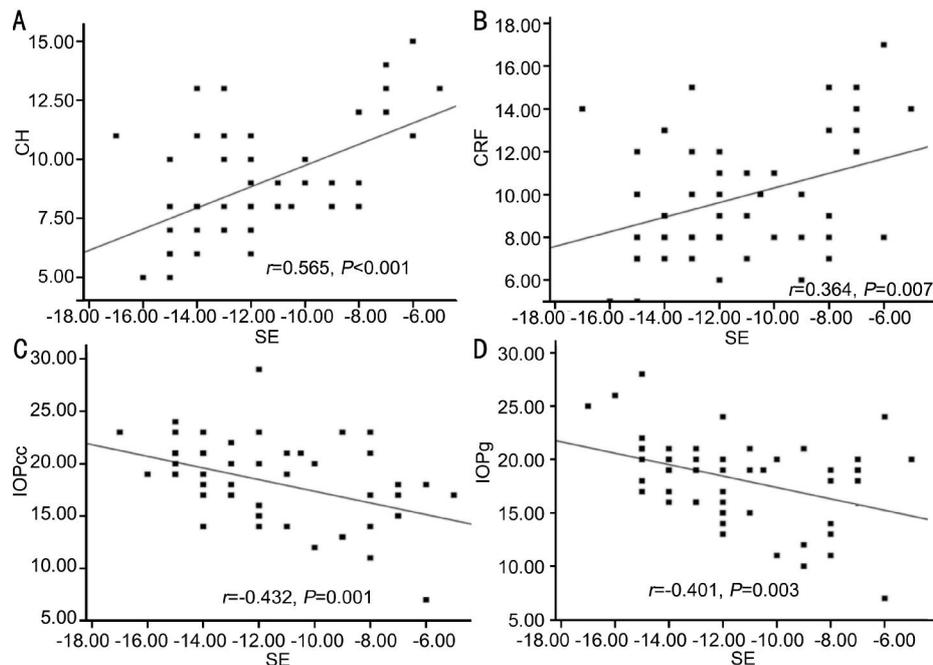


Figure 1 Correlation between SE (diopters) and CH (mm Hg) (A), CRF (mm Hg) (B), IOPcc (mm Hg) (C), and IOPg (mm Hg) (D) in the pathological myopic subjects CH: Corneal hysteresis; CRF: Corneal resistance factor; IOPcc: Corneal-compensated intraocular pressure; IOPg: Noncontact tonometer intraocular pressure; SE: Spherical equivalent.

and increased incidence of retinal detachment, and decreased scleral thickness and elasticity are the well-known myopic changes^[11-14]. It has been revealed that myopia development is related with reduction in scleral thickness and extracellular matrix, increase in the collagen-degrading enzyme matrix metalloproteinase and sclera extensibility^[15]. Further, decrease in the diameter of the scleral collagen fibrils and the rate of proteoglycan synthesis has been found in the development of myopia, which results in scleral thinning and the loss of scleral tissue^[14,16,17]. Similar changes might occur in the cornea in the development of myopia^[18]. It has been reported that corneal biomechanics reflect the viscoelastic properties of the cornea and mechanical strength of stromal collagen fibrils interacting with the extracellular proteoglycan matrix^[19]. Therefore, it is not surprising to find lower CH and CRF in patients with pathological myopia.

Jiang *et al*^[2] investigated the association between corneal biomechanical properties and the degree of myopia in 72 Chinese subjects aged between 11-65y. In accordance with our results, they found that CH was significantly lower in high myopia (SE<6.00 D) compared with both low and non-myopia. In addition, CH and CRF was positively correlated to refraction. On the other hand, in a study evaluating corneal biomechanical parameters measured with ORA in Singaporean children aged 13.97±0.89y with a mean SE of -2.35±2.49 D, CH and CRF did not vary with myopia status^[7]. In another study, Fontes *et al*^[20] investigated corneal biomechanical properties with topographic parameters (by the Oculus Pentacam) and refractive data in a population of healthy Brazilian patients aged 46.5±21.04y with a mean SE

of -1.16±3.48 D. Neither CH nor CRF was correlated with SE. We believe that these conflicting results might be due to different degrees and ranges of myopia.

In the present study, IOPg and IOPcc were significantly higher in the pathological myopic group than in the control group. It has been found that the average IOP measured by Goldmann applanation tonometry in myopic children was significantly higher than that in non-myopic children^[21]. In consistent with our results, Shen *et al*^[8] displayed that both IOPg and IOPcc measured by ORA were significantly higher in the high myopes compared to the controls. In addition, the results of studies by Wong *et al*^[22] and Xu *et al*^[23] were in accordance with ours. However, using a noncontact tonometry, Lee *et al*^[19] found no correlation between IOP and axial length. The degree of refractive error, the method of measuring IOP, and the different study population might be the reasons for this controversial result. Although several studies have shown that myopia is associated with increased IOP, the cause remains inconclusive^[8,21-23]. Schmid *et al*^[24] hypothesized that the increased IOP is associated with an increased stress of the global wall and a decreased ocular rigidity in the myopic eye.

In the present study, although there was a moderate positive correlation between CRF and IOPg, there was a very weak negative correlation, which can be ignored, between CRF and IOPcc. In this regard, previous studies^[25,26] have found similar results to ours. Therefore, it can be speculated that IOPcc may be more reliable than IOP values for evaluation of IOP. In conclusion, the present study displayed that pathological myopia affected biomechanical properties measured by ORA.

CH and CRF were positively correlated with SE while IOPcc and IOPg were negatively correlated with SE in pathological myopic patients. The results of corneal biomechanical properties measured by ORA may need to be appreciated by taking refraction into account. Further, pathological myopia might be related with the increased IOP. Additional longitudinal studies are warranted to clarify the clinical relevance of these findings on the progression of myopia.

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