

Original Article

Measurement of anterior segment parameters in Saudi adults with myopia



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Abstract

Purpose: To measure anterior segment parameters of the eye in myopic Saudi population using Pentacam.

Method: This is retrospective cross-sectional study. Subjects were divided into three groups: low, moderate and high myopia groups. Anterior segment parameters including: central corneal thickness (CCT), thinnest corneal thickness (TCT), apex corneal thickness (Apex CT), corneal volume (CV), anterior chamber depth (ACD), anterior chamber volume (ACV) and corneal astigmatism (CA) were measured by Pentacam.

Results: A total of 504 eyes of 252 Saudi subjects with myopia were included in this study. The mean age \pm standard deviation (SD) of subjects was 28.73 ± 6.18 years. The mean CCT, TCT, Apex CT, CV, ACD, ACV and CA for all myopic subjects were 557.21 ± 29.36 , 554.09 ± 29.28 , 556.10 ± 37.06 , $61.30 \pm 3.23 \mu\text{m}$, 3.31 ± 0.27 mm, $211.15 \pm 34.22 \text{ mm}^3$ and 0.89 ± 0.52 D, respectively. No significant differences ($P > 0.05$) were found between right and left eyes in all anterior segment parameters of all myopic eyes. However, a significant difference ($P < 0.05$) was found in ACD between low (3.27 ± 0.26 mm) and moderate (3.35 ± 0.30 mm) myopic groups. Within low myopia group, significant differences ($P < 0.05$) were found in ACD, ACV and CA between different genders. Anterior chamber depth and ACV values were lower in females while CA was lower in males. In addition, significant positive correlation was found between ACV and ACD in all myopic groups.

Conclusion: This study provided valuable measurements of the anterior segments parameters of the eye in myopic Saudi population. These parameters could be useful for ophthalmic practitioners in the clinic.

Keywords: Corneal thickness, Anterior chamber, Corneal astigmatism, Pentacam, Myopia

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Introduction

Measuring the parameters of the anterior segment of the eye is an essential test conducted in ophthalmic clinics. These parameters include: central corneal thickness (CCT), thinnest corneal thickness (TCT), apex corneal thickness (Apex CT), corneal volume (CV), anterior chamber depth (ACD), anterior chamber volume (ACV)¹ and corneal astigmatism (CA).²

These measurements should be conducted precisely by ophthalmic practitioners for prescribing appropriate contact lenses³ and/or calculating the power of intraocular lens (IOL) during IOL implant surgery.^{4–7} For example, CCT, the distance between the anterior and posterior corneal surfaces,¹ is considered the main parameter that should be measured before refractive surgeries, especially laser assisted in situ keratomileusis.⁸ In addition, TCT, which signifies the

Received 6 October 2017; received in revised form 20 April 2018; accepted 30 April 2018; available online 14 May 2018.

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thinnest point of the cornea, should be measured when planning different types of corneal refractive surgeries using excimer lasers.⁹ CV is a new ocular parameter used in ophthalmic clinics to detect keratoconus,¹ while ACD, which is the distance between the corneal surface and the lens anterior surface, is essential for calculating of IOL power.⁸

These parameters can be measured using different instruments such as Pentacam^{1,10} and Orbscan.^{11,12} Pentacam employs a new technique that is widely used to measure the parameters of the anterior segment of the eye. Many studies^{1,5,8,10,12–16} have used Pentacam to measure the anterior segment parameters of the eye and have yielded accurate results.

Measurements of anterior segment parameters of the eye might differ among different ethnic populations. For example, the anterior segment parameters of the eye were found to differ between Indian,¹ Iranian,⁵ and Chinese populations.¹⁷ These differences among different populations could be due to genetic, environmental, or climatic factors, or differences in the instruments used for measurement.¹⁸

To our knowledge, no previous study has measured all the parameters of the anterior segment (corneal and anterior chamber parameters) among Saudi adults with different severities of myopia. Thus, the aim of this study was to measure the anterior segment parameters of the adult population with myopia in Saudi Arabia, by using Pentacam. The information about the mean anterior segment parameters of Saudi adults with myopia provided in this study will be useful to researchers and clinicians for assessing patients with corneal disease such as keratoconus and glaucoma, for screening patients scheduled to undergo refractive surgeries,¹⁸ and for prescribing and accurately measuring the power of contact lenses and IOLs.^{5,7}

Material and methods

This retrospective, cross-sectional study used data collected from patient medical records at AlHokama Eye Specialist Center in Riyadh. Both male and female Saudi patients with myopia who were aged between 18 and 39 years were included. The patients were divided into three groups according to the degree of myopia: low myopia group (<3.00 DS), moderate myopia group (3.00–6.00 DS), and high myopia group (>6.00 DS).¹⁹ This study was approved by the Human Research Ethics Committee of the College of Applied Medical Science, King Saud University, Riyadh, Saudi Arabia (no. CAMS 132-36/37), and adhered to the tenets of the Declaration of Helsinki.

The study included patients with a best-corrected visual acuity (BCVA) of 20/20 or better. Patients with ocular disease, corneal disease (dystrophies), corneal ectasia (keratoconus), glaucoma, cataract, ocular trauma, or systemic diseases such as diabetes mellitus and rheumatoid arthritis were excluded from this study. Patients with a previous history of ocular surgery, contact lens use, or pregnancy were also excluded.

Ocular and visual examination results, including those for subjective refraction with BCVA, slit-lamp biomicroscopy, and Pentacam evaluation, were obtained from the patients' medical records. The anterior segment parameters of the eye, including CCT, TCT, apex CT, CV, ACD, ACV, and CA, measured using Pentacam were collected. Pentacam is a Scheimpflug imaging device comprising two cameras. The

first camera is centrally located and is used to monitor fixation, while the second rotates 360 degrees to capture 12–50 images during a scan time of 2 seconds. It generates 138,000 true elevation points for each image.²⁰

Statistical analysis

IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. As the data were normally distributed, t-test, ANOVA, and Pearson correlation tests were used to compare the measured parameters between groups. A dependent-samples t-test was used to investigate the difference in anterior segment parameters between the right and left eyes in all the groups (low, moderate, and high myopia groups). An independent-samples t-test was performed to evaluate the difference in anterior segment parameters between male and female patients, as well as to investigate the difference in anterior segment parameters among all myopia groups. Pearson correlation test was performed to determine the association between the parameters.

Results

Participants

In total, 252 patients with myopia were included in this study. Their mean age \pm standard deviation (SD) was 28.73 \pm 6.18 years (range, 18–39 years). The low myopia group included 125 patients (70 men; 55 women), the moderate myopia group included 98 patients (45 men; 53 women) and the high myopia group included 29 patients (7 men; 22 women).

No significant sex difference ($P > 0.05$) was observed in all the myopia groups ($n = 122$ men, 48%). In addition, no significant difference ($P > 0.05$) was observed between the right and left eyes for all the anterior segment parameters. Therefore, the right eyes of the patients were used for the comparisons between groups (i.e., the severity of myopia and patient sex).

No significant difference was observed in all the anterior segment parameters between all the myopia groups ($P > 0.05$) (Table 1).

Although ACD was higher in the moderate myopia group than in the low and high myopia groups (Table 1), the values were not statistically significant ($P > 0.05$).

A comparison of the anterior segment parameters between the eyes in the low and moderate myopia groups revealed a significant difference in ACD ($P = 0.03$). The value of ACD in the low myopia group (3.27 ± 0.26) was lower than that in the moderate myopia group (3.35 ± 0.30).

The effect of sex on the anterior segment parameters of the eyes was investigated in all the myopia groups. The low myopia group showed a significant difference in ACD ($P < 0.05$), ACV ($P = 0.00$), and CA ($P = 0.03$) between men and women. The ACD and ACV values were lower in women than in men, while CA was higher in women than in men (Table 2).

However, sex did not affect these parameters in the moderate and high myopia groups, because no significant sex differences ($P > 0.05$) were observed in these parameters. Nevertheless, a significant difference in CA ($P = 0.03$) was observed in the high myopia group (Table 2).

Table 1. Anterior segment parameters for all groups (low myopia, moderate myopia, and high myopia).

Parameter (252 eyes)	Mean \pm SD			P value
	Low myopia n = 125	Moderate myopia n = 98	High myopia n = 29	
CCT (μm)	556.37 \pm 28.82	559 \pm 30.55	554.86 \pm 28.19	0.73
TCT (μm)	553.12 \pm 28.74	555.79 \pm 30.45	552.52 \pm 28.26	0.76
Apex CT (μm)	554 \pm 43.08	559.14 \pm 30.50	554.86 \pm 28.58	0.58
CV (mm^3)	61.34 \pm 3.24	61.43 \pm 3.30	60.95 \pm 3.04	0.83
ACV (mm^3)	207.46 \pm 32.44	213.44 \pm 36.41	218.76 \pm 32.55	0.17
ACD (mm)	3.27 \pm 0.26	3.35 \pm 0.30	3.33 \pm 0.23	0.07
CA (D)	0.84 \pm 0.50 D	0.91 \pm 0.51	1.06 \pm 0.60	0.12

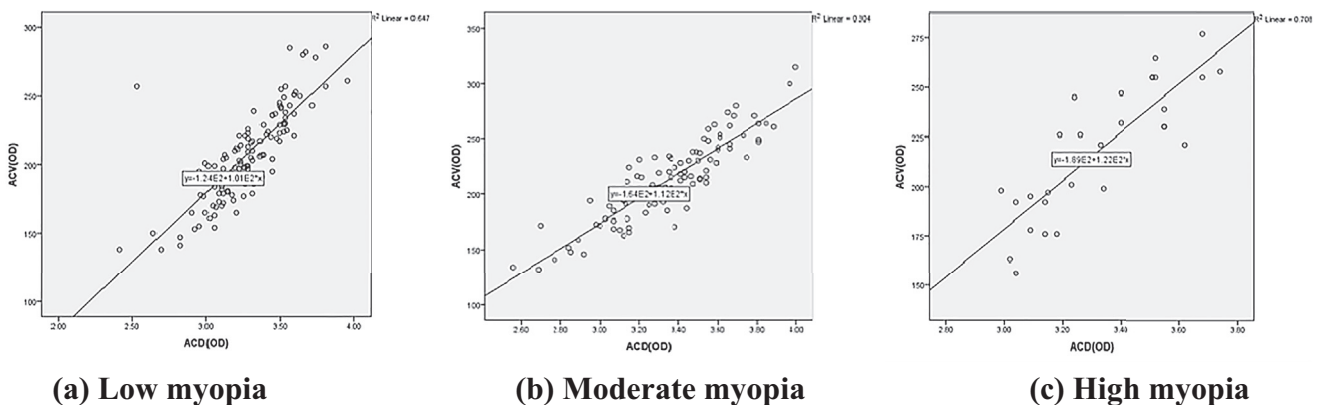
CCT, central corneal thickness; TCT, thinnest corneal thickness; Apex CT, apex corneal thickness; CV, corneal volume; ACV, anterior chamber volume; ACD, anterior chamber depth; CA, corneal astigmatism.

Table 2. Comparison of anterior segment parameters between sexes in all myopia groups.

Groups	Parameters						
	CCT (μm)	ApexCT (μm)	TCT (μm)	CV (mm^3)	ACV (mm^3)	ACD (mm)	CA (D)
<i>Low myopia</i>							
M (70)	557.40 \pm 27.57	552.21 \pm 51.10	554.19 \pm 27.37	61.66 \pm 3.19	217.03 \pm 31.63	3.35 \pm 0.25	0.76 \pm 0.46
F (55)	555.05 \pm 30.54	556.25 \pm 30.27	551.76 \pm 30.60	60.92 \pm 3.28	195.27 \pm 29.46	3.18 \pm 0.23	0.95 \pm 0.54
P value	0.65	0.61	0.64	0.21	0.00	0.00	0.03
<i>Moderate myopia</i>							
M (45)	557.89 \pm 30.43	557.96 \pm 30.50	555.07 \pm 30.54	61.17 \pm 3.59	219.51 \pm 34.05	3.39 \pm 0.30	0.88 \pm 0.54
F (53)	559.92 \pm 30.91	560.15 \pm 30.76	556.40 \pm 30.66	61.49 \pm 3.06	208.28 \pm 37.84	3.32 \pm 0.28	0.93 \pm 0.49
P value	0.74	0.73	0.83	0.64	0.13	0.25	0.58
<i>High myopia</i>							
M (7)	549.71 \pm 27.52	550.14 \pm 28.04	547.14 \pm 26.62	60.02 \pm 1.81	223.29 \pm 44.75	3.41 \pm 0.32	0.64 \pm 0.41
F (22)	556.50 \pm 28.84	556.36 \pm 29.23	554.23 \pm 29.14	3.32 \pm 61.24	218.05 \pm 29.73	3.31 \pm 0.19	1.19 \pm 0.59
P value	0.59	0.63	0.57	0.37	0.72	0.30	0.03

CCT, central corneal thickness; TCT, thinnest corneal thickness; Apex CT, apex corneal thickness; CV, corneal volume; ACV, anterior chamber volume; ACD, anterior chamber depth; CA, corneal astigmatism.

Statistically significant, $p < 0.05$.

**Fig. 1.** Correlation between ACV and ACD in the low (a), moderate (b), and high myopia (c) groups. All figures show positive correlations between ACD and ACV. ACD, anterior chamber depth; ACV, anterior chamber volume.

The association between ACV and ACD was investigated in all the myopia groups. The results showed a significant positive correlation ($r = 0.85$, $P = 0.000$) in patients with different severities of myopia. Moreover, a significant positive correlation was found in each group (Fig. 1).

Discussion

This study measured the anterior segment parameters of the eyes in three myopia groups (i.e., low, moderate, and high) by using Pentacam Scheimpflug imaging. The results of this study showed no significant difference in anterior segment parameters between the right and left eyes. Similarly,

no significant differences in these parameters were found between the right and left eyes in the Indian population analyzed in a previous study.¹

Ethnicity is a factor that could affect the measurement of anterior segment parameters of the eye, such as CCT, ACD, and CV. Table 3 shows the differences in anterior segment parameters measured in different studies conducted on different populations. Many studies found that the measurement of CCT^{1,18,21} differed among different ethnic populations. The present results showed that the CCT value of the Saudi population was higher than that of the Indian adult population¹ even though Pentacam was used in both studies. The differences in mean CCT between the present study and

Table 3. Anterior segment parameters measured among different populations.

Study	Ethnicity	Instrument	n	Age range	CCT (μm)	TCT (μm)	CV (mm^3)	ACD (mm)	ACV (mm^3)	Type of RE
Current study Al Farhan, 2014	Saudi Arabian	Pentacam	252	18–39	557.21 \pm 29.36	554.09 \pm 29.2	61.30 \pm 3.23	3.31 \pm 0.27	211.15 \pm 34	Myopia
	Saudi Arabian	Orbscan II UBM	60	19–30				3.13 \pm 0.34		Myopia
		Artemis-2 VHFUS						2.96 \pm 0.27 2.87 \pm 0.31		Hyperopia
Al Mezaine et al., 2008	Saudi Arabian	Pentacam	492	N/A	552.4 \pm 37.0 544.1 \pm 35.4					Myopia Hyperopia
Iyamua and Osuobenib, 2012 Hosseini et al., 2013	Nigerian	UP	130	20–79	548.97 \pm 34.28	542 \pm 35.19	61.6 \pm 4.17	3.14 \pm 0.33	177.77 \pm 29	N/A
	Indian	Pentacam	60	17–39	544.95 \pm 35.42					Myopia Hyperopia
Mostafa, 2014	Southern Egyptian	UP	4,368	16–60	530.06 \pm 38.03					Myopia Hyperopia Emmetropia
Yo and Ariyasu, 2005	African Americans	UP	8.9%	25–54	530 \pm 6					Myopia
	Asians		20.7%	19–61	545 \pm 3					
	Hispanics		34.5%	21–70	542 \pm 4					
	Caucasians		34.4%	20–70	542 \pm 3					
Qin et al., 2012	Asian	OCT	19	22–51				3.68 \pm 0.35		N/A
	Caucasian		14					3.87 \pm 0.35		
Feng et al., 2011	Chinese	Pentacam	100	25–65				3.14		Myopia Emmetropia
	Egyptian		75					3.18		
	German		66					3.14		
	Indian		104					3.13		
	New Zealand		56					2.91		
	Saudi Arabian		8					4.03		
	American		30					3.24		
Fontes et al., 2010	Brazilian	Pentacam	43	18–72	543.90 \pm 34.87		60.19 \pm 3.40	3.07 \pm 0.42		N/A
Emre et al., 2007	Turkish	Pentacam	112	13–64	532.2 \pm 31.9		59.4 \pm 3.5	3.1 \pm 0.3		N/A

CCT, central corneal thickness; TCT, thinnest corneal thickness; CV, corneal volume; ACD, anterior chamber depth; ACV, anterior chamber volume; RE, refractive error; UBM, ultrasound biomicroscope; VHFUS, very-high-frequency ultrasound scanner; UP, ultrasound pachymetry; N/A, not available; OCT, optical coherence tomography.

previous studies could be due to genetic, environmental, climatic, or other factors.¹⁸

A previous study investigated the variations in ACD among the adult populations of nine different countries (Brazil, China, Egypt, Germany, India, Japan, New Zealand, Saudi Arabia and United States). The results showed that ACD was shallower (2.91 mm) in the New Zealand population ($P < 0.0001$) than in the Chinese (3.14 mm), Egyptian (3.18 mm), Germany (3.14 mm), Indian (3.13 mm), Saudi Arabian (4.03 mm), and American populations (3.24 mm) ($P < 0.05$ each).¹⁵

Yo and Ariyasu (2005) compared CCT in African Americans, Asians, Hispanics, and Caucasians and found thinner CCTs in African Americans (530 μm) than in Caucasians (545 \pm 3 μm). However, no significant differences in CCT were found between the Asians (542 \pm 4 μm), Hispanics (542 \pm 3 μm), and Caucasians (545 \pm 3 μm).²² Although the present study found that ACD measurements were similar among patients with different severities of myopia, ACD could vary between different ethnic groups.²³

Few studies have measured some anterior segment parameters of the eye, such as CCT⁸ and ACD,²⁴ in the Saudi adult population. These studies measured the parameters and compared their measurements by using different instruments such as the Oculus Pentacam Scheimpflug system, DGH ultrasound pachymeter (UP),⁸ Orbscan II, ultrasound biomicroscopy (UBM), and Artemis-2 very-high-frequency ultrasound scanner (VHFUS).²⁴ A study was performed to compare CCT measured using Oculus Pentacam and DGH UP in order to determine the agreement between the two instruments in the healthy Saudi population. It found that the mean CCT was 552.4 \pm 37.0 μm and 544.1 \pm 35.4 μm with Oculus Pentacam and DGH UP, respectively. A high correlation was observed between the CCT measurements obtained using both devices ($r = 0.912$, $P < 0.001$).⁸

Another study compared ACD measured by using Orbscan II, UBM, and Artemis-2 VHFUS among 60 normal subjects aged between 19 and 30 years. It found that the mean ACD \pm SD measured was 3.13 \pm 0.34 mm for Orbscan II, 2.96 \pm 0.27 mm for UBM, and 2.87 \pm 0.31 mm for Artemis-2 VHFUS. No significant difference was observed in ACD measured using UBM and Artemis-2 VHFUS ($P > 0.05$). However, a significant difference was observed in ACD measured using Orbscan II and that measured using ($P < 0.01$) and Artemis-2 VHFUS ($P < 0.001$).²⁴

Another study used optical coherence tomography to measure and compare ACD values between Asian and Caucasian populations. The results showed that ACD was 3.68 \pm 0.35 mm in the Asian population and 3.87 \pm 0.35 mm in the Caucasian population. No significant differences were observed ($P = 0.11$) in ACD between different ethnic groups, suggesting that ethnicity did not affect the results.²⁵

The ACD values measured in a previous study on the Saudi population were higher (4.03)¹⁵ than those measured in the present study (3.31 \pm 0.27 mm). This variation could be attributed to the small sample size (8 patients) of the previous study.

Rather than measuring CCT alone, measuring CV with CCT might provide more valuable information to monitor central corneal swelling. Our results showed that CV in the Saudi population (61.30 \pm 3.23 mm) was similar to that in the Indian (61.64 \pm 4.17 mm)¹ and Brazilian populations (60.19 \pm 3.40 mm).²⁶ However, CV was slightly lower than

that in the Turkish population (59.4 \pm 3.5 mm).²⁷ These differences could be due to anatomical differences in the eye structures in different ethnic groups.²⁸

Differences in anterior segment parameters of the eye could be affected by sex. For example, CCT was thicker in men than in women in the Korean ($P = 0.001$)⁹ and southern Egyptian populations ($P = 0.04$).²⁹

However, our results did not show any significant difference in CCT between men and women. Similarly, CCT measured using UP was not found to be significantly different between men and women in the Saudi³⁰ and Chinese³¹ populations.

In the low myopia group in the present study, ACD and ACV were lower in women than in men. Similarly, ACD was lower in Latino women than in men. This indicates that women had shallower ACD than did men³² because of their shorter stature and genetic difference.³³ However, sex did not correlate with ACD in the Indian population ($P = 0.56$).³³

This study provided evidence that CCT measurements could not be affected by the severity of myopia, and this was supported by a southern Egyptian study that found CCT to be similar among emmetropes, hyperopes and myopes.²⁹ This is because the stretching mechanism in myopia, which causes thinning of the sclera, does not affect the cornea.³⁴

The severity of myopia could affect ACD measurements. Our results showed that ACD was lower in the low myopia group than in the moderate myopia group. Similarly, previous studies found a significant increase in ACD with increasing level of myopia severity in the Iranian³⁵ and Chinese populations.¹⁷ This could be because in the myopic eye, the eyeball becomes more elongated because of increasing axial length, which in turn leads to an increase in ACD and, therefore, an increase in myopia severity.¹⁷ However, another study found no significant difference in ACD between patients with different myopia severities (i.e., low, moderate, and high) and controls in a Malaysian adult population.³⁶

Using different instruments to measure the anterior segment parameters of the eye could lead to different results. A previous study on 66 patients with normal eyes (< -3 DS) aged between 5 and 89 years and 59 patients with high myopia (> -6 DS) aged between 5 and 79 years aimed to measure the anterior segment biometrics and to compare these measurements between IOLMaster and Pentacam HR. The two instruments showed a significant difference in ACD measured in the control group (0.003), with higher ACD values obtained using Pentacam than using IOLMaster; however, no significant differences were observed in the high myopia group (0.280).¹⁰ This finding could be attributed to the accommodative changes in ACD, which was higher in normal eyes than in eyes with high myopia. Thus, significant differences were observed in normal eyes.³⁷ However, the present results showed no significant difference in ACD measurements between the high and low myopia groups, which could be due to the small sample size of the high myopia group. Therefore, the present finding may not be representative of measurements in patients with high myopia.

This study has some limitations. First, the sample size of the high myopia group was small and, thus, the results related to this group could not be representative of the general population. Second, the study did not include a control group (emmetropes).

A study including subjects with high myopia, hyperopia as well as controls is recommended for future research to

compare the anterior segment parameters between these groups.

Conclusions

This study provided valuable measurements of the anterior segment parameters of the eye in a Saudi population with myopia. These parameters can assist ophthalmic practitioners in assessing certain ocular diseases such as keratoconus and glaucoma and in refractive surgery screening.

Conflict of interest

The authors declared that there is no conflict of interest.

Acknowledgement

The authors thank "Research Center of the Female Scientific and Medical Colleges", Deanship of Scientific Research and RSSU at King Saud University for their technical support.

Funding

This research project was supported by a grant from the "Research Center of the Female Scientific and Medical Colleges", Deanship of Scientific Research, King Saud University.

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