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Anterior Segment Eye Assessment of Refractive Surgery Candidates in the Southeast of Iran

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Abstract

Anterior segment eye parameters are essential factors in diagnosis, screening and management of abnormal ocular conditions. Based on the previous studies, they might differ from one race or population to another. Sistan-and-Baluchestan province, the southeast of Iran, has special weather conditions and race, plus lack of research on these diagnostic factors. Hence, the objective of the present study was to assess anterior segment parameters using pentacam in this area. 800 eyes of subjects which had been referred to the Al-Zahra eye hospital of Zahedan, the capital city of the province, for corneal refractive surgery from October 2014 to March 2015 participated in this research. 95% confidence limits for mean of central corneal thickness, anterior chamber depth and volume were (536.02, 541.20), (3.13, 3.18) and (187.63, 192.58) respectively. Multiple linear regression models showed a lower mean central corneal thickness, and maximum/minimum of keratometry, for males than females, adjusting for age and spherical equivalent. Inversely, anterior chamber depth, and volume were more in males. In order to diagnosis and treating ocular diseases which have effect on retinal thickness, precisely specification of predictive factors is highly needed.

Keywords: anterior segment eye, central corneal thickness, anterior chamber depth, anterior chamber volume, pentacam

1. Introduction

The anterior segment eye parameters such as corneal central thickness (CCT), anterior chamber depth (ACD), and anterior chamber volume (ACV) are important in assessment of ocular disorders (Hashemi, Falavarjani, Aghai, Aghdam, & Gordiz, 2013). CCT is a substantial factor for corneal health evaluation in diagnosis, screening and management of abnormal ocular conditions (Al-Mezaine et al., 2007). Rapid advances in corneal refractive surgery for correcting refractive errors, have made CCT measurements a key factor during the pre-operative ophthalmic checkups of the patients (Fahd, Cherfan, Raad, Asouad, & Awwad, 2014; Karen, Ruth, Manny, Leslie, & Katherine, 2012). CCT values also help to determine the appropriate type of surgery which result in less post-operative complications (Pallikaris, Kymionis, & Astyrakakis, 2001; Binder et al., 2003). Anterior chamber parameters (ACD and ACV) are helpful for surgeons implanting phakic intra ocular lens (IOL) during the pre-operative examinations (Kent, 2005; Jain & Grewal, 2009).

Another substantial reason behind the necessity of conducting this research is glaucoma. According to the World Health Organization (WHO) report, glaucoma is the second leading cause of blindness in the world (WHO, 2004). Early detection and first actions are effective in lessening the progress of this disease (Channa, Mir, Shah, Ali, & Ahmad, 2009). Intra ocular pressure (IOP) alone is not sufficient to diagnosis glaucoma (Doughty & Zaman, 2000). CCT values is an important factor to consider when examination of glaucoma (Whitacre, Stein, & Hassanein, 1993; Ehlers, Bramsen, & Sperling, 1975; Channa et al., 2009). It has been confirmed that CCT affects IOP results. That is, for per 70µm CCT below or above the center of normal limits, 5mmHg error occurs in the measuring of IOP (Channa et al., 2009; Ehlers et al., 1975). Therefore, it is noteworthy to measure corneal thickness precisely and reliably.

Many diagnostic imaging tools used for measuring the optical and anatomical properties of the anterior segment eye. One of the most reliable instruments to evaluate the corneal refractive features is Pentacam (Piñero, González, & Alió, 2009; Chen & Lam, 2009; Shankar, Taranath, Santhirathelagan, & Pesudovs, 2008). The pentacam imaging device has used for this purpose since 2004 (Hashemi et al., 2013).

Pentacam is the first tool to use a rotating Scheimpflug camera to take multiple images of the anterior segment to generate three-dimensional images and measurements of the eye (Jain & Grewal, 2009).

This devise is a non-invasive instrument. Several studies also have indicated a high reproducibility in pentacam (Shankar et al., 2008; Amano et al., 2006; Barkana et al., 2005; Ambrosio, Alonso, Luz, & Coca Velarde, 2006; ODonnell & Maldonado-Codina, 2005; Khoramnia, Rabsilber, & Auffarth, 2007; Lam & Chen, 2007; Buehl, Stojanac, Sacu, Drexler, & Findl, 2006; Lackner, Schmidinger, & Skorpik, 2005; Meinhardt, Stachs, Stave, Beck, & Guthoff, 2006). Thus, it is functional in screening and management of corneal diseases over time. One of the great advantages of Pentacam is that it can re-register the central points and eliminate the eye movement during the examination. It also can map any structure in the anterior segment that is not opaque (Jain & Grewal, 2009). Hence, we used pentacam to assess anterior segment eye because of its distinguishable features. In addition, following our literature reviews, it sounded no previous related studies have been done in Sistan-and-Baluchestan province.

Many studies have indicated that CCT varies from one race or population to another (La Rosa, Gross, & Orengo-Nania, 2001; Lee, Kim, Ha, Seong, & Hong, 2007; Morad., Shavon, Hefetz, & Nemet, 1998; Hashemi et al., 2013). Thus, special weather conditions and race in this region of Iran might be another strong cause of conducting the current research.

The objective of the present study was to assess anterior segment eye parameters using pentacam in a sample of the southeast of Iran. We also evaluated the relationship between central corneal thickness and other anterior segment factors after adjusting for age and gender.

2. Method

This cross-sectional study was conducted in Zahedan, capital city of Sistan-and-Baluchastan province, in the southeast of Iran. 800 eyes (400 subjects) which had been referred to the Al-Zahra eye hospital of Zahedan for corneal refractive surgery from October 2014 to March 2015 participated in this research.

We met a set of following inclusion criteria: IOP smaller than 21 mmHg, no contact lens use for two weeks in soft lenses and three weeks for hard lens before preoperative examination, no pregnancy, no history of trauma and ocular surgery, no preexisting ocular pathology, inability to fixate on the target and inability to cooperate with the protocol. Since our examination lasted a short time with no medical intervention, we defineded no special exclusion criteria accept the routines such as refusing during the examination and subjects suspicious of keratoconus. The written consent was obtained from the subjects before refractive surgery.

Demographic characteristics and clinical measures of all subjects were recorded. A detailed eye examination was performed for each individual, including visual acuity testing with Snellen E-chart under standard light condition at a distance of 4m. Objective Refraction was measured with auto-refraction (Huvitz Auto ref-keratometer, HRK-7000, Korea, http://huvitz.en.ec21.com) and static retinoscopy (Heine Beta 200 retinoscope, HEINE Optotechnic, Germany, http://www.heine.com) was done to check the results. Refractive error data were converted into spherical equivalent (SE). Myopia was defined as an SE lower than -0.50 diopters (D), hyperopia upper than +0.50 D and emmetropia was defined as an SE between these two limits. Slit lamp biomicroscopy (Haag-Streit BM 900®, Bern Switzerland) was performed in all patients. IOP measured with Goldmann applanation tonometry.

We used pentacam device (Oculus Optikgerδte GmbH, Wetzlar, Germany, http://www.oculus.de) for the anterior segment eye examinations. This device creates clinically reproducible information from the anterior corneal surface to the posterior lens surface in a single scan. It also takes images of the anterior segment by a rotating Scheimpflug camera measurement and a monochromatic slit-light source [UV-free blue light emitting diode (LED) at wavelength of 475 nm]. This rotating process supplies pictures in three dimensions. The Pentacam consists of two cameras. One is placed in the center for the purposes of detection of the orientation and size of the pupil and to control fixation. The second is mounted on rotating wheel to capture images from the anterior segment. It takes 50 images in approximately two seconds, Overall 138000 true elevation points for both the corneal front and back surfaces. Eye movements are recorded and corrected simultaneously. The measurement repeats when scanning process fails the quality specifications (Fahd et al., 2014; Jain & Grewal, 2009; Kent, 2005). All measurements were done by three same experienced technicians.

2.1 Statistical Analysis

Data cleaning and quality control performed after information gathering. This step included correcting possible errors, missing data analysis, and outlier detection. There were some illogical errors resulted from data entry step. We checked them again and corrected to the true values. One missing value appeared at the CCT record of the right eye. The missing imputed using regression method. There were also eight subjects suspicious of keratoconus. For the sake of efficiency, they were eliminated from analysis.

Apart from descriptive statistics and simple cross tabulation, a linear multiple regression model was applied to identify the predictors of outcomes of interest. Independent samples t-test and analysis of variances (ANOVA) used for comparing the mean of two and three groups respectively. Pearson's correlation coefficients (r) were calculated for bivariate relationships. 95% confidence interval of the means reported. $P<0.05$ regarded as significant. SPSS (Version 11.5, SPSS Inc., Chicago, USA) statistical package were used for analysis.

3. Results

Table 1 shows descriptive statistics by gender for variables of interest. Among the total of 800 participants, 446 (55.8%) subjects were female. In whole sample, mean CCT was 538.61 µm (standard deviation=37.36). Quartiles give more information about the distribution of variables. 50% of subjects had CCT between 519 and 562 µm. The maximum ACD of males was 6.10 which was 2.02 mm higher than maximum of females. The last column presents the comparison of variables' means by gender. The mean of age, SE, CCT, maximum keratometry (Kmax), minimum keratometry (Kmin) differed significantly between males and females.

Table 2 indicates some statistics by refractive error categories in detail. 95% confidence limits for mean of central corneal thickness, anterior chamber depth and volume were (536.02, 541.20), (3.13, 3.18) and (187.63, 192.58) respectively. The mean CCT in emmetropia, myopia, and hyperopia categories were 507.27±71.58, 540.95±31.71, and 527.98±69.80 µm, respectively. Results showed that there were significant differences among the average of CCT in three categories ($P=0.016$).

Bivariate correlations calculated before regression analysis. Correlation analysis indicated inverse relationship between CCT and age ($r=-0.35$, $P<0.001$). It means that CCT decreases with age increase. Also, the negative correlation found in gender groups (females: $r=-0.05$, $P=0.281$; males: $r=-0.48$, $P<0.001$), and different refractive errors types (myopia: $r=-0.10$, $P=0.005$; hyperopia $r=-0.76$, $P<0.001$; emmetropia: $r=-0.61$, $P<0.001$). The correlation between CCT and refractive error degree was negative and substantial ($r=-0.08$, $P=0.019$), indicating that while refractive error rises, CCT decreases. We didn't found any considerable correlation between anterior chamber depth/volume and CCT. Also, the observations presented sufficient evidence of the relationship between anterior chamber volume and refractive error degree ($P=0.028$). In addition, our study revealed a noteworthy inverse correlation between age and anterior chamber depth/volume ($P<0.001$).

Finally, we compared the genders through fitting multiple linear regression models using different responses (first column) but the same predictors of interest. Table 3 presents the complete results. The fitted model showed a lower mean of Kmax, Kmin, and CCT, for males than females, adjusting for age and spherical equivalent. Inversely, anterior chamber depth, and volume were more in males.

Table 1. Summary statistics for key variables of the sample by gender in Zahedan, southeast of Iran, 2015

	Total (n=800)						**Male (n=354)**						**Female (n=446)**						
	Mean (SD)	**min**	**Q1**	**Q2**	**Q3**	**max**	**Mean (SD)**	**min**	**Q1**	**Q2**	**Q3**	**max**	**Mean (SD)**	**min**	**Q1**	**Q2**	**Q3**	**max**	**P**
Age (year)	28.74 (10.72)	17	23	26	31	82	29.92 (14.51)	17	22	25	31	82	27.80 (6.12)	17	24	27	31	63	**0.011***
SE (Diopter)	-3.62 (2.34)	-16.25	-5.13	-3.50	-2.13	5.88	-2.97 (2.30)	-9.50	-4.50	-2.75	-1.50	4.00	-4.13 (2.24)	-16.25	-5.38	-4.13	-2.63	5.88	**< 0.001†**
CCT (µm)	538.61 (37.36)	300	519	537	562	661	535.33 (43.31)	300	515.75	539.00	564.00	644	541.21 (31.66)	396	520.00	536.00	560.25	661	**0.033***
ACD (mm)	3.16 (0.35)	1.59	2.97	3.18	3.37	6.10	3.18 (0.42)	1.59	2.99	3.23	3.40	6.10	3.14 (0.29)	2.00	2.96	3.15	3.32	4.08	**0.154**
ACV (mm^3)	190.11 (35.72)	65	167	190	216	300	190.69 (39.61)	65	168.00	194.50	219.00	274	189.64 (32.34)	107	167.00	187.50	212.25	300	**0.687**
Kmax	44.75	36.20	43.80	44.70	45.70	49.90	44.53	36.20	43.40	44.40	45.50	49.90	44.92	37.30	44.00	44.90	45.90	49.00	<

(mm)	(1.55)						(1.71)						(1.39)						**0.001†**
Kmin (mm)	43.32 (1.64)	32.20	42.40	43.30	44.30	49.30	43.02 (1.80)	32.20	42.10	43.00	44.00	49.30	43.55 (1.46)	35.70	42.70	43.50	44.50	48.60	< **0.001†**

Note. SE: spherical equivalent; CCT: central corneal thickness; ACD: anterior chamber depth; ACV: anterior chamber volume; Kmax: maximum keratometry; Kmin: minimum keratometry; P: significance value; SD: standard deviation; Q1: first quartile; Q2: median; Q3: third quartile; * P<0.05; † P<0.01

Table 2. Summary statistics for key variables of the sample by spherical equivalent groups in Zahedan, southeast of Iran, 2015

	Emmetropia (n=49)			**Myopia (n=734)**			**Hyperopia (n=17)**			
	Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**Mean**	**SD**	**CI**	**P**
Age (year)	43.51	22.58	(37.02,50.00)	27.37	7.61	(26.82,27.93)	44.88	22.98	(33.07,56.70)	< **0.001†**
SE (Diopter)	-0.14	0.44	(-0.27,-0.01)	-4.00	1.99	(-4.14,-3.86)	2.86	1.58	(2.05,3.67)	< **0.001†**
CCT (µm)	507.27	71.58	(486.71,527.83)	540.95	31.71	(538.65,543.24)	527.98	69.80	(492.09,563.87)	**0.016***
ACD (mm)	3.00	0.58	(2.83,3.16)	3.18	0.32	(3.15,3.20)	2.79	0.42	(2.58,3.01)	< **0.001†**
ACV (mm^3)	165.88	46.82	(152.43,179.32)	192.71	33.83	(190.25,195.16)	147.65	26.03	(134.26,161.03)	< **0.001†**
Kmax (mm)	44.52	1.99	(43.95,45.10)	44.77	1.50	(44.66,44.88)	44.35	2.08	(43.28,45.42)	**0.313**
Kmin (mm)	42.09	2.29	(41.43,42.74)	43.41	1.52	(43.30,43.52)	42.57	2.54	(41.27,43.88)	< **0.001†**

Note. SE: spherical equivalent; CCT: central corneal thickness; ACD: anterior chamber depth; ACV: anterior chamber volume; Kmax: maximum keratometry; Kmin: minimum keratometry; SD: Standard Deviation; CI: Confidence Interval; * P<0.05; † P<0.01

Table 3. Results of multiple linear regression model for the sample of Zahedan, southeast of Iran, 2015

Dependent Variable	**Gender (Ref=Female)**		**Age**		**Spherical Equivalent**	
	B	**P**	**B**	**P**	**B**	**P**
CCT (µm)	-2.469	0.337	-1.176	< 0.001†	-0.798	0.154
ACD (mm)	0.058	0.022*	-0.006	< 0.001†	-0.007	0.226
ACV (mm^3)	4.549	0.065	-1.115	< 0.001†	-0.984	0.067
Kmax (mm)	-0.347	< 0.01†	0.019	< 0.001†	-0.072	< 0.01†
Kmin (mm)	-0.426	< 0.001†	-0.007	0.183	-0.070	< 0.01†

Note. CCT: central corneal thickness; ACD: anterior chamber depth; ACV: anterior chamber volume; Kmax: maximum keratometry; Kmin: minimum keratometry; * P<0.05; † P<0.01

4. Discussion

The average CCT differs in various populations and races (La Rosa et al., 2001; Lee et al., 2007). This could be due to the differences in age, gender, genetic factors, weather conditions, diurnal change, diseases (e.g. diabetics), refractive error degree, nutrition intake, device type used for corneal thickness (contact and non-contact) measurement in various studies (Hoffmann et al., 2013; Channa et al., 2009). In the current study, the mean CCT calculated 538.61±37.36 µm. This average was 550.5 µm in Mashhad, northeast of Iran (Yekta et al., 2014), 532 µm in Japanese people (Aghaian, Choe, Lin, & Stamper, 2004), 531±33 in Pakistan (Channa et al., 2009), 537±34 µm in India (Thomas, Korah, & Muliyil, 2000) and 550±33.1 µm in Nigeria (E. Iyamu, J. E. Iyamu, & Amadasun, 2013). As you see, the mean CCT in our study is slightly the same line with northeast of Iran, Pakistan, and India researches. It is evidence that race and weather conditions might influence CCT.

It is believed that subjects with CCT equals 555 µm or less have more risk of glaucoma progress (esp. POAG) than individuals with CCT more than 588 µm (Gordon et al., 2002; Channa et al., 2009). Based on our results, it seems southeastern residents of Iran have more chance to suffer from glaucoma and its progress. Thus, early routine checkups (e.g. IOP and CCT examination) for diagnosis glaucoma are suggested in youths.

Our findings showed significant difference of mean CCT between genders. This might be due to hormonal changes in female individuals (Siu & Herse, 1993; Lekskul et al., 2005). Therefore, it should be considered in refractive error surgeries.

An inverse relationship between CCT and age ($P<0.001$) revealed in our research. This correlation also detected in genders (males: $P<0.001$; females: $P=0.05$) and different refractive error types (myopia: $P=0.005$, emmetropia: $P<0.001$, hyperopia: $P=0.001$) separately. Linear regression model indicated by the end of each decade, CCT reduces 11.76µm. This negative relationship supported with Iyamu et al. (2013), Lekskul et al. (2005) studies, which reported 6 and 0.28 µm reduction of CCT per each decade increase of age, respectively.

Our results revealed a significant negative correlation between CCT and refractive error degree ($P=0.019$) which is in line with Aghaian et al. (2004) in Japan. Chen & Lam. (2009) and Tong et al. (2004) found no evidence confirming the relationship. The possible reason could be age, race, and measurement technics differences in studies.

It is worth noting that although CCT average is more in hyperopia than other categories, the conclusion regarding the CCT average among three refractive error categories is not clear. Vague and inverse results of different studies are challenging. Thus, separate and precise research design, especially with multistage sampling framework would be helpful.

Our findings indicated the mean anterior chamber depth and volume in myopic individuals is more than other two types, which supported by Rabsilber et al. (2006) and Murata et al. (2007). As a result, it seems hyperopia and emmetropia individuals are high risk for primary angle-closure glaucoma (Hashemi et al., 2013). Neither anterior chamber depth nor anterior chamber volume correlated with CCT, which is the same as Chen findings (2009). Although, there were no significant correlation between gender and anterior chamber volume, we found an inverse relation between age and anterior chamber depth (and volume), which confirmed by Yekta et al. (2014).

We observed no substantial relationship between Kmax (Kmin) and CCT. Otherwise, the corneal curvature and spherical equivalence indicated significant correlation. These findings are as same as Yekta et al. (2014), Hashemi et al. (2013).

The present study agrees with the majority of researches (Carney, Mainstone, & Henderson, 1997; Budak, Khater, Friedman, Holladay, & Koch, 1999; Hashemi et al., 2013) that on average corneal power in myopia is about 1.0 D greater than in hyperopia.

Linear regression models indicated a lower CCT and Kmax (Kmin) in men after adjusting for equivalence sphere and age. The possible reason could be raging hormones in women (Siu & Herse, 1993). Also anterior chamber depth and volume was more in men than women, which supported by results of Yekta (2014).

This study has some **limitations**. 1) Although the present study conducted at the biggest refractive error surgery center between two centers of Zahedan, using the second center might enhance the coverage. Furthermore, at the design stage, the residency of referred subjects to the center indicated coverage of whole province. 2) In spite of selection a large sample size, there were fewer subjects into the hyperopia and emmetropia strata. That was predictable, since participants referred to the center for refractive error surgery. 3) We did not record socioeconomic status of participants which might affect the results. In general, this province known as an unprivileged region.

This study had several **strengths**. First, the assessment of corneal refractive parameters allows examiners to have more control over refractive error progress. CCT considered as a major factor in keratoconus diagnosis (Falavarjani et al., 2010; Fahd et al., 2014), precise IOP measurement, and early detection of open-angle glaucoma (Channa et al., 2009). Anterior chamber parameters could be helpful to IOL power calculation of cataract patients (Shankar et al., 2007). Which is why those cornea refractive parameters as the most powerful eye's refractive part have given special attention in our study? Second, to the best of our knowledge, the present research is the first study for evaluation of corneal refractive parameters in a wide range of refractive errors using pentacam device, in the southeast of Iran. Third, based on national reports, our study region has unique socioeconomic properties (Statistical Center of Iran (SCI), 2011) which could make our findings different from others. Thus, it was of high interest reporting normal limits of corneal refractive parameters for the people living in this region of the country. Normal ranges could alleviate diagnosis and treatment of abnormal eyes. They also might reduce corneal ectasia risk after refractive error surgeries (Randleman, Russel, Ward, Thompson, & Stulting, 2003; Binder et al., 2005). Fourth, we used pentacam, a high precision device, which generates valid and reproducible information of anterior segment parameters.

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Competing Interests Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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