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Original Article

The ocular biometric and corneal topographic characteristics of high-anisometropic adults in Taiwan

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Abstract

Background: To investigate the difference of ocular biometric and corneal topographic characteristics between the two eyes in high anisometropes with difference of 4 D or more in spherical component.
Methods: Fifty-one young anisometropic men were collected. Detailed ocular examinations, including cycloplegic autorefraction, best-corrected visual acuity, intraocular pressure, A-scan, and Orbscan topography were done and recorded. The comparisons between two eyes were performed and the correlations between different ocular parameters were evaluated.
Results: The mean axial length in the more myopic/less hyperopic eye was longer than that in the less myopic/more hyperopic eye [difference 1.8 mm, 95% confidence interval (CI) 1.6–2.0 mm, $p < 0.001$]. The mean thinnest corneal thickness in the more myopic/less hyperopic eye was an average of 4.0 μm thicker than that in the other eye (95% CI 1.2–6.8 μm, $p = 0.007$). The mean anterior chamber depth in the more myopic/less hyperopic eye was an average of 0.05 mm (95% CI 0.02–0.07 mm, $p < 0.001$) more than that in the other eye. The curvature and size of cornea were not significantly different.
Conclusion: The anterior chamber depth is deeper, axial length is longer, and thinnest corneal thickness is thicker in the more myopic/less hyperopic eye of high-anisometropic patients. Anisometropic eyes provide the chance to understand the biometric changes of eyeball with different refractive statuses in the same person. Such information is helpful for us to calculate the intraocular lenses power in cataract surgery and to do the surgical planning for corneal refractive surgery in eyes of different refractive power.

Keywords: Anisometropia; Corneal topography; Intraocular pressure

1. Introduction

Ocular biometric and topographic characteristics are important measurements in different fields in ophthalmology. Corneal thickness is an important guiding parameter in corneal refractive surgery, allowing determination of the extent of safe stromal ablation.[1] The central corneal thickness (CCT) and the anterior chamber depth (ACD) are considered as the screening risk factors for glaucoma.[2–5] Recently, ACD was used as an important adjunctive to axial length (AL) and corneal power in calculating the power of intraocular lenses in the new theoretical biometric formulas.[6,7]

Anisometropia, the difference in the refractive errors between the eyes, is believed to be an important factor for developing amblyopia. Habitual anisometropia with more than 1.00 D was reported to be common;[8] however, high anisometropia is rare. High degrees of anisometropia cause disparity in image size between the two eyes of anisometropia (aniseikonia) and it has traditionally been believed that anisometropia of more than 3.5 D inhibits fusion.[9,10] Refractive surgery, such as laser *in situ* keratomileusis, has been considered in pediatric and adolescent patients with high anisometropia to reverse the anisometropia and prevent amblyopia.[11,12] There is little information in the

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literature on the individual optical components and biometric variables in the eyes of patients with high anisometropia. The aim of this study was to investigate the difference of ocular biometric and corneal topographic characteristics between the two eyes in high anisometropes with difference of 4 D or more in spherical component.

2. Methods

Patients with difference of 4 D or more in spherical component of anisometropia between both eyes as determined by cycloplegic refraction were collected. This was a retrospective study of optic components of high-anisometropic patients in our military screening clinic from August 2001 to July 2005. Refractive error was expressed in negative cylinder format. The study protocol had the approval of the ethics committee at Kaohsiung Veterans General Hospital (VGHKS95-095) and complied with the guidelines set forth in the Declaration of Helsinki. Detailed ophthalmological examinations were done for every anisometropic patient after stopping any kind of contact lenses for more than 2 weeks, including manifest and cycloplegic autorefraction, best-corrected visual acuity, intraocular pressure, A-scan, and Orbscan topography. Cycloplegic refraction was done by instilling one drop of 1% cyclopentolate every 15 minutes at least 3 times, and the extent of cycloplegia was judged until no pupil movement with penlight, and cycloplegic refraction was determined until no fluctuation through three consecutive measurements using Topcon RM-8800 autorefractor (Topcon, Tokyo, Japan). AL was measured using a Storz A/B 5500 Biometric Ruler (Sonomed, New York, USA) with a 10-MHz focusing transducer and a soft probe while the patients looked at a small black fixation point at 3-m distance. The average of five sets of measurements was calculated and recorded. The simulated keratometry (SimK), horizontal corneal diameter, and the curvature of best-fit sphere were obtained from the anterior and the posterior float maps created by the Orbscan II (Bausch and Lomb, Rochester, NY, USA). The thinnest point on corneal pachymetry was recorded. An acoustic factor of 0.92 adjustment for discrepancy between ultrasound and Orbscan II pachymetry was applied for all scans. Intraocular pressure (IOP) was measured using a Topcon CT-80 noncontact tonometer (Topcon, Tokyo, Japan) and patients were asked to look at the black fixation target to minimize fluctuations due to eye position and direction of gaze. The median of three consecutive readings was recorded with the fluctuation less than 1 mmHg. Eyes with any ocular pathology, any previous ocular disease except amblyopia, or any previous ocular surgery were all excluded.

Normality of data was confirmed by using Kolmogorov−Smirnov test in each group. Paired t test was used to compare the means of the continuous variables in each eye, with $p < 0.05$ being considered significant. Correlations between parameters were studies using the Pearson correlation test. All results were analyzed statistically using the SPSS 12.0 software package (SPSS Inc., Chicago, IL, USA) for Windows.

3. Results

Fifty-one high-anisometropic male patients were enrolled in this study, including 29 anisomyopia, 20 antimetropia, and 2 anisohyperopia. Patient age ranged from 19 years to 30 years (23.41 ± 1.99 years). The mean anisometropia was 4.87 D in spherical equivalent with standard deviation (SD) of 1.31 D. Subgroup analyses were done in anisomyopic and antimetropic patients.

The mean thinnest corneal thickness (TCT) in the more myopic/less hyperopic eye was an average of 4.0 μm more than that in the less myopic/more hyperopic eye (95% CI 1.2−6.8 μm, $p = 0.007$). The mean IOP in the more myopic/less hyperopic eye was an average of 0.6 mmHg (95% CI 0.05−1.1 mmHg, $p = 0.03$) higher than that in the other eye. The mean ACD in the more myopic/less hyperopic eye was an average of 0.05 mm (95% CI 0.02−0.07 mm, $p < 0.001$) more than that in the other eye. The mean AL in the more myopic/less hyperopic eye was 26.13 mm (SD = 1.20), an average of 1.8 mm (95% CI 1.6−2.0 mm, $p < 0.001$) more than that in the less myopic/more hyperopic eye ($p < 0.001$) (Table 1). ACD and total AL in more myopic/less hyperopic eyes were longer than those in the other eyes by approximately 1.5% and 7.5% respectively. Fig. 1 shows the relationship between the percentages of ACD and AL of more myopic/less hyperopic eyes and difference of cycloplegic spherical equivalent. The regression lines in the graph illustrate that ACD and AL of the more myopic/less hyperopic eyes are not proportionately increased in these high-anisometropic patients.

The difference between the two eyes of high anisometropes was not statistically significant in any parameters relating corneal curvature, including mean SimK and the best-fit sphere of anterior surface and posterior surface. And there was no statistically significant difference of horizontal corneal diameter between the two eyes of high anisometropes (Table 2).

Table 1
Cycloplegic refraction, IOP, ACD, and AL between the two eyes of high anisometropia ($n = 51$)

	More myopic/less hyperopic eye		Less myopic/more hyperopic eye		Difference	95% CI	t	p
	Mean	SD	Mean	SD				
SE (D)	−5.66	2.70	−0.79	3.04	−4.87	−5.24 to −4.50	−26.54	<0.001[a]
IOP (mmHg)	17.4	3.1	16.8	3.2	0.6	0.05−1.1	2.23	0.03[a]
ACD (mm)	3.15	0.26	3.10	0.27	0.05	0.02−0.07	3.71	<0.001[a]
AL (mm)	26.1	1.2	24.3	1.3	1.8	1.6−2.0	17.57	<0.001[a]

[a] Statistical significance.
AL = axial length; ACD = anterior chamber depth; CI = confidence interval; IOP = intraocular pressure; SD = standard deviation; SE = cycloplegic spherical equivalent.

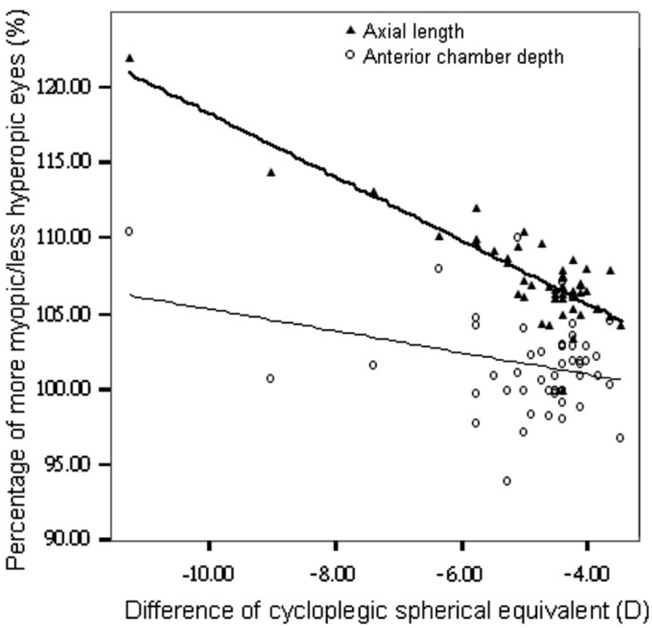

Fig. 1. Relation between the percentages of anterior chamber depth and axial length in more myopic/less hyperopic eyes and the difference of cycloplegic spherical equivalent.

There was a positive correlation between the IOP and TCT (more myopic/less hyperopic eye: r = 0.31, p = 0.03; less myopic/more hyperopic eye: r = 0.31, p = 0.03) and a weak positive correlation between the IOP and ACD (more myopic/less hyperopic eye: r = 0.35, p = 0.02; less myopic/more hyperopic eye: r = 0.26, p = 0.07). However, the TCT seemed to be independent of ACD (p = 0.68, p = 0.91, respectively) and AL (p = 0.87, p = 0.64, respectively). ACD showed a good correlation to AL (more myopic/less hyperopic eye: r = 0.47, p = 0.001; less myopic/more hyperopic eye: r = 0.52, $p < 0.001$) (Table 3). Furthermore, the SimK showed a weak negative correlation to AL (more myopic/less hyperopic eye: r = −0.32, p = 0.02; less myopic/more hyperopic eye: r = −0.26, p = 0.07).

In the subgroup analysis, the results were similar in both the high-anisomyopic and high-antimetropic patients except for the difference of IOP between the two eyes of high anisometropes. The TCT was thicker, the ACD was deeper, and the AL was longer in the more myopic eye than that in the less myopic eye in the high-anisomyopic patients (p = 0.02, 0.02, and <0.001, respectively). And in high-antimetropic patients, the results were similar in the more myopic eye than in the more hyperopic eye (p = 0.047, 0.03, and <0.001, respectively). The difference of IOP between the paired eyes was different in high-anisomyopic and in high-antimetropic patients. In the high-anisomyopic group, the mean IOP in the more myopic eye was an average of 1.0 mmHg (95% CI 0.3−1.9 mmHg, p = 0.004) higher than that in the less myopic eye. But there was no statistically significant difference of IOP between the two eyes in high-antimetropic group (mean 16.6 mmHg, SD 2.9 mmHg in the more myopic eye and mean 16.5 mmHg, SD 3.1 mmHg in the more hyperopic eye, p = 0.81) (Table 4).

4. Discussion

High anisometropia is a good model to understand the difference of two eyes of anisometropia because it is especially suited for the measurements of ocular biometric and topographic findings because of the significant difference between the two eyes. Significantly thicker cornea, deeper ACD, and longer AL were found in the more myopic/less hyperopic eye than in the less myopic/more hyperopic eye of the high-anisometropic patients in this study. To our knowledge, the mean TCT between the paired eyes of high anisometropia has not been discussed before. But there were some studies that mentioned the relationship between CCT and refractive power.[13−15] Chang et al. reported that corneas were thinner in more myopic eyes in young Taiwanese patients,[13] but Fam showed that CCT was distributed over a large range but did not correlate with the degree of myopia in Chinese patients in Singapore, aged from 15 years to 59 years.[14] In the European Glaucoma Prevention Study, myopic eyes had even slightly thicker corneas than normal or hyperopic eyes, but they showed that larger CCT measurements correlated with male gender and younger age.[15] CCT is reported to be

Table 2
Corneal characteristics between the two eyes of high anisometropes (n = 51)

	More myopic/less hyperopic eye		Less myopic/more hyperopic eye		Difference	95% CI	t	p
	Mean	SD	Mean	SD				
Curvature								
Ant BFS (D)	41.92	1.24	41.87	1.31	0.05	−0.07−0.18	0.85	0.40
Post BFS (D)	51.59	1.78	51.71	1.82	−0.12	−0.33−0.10	−1.08	0.28
Mean SimK (D)	42.76	1.36	42.65	1.44	0.11	−0.04−0.27	1.47	0.15
Thickness								
TCT (μm)	533.3	32.0	529.3	31.7	4.0	1.2−6.8	2.84	0.007[a]
Size								
WTW (mm)	11.69	0.45	11.72	0.39	0.02	−1.46−1.03	−0.34	0.73

[a] Statistical significance.
Ant BFS = anterior best-fit sphere; CI = confidence interval; Post BFS = posterior best-fit sphere; SD = standard deviation; SimK = simulated keratometry; TCT = thinnest corneal thickness; WTW = white to white horizontal corneal diameter.

Table 3
Correlation between the IOP, TCT, ACD, and AL in each eye of high anisometropes

		TCT		ACD		AL	
		r	*p*	r	*p*	r	*p*
IOP	More myopic/less hyperopic eye	0.31	0.03*	0.35	0.02*	0.28	0.06
	Less myopic/more hyperopic eye	0.31	0.03*	0.26	0.07	0.27	0.07
TCT	More myopic/less hyperopic eye	1		−0.06	0.68	−0.02	0.87
	Less myopic/more hyperopic eye			−0.02	0.91	−0.07	0.64
ACD	More myopic/less hyperopic eye	–		1		0.47	0.001*
	Less myopic/more hyperopic eye					0.52	<0.001*

*A p value <0.05.
ACD = anterior chamber depth; AL = axial length; IOP = intraocular pressure; TCT = thinnest corneal thickness.

associated with IOP,[16–20] sex, age,[15,21] and serum glucose level.[22–24] Our study included only men with age between 18–30 years, and thus reduced the possibility of confounding effects of age and sex. A thicker cornea was found in the more myopic/less hyperopic eye than in the less myopic/more hyperopic eye in these high-anisometropic young men.

High IOP was thought to be one of the causes of axial elongation,[25,26] and axial elongation was considered to be the main cause for anisometropia.[27–30] The difference of intraocular pressure between the two eyes in anisometropia has been discussed in previous studies with conflicting results.[31–33] Tomlinson and Philips found the eyes with the greater AL in a pair had the higher ocular tension, but failed to demonstrate a significant difference in IOP between the two eyes in 13 anisometropic children.[32] Lee and Edwards showed no differences in IOP between the eyes of 67 anisometropia children (difference in spherical component was 2 D or more).[33] Bonomi et al. demonstrated a significantly lower IOP in the more myopic eye of anisomyopic patients, but there was no difference in IOP between the eyes when only one eye was myopic.[31] However, our study showed that the more myopic eye has a higher IOP than the less myopic eye in high-anisomyopic young men with the difference of 4 D or more in spherical component. We speculate that large difference of refractive power between the two eyes might be the reason for the discrepancy between our results and others'. A positive association between IOP and increasing degrees of myopia after adjustment for age was also reported by Nomura.[34] Furthermore, IOP has the tendency to vary with age,[35,36] the confounding age factor was minimized in our study as we included only young men. The association of thicker CCT with higher measured IOP in the healthy eyes of children and adults has been reported in the literature.[16–20,37,38] Our results support that positive correlation is existing between measured IOP and CCT.

Although several studies have been conducted to investigate the relationship between refractive errors of myopia and corneal curvature,[13,39] there are few focusing on cases of anisometropia. In the report by Chang et al., flatter corneal curvature was found as the eyeball elongates in myopia progression, but the spherical equivalent didn't correlate with corneal curvature.[13] Our study showed similar results in high-anisometropic patients; the anterior corneal surface was flatter in eyes with longer AL, but no difference of corneal curvature was found between the two eyes. Whereas the AL was longer in the more myopic/less hyperopic eye than the other eye in this study. The correlation between spherical equivalent and AL was high (more myopic/less hyperopic eye: $r = -0.76$, $p < 0.001$; less myopic/more hyperopic eye: $r = -0.86$, $p < 0.001$). Our results supported that refractive error was predominantly axial in nature.

The anterior chamber has traditionally known to be deeper in higher myopia. [40] Our results supported this theory and showed deeper ACD in the more myopic/less hyperopic eye than in the other eye in high anisometropes and ACD showed a good correlation to AL. It was interesting that the ACD and AL of the more myopic/less hyperopic eyes were not proportionately increased in high anisometropes in this study. A recent biometric investigation concluded that the anterior

Table 4
Subgroup analyses of difference of cycloplegic refraction, IOP, TCT, ACD, and AL between the two eyes of high anisomyopia and high antimetropia

	Anisomyopia (n = 29)			Antimetropia (n = 20)		
	Difference	95% CI	*p*	Difference	95% CI	*p*
SE (D)	−4.59	−5.00 to −4.17	<0.001[a]	−5.28	−6.01 to −4.56	<0.001[a]
TCT (μm)	4.5	0.7–8.2	0.02[a]	3.6	0.7–9.1	0.047[a]
IOP (mmHg)	1.0	0.3–1.9	0.004[a]	0.1	−0.8–1.0	0.81
ACD (mm)	0.05	0.02–0.07	0.02[a]	0.06	0.008–0.12	0.03[a]
AL (mm)	1.6	1.4–1.9	<0.001[a]	2.0	1.7–2.5	<0.001[a]

[a] Statistical significance.
ACD = anterior chamber depth; AL = axial length; CI = confidence interval; IOP = intraocular pressure; SD = standard deviation; SE = cycloplegic spherical equivalent; TCT = thinnest corneal thickness.

chamber, lens thickness, vitreous chamber, and AL of the anisometropic amblyopic eye (mean anisometropia 1.96D) were proportionately comparable.[41] In that study, the ACD and AL in less hyperopic (nonamblyopic) eye were longer than that of the other (amblyopic) eye by approximately 4%. In our high-anisometropic patients, the more myopic/less hyperopic eyes had an anterior chamber 1.63% deeper and AL 7.45% longer than that of the less myopic/more hyperopic eyes. the more the difference of spherical equivalence between the two eyes, the more the AL change contributed compared with the ACD change. These results further supported that the difference in refractive error between two eyes of high anisometropia was predominantly axial in nature, especially the difference of the length of the posterior segment.

In conclusion, the two eyes of anisometropia are good models to understand the biometric characteristics of eyeballs with different refractive powers. The TCT is thicker, ACD deeper, and AL longer in the more myopic/less hyperopic eyes of high-anisometropic patients. The IOP is higher in the more myopic eye in high-anisomyopic patients. But the curvature and size of cornea are not significantly different between the two eyes of anisometropia. Such information is helpful for us to understand the change of eyeballs with different refractive status in the same person.

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