

White-to-white corneal diameter: normal values in healthy Iranian population obtained with the Orbscan II

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Abstract

• **AIM:** To determine the normative values of white-to-white corneal diameter with Orbscan II Topography System and to compare right and left eyes data in the normal young population.

• **METHODS:** A total of 1001 healthy participants aged 18–45y participated in this observational cross-sectional study. The study population consisted of 616 female and 385 male subjects. The corneal diameter was measured with the Orbscan II. The differences between genders, between right and left eyes and age-related changes were evaluated. Statistical analyses were performed using Student's *t*-test.

• **RESULTS:** The average white-to-white distance in our study population was recorded as 11.65 ±0.36 mm (median: 11.60 mm, mode: 11.70 mm, minimum: 10.50 mm and maximum: 13.60 mm). The white-to-white distance was 11.60±0.35 mm in males and 11.71±0.36 mm in females which was statistically different between genders (*P*<0.01). However, white-to-white distance was not statistically different between right and left eyes. In addition, this parameter decreased with increasing age. Considering 95% confidence interval, corneal diameter less than 10.93 mm and greater than 12.34 mm would be considered as microcornea and megalocornea, respectively based on this study population, using the Orbscan II topography.

• **CONCLUSION:** Detailed description and analysis of corneal diameter with Orbscan demonstrate that the obtained average value of horizontal white-to-white is higher in male than female and decreases slightly with increasing age. Our data also suggests the cut off values for definition of microcornea and megalocornea, which can be employed with this population.

• **KEYWORDS:** white-to-white; corneal diameter; Orbscan II; normal population

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INTRODUCTION

The white-to-white (WTW) corneal diameter is the horizontal distance between the borders of the corneal limbus. The measurement of WTW has been used in management and diagnosis of several ocular conditions such as congenital glaucoma, micro- and megalocornea^[1]. In addition, WTW is required for haptic size calculation in angle-supported intraocular lenses (IOLs), anterior chamber IOLs and a phakic IOL implantation, the size of a capsular tension ring (CTR) and IOL calculation in cataract surgery (third generation formulas)^[2-4]. It has been also shown that the WTW diameter is correlated with the lens diameter^[5].

There are several techniques for measurement of WTW diameter, which can be divided into two main groups: manual (*i.e.* calipers and scales in slit-lamp) and automated devices (*i.e.* ultrasonic biomicroscopy, IOLMaster, magnetic resonance imaging (MRI), Orbscan II and optical coherence tomography (OCT)^[6-9]. Between aforementioned methods, caliper and Orbscan II are the most commonly used techniques.

The aim of the current study was to determine the normal horizontal WTW values in a normal Iranian population. In addition, the differences between genders, between right and left eyes and age-related changes were investigated.

SUBJECTS AND METHODS

One thousand and one healthy volunteers (age range: 18–45y; 616 females, 385 males) were enrolled in this observational cross-sectional study. A detailed ocular history was taken from each subject and the following exclusion

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criteria were adopted: a history of any deviation or strabismus, previous ocular or/and refractive surgeries, contact lens wear, corneal anomalies, any ophthalmic or systemic drug consumption.

To ensure that all volunteers met the inclusion/exclusion criteria, complete ophthalmologic and orthoptic examination were performed prior to the experiment, including slit-lamp biomicroscopy and dilated pupil funduscopy. Horizontal WTW corneal diameter was measured in all participants with the Orbscan II (Bausch & Lomb, Technolas, NY, USA). The Orbscan is a non-contact scanning-slit topography system that employs a slit beam to produce multiple slit images of the anterior segment. It uses digital image processing for WTW distance measurements. A digital grey-scale anterior segment image is reconstructed from 140 slit images. The computer automatically detects the corneal limbus by comparing the grey-scale steps and calculates the corneal diameter. This technique automatically rejects the low quality images and the maximum resolution of the Orbscan is 2 mm within the central corneal surface.

In the current study, all WTW measurements were performed by the same examiner and three valid repeated measurements were made for each eye and then averaged. For accurate measurement, all participants were asked to keep their head position stable (straight ahead) and the examiner tried to make adjustment and have a focused sharp image of each eye, using the joystick of the instrument.

Informed consent was obtained from each participant after the nature of the experimental procedures had been explained. The study was followed the tenets of the Declaration of Helsinki and approved by the Ethics Committee of Mashhad University of Medical Sciences.

Statistical Analysis Statistical analyses were performed using SPSS Windows version 16 (SPSS, Inc., Chicago, IL, USA). The variables were expressed as mean \pm SD and the Student's *t*-test was used to compare differences. The Pearson correlation coefficient was calculated and linear regression analysis was applied to the data to investigate the relationship between age and the corneal diameter. Furthermore, age group classification was performed by dividing ages into five age groups (Table 1). The level of significance was set at *P* value of 0.05 or less.

RESULTS

The present study comprised 1001 individuals (2002 eyes, age range: 18-45y). Of all participants recruited, 616 (61.54%) cases were female and 385 (38.46%) were male. The mean \pm SD age was 29.07 \pm 5.86y (male: 28.86 \pm 5.53y and female: 29.01 \pm 3.77y). The average WTW distance in the study population was 11.65 \pm 0.36 mm. In addition, median, mode, minimum and maximum of WTW from all participants were 11.60 mm, 11.70 mm, 10.50 mm and 13.60 mm, respectively.

Table 1 The comparison of mean WTW corneal diameter between right and left eyes in different age groups and total values

Gender	Age (a)	Right eye		Left eye	
		Mean \pm SD	Range	Mean \pm SD	Range
Male	Under 20	11.63 \pm 0.34	11.00-12.10	11.66 \pm 0.33	11.10-12.20
	20-25	11.65 \pm 0.39	10.50-13.20	11.63 \pm 0.37	10.60-13.60
	25-30	11.65 \pm 0.36	10.70-12.60	11.63 \pm 0.35	10.70-12.60
	30-35	11.59 \pm 0.33	10.70-13.00	11.57 \pm 0.32	10.70-12.80
	More than 35	11.48 \pm 0.30	10.60-12.20	11.48 \pm 0.28	10.70-12.10
Female	Under 20	11.78 \pm 0.35	11.00-12.20	11.84 \pm 0.35	11.10-12.30
	20-25	11.76 \pm 0.32	10.80-12.60	11.77 \pm 0.32	10.40-12.50
	25-30	11.75 \pm 0.42	10.80-13.30	11.69 \pm 0.37	10.80-12.90
	30-35	11.72 \pm 0.31	11.10-12.40	11.70 \pm 0.31	11.00-12.40
	More than 35	11.66 \pm 0.42	10.90-13.10	11.63 \pm 0.38	10.90-12.50
Total	Under 20	11.73 \pm 0.34	11.00-12.20	11.77 \pm 0.35	11.10-12.30
	20-25	11.69 \pm 0.37	10.50-13.20	11.68 \pm 0.36	10.60-13.60
	25-30	11.69 \pm 0.39	10.70-13.30	11.66 \pm 0.36	10.70-12.90
	30-35	11.64 \pm 0.33	10.70-13.00	11.62 \pm 0.32	10.70-12.80
All	More than 35	11.56 \pm 0.37	10.60-13.10	11.54 \pm 0.33	10.70-12.50
	Males	11.61 \pm 0.036	11.50-13.20	11.60 \pm 0.35	10.60-13.60
	Females	11.73 \pm 0.38	10.80-13.30	11.71 \pm 0.36	10.80-12.90
	All	11.66 \pm 0.37	10.50-13.30	11.66 \pm 0.31	10.60-13.60

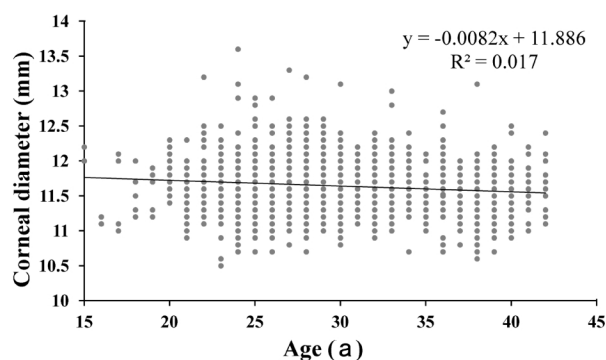


Figure 1 Correlation between white-to-white diameter and age.

The mean \pm SD of WTW distance was 11.60 \pm 0.35 mm in males and 11.71 \pm 0.36 mm in females. Difference in gender was statistically significant different in the Student's *t*-test (*P* < 0.01).

Considering age in our study, we classified all participants into 5 age groups (Table 1). Pearson's correlations showed significant correlation between the corneal diameter and age (*P* < 0.001, *r* = 0.13). Horizontal WTW distance measured with the Orbscan II decreased with increasing age (Figure 1). Finally, we compared the WTW distance between right and left eyes in this study (Table 1). The mean WTW distance in right eye was 11.66 \pm 0.37 mm in comparison with 11.66 \pm 0.31 mm in the left eye. This difference did not reach statistical significance (*P* = 0.26).

DISCUSSION

In the current study, we measured the horizontal WTW corneal diameter in a large sample of normal individuals (2002 eyes) to evaluate the distribution and normal values of this biometric parameter. The WTW corneal diameter is important parameter in phakic IOL implantation in angle-

supported IOLs^[6]. Therefore, precise measurements of the WTW prevent several complications resulting from over-calculation or under-calculation of the size of anterior chamber IOLs. In addition, it can be used as an index for monitoring congenital glaucoma^[1]. Understanding this normal value is also mandatory in diagnosis and management of several ocular disorders.

There are several methods for WTW measurement, including manual devices which are more operator dependent and less accurate, and automated instruments such as IOLMaster, OCT and Orbscan. We have used Orbscan II (Bausch & Lomb, Technolas, NY, USA) for this purpose, as it has been previously shown that this instrument produces accurate and reproducible WTW results, although WTW values are greater with the IOLMaster biometry technique^[8-12]. It should be noted that in the current study, all measurements have been made by the same operator to minimize the systematic error.

The average WTW distance in our study population was reported to be 11.65 ± 0.36 mm. Considering previous investigations, in one study by Khng *et al*^[13], the horizontal corneal diameter-measured in cadavers by calipers-was found to be 11.46 mm which was 0.8 mm more than its vertical diameter^[13]. In another study, Kohonen and colleagues demonstrated that the mean \pm SD of WTW measured with Orbscan II was 11.84 ± 0.40 mm^[12]. In addition, the average of WTW, measured with the Orbscan II, was reported as 11.78 ± 0.43 mm by Baumeister *et al*^[6], 11.67 ± 0.29 mm by Salouti *et al*^[7], 11.65 ± 0.32 mm by Dinc *et al*^[11], 11.60 ± 0.37 mm by Srivannaboon *et al*^[14], and 11.72 ± 0.42 mm in Ruffer's *et al*^[10] study. Verkataraman and colleagues noted that the mean WTW was 11.74 ± 0.32 mm, with the Orbscan, and slightly less than values obtained from Eyemetrics software-based measurement (11.92 ± 0.32 mm)^[3]. In Tehran eye study, the mean WTW by Orbscan II, reported by Hashemi *et al*^[15], was 11.68 mm. On the other hand, Tananuvat and colleagues measured the mean WTW as 11.61 ± 0.36 mm, with the same technique^[16]. The mean horizontal corneal diameter measured by Orbscan II in our study population was very similar to aforementioned studies. It can be implied that the WTW values do not differ significantly in various ethnic groups. In addition, there was a significant difference in the mean WTW between genders in our study population which is a similar finding in comparison with previous reports^[15,17]. Furthermore, there was no significant difference between right and left eyes; contralateral eye comparison was not found in previous literature search. According to our study results with 95% confidence interval, corneal diameter less than 10.93 mm and greater than 12.34 mm, examined with the Orbscan II, would be considered as microcornea and megalocornea, respectively. Although, our proposed definitions of micro-

and megalocornea are in good agreement with the range suggested by previous studies, part of the difference may attribute to the various measurement techniques^[10]. It should be noted that, these definitions are of great importance in the diagnosis of several ocular conditions such as macular dystrophies and keratoconus^[18].

In our study, horizontal WTW distance measured with the Orbscan II decreased with increasing age. Our results are in agreement with some of the previous investigations, although a range of previous investigations could not found a relationship between WTW distance and age^[10,15,19,20]. It should be noted that we have limited our age range up to 45y to decrease the chance of inaccurate Orbscan II readings which may caused by arcus senilis. This age-related decrease in the cornea diameter may be due to changes in the corneal architecture and biochemical properties^[21]. In addition, this may be explained by the smaller average height of the normal population with increasing age. Specific facial measurements such as inter outer orbital distance and interpupillary distance have been shown to decrease with age, which may have also an effect on corneal diameter^[22,23]. Further evolution is required to investigate the exact reason of age-related changes of the corneal diameter.

There is an important limitation in this study which needs to be addressed. Unfortunately, we did not record the refractive error data in this study. However, previous studies have reported conflicting results regarding the relationship between the refractive error and corneal diameter^[9,24]. Further investigations are required to investigate the relationship between the refraction, axial length and corneal diameter in an Iranian population.

Finally, because of our large number of participants and our exclusion criteria based on a wide range of ophthalmic diseases, our results can be employed as a reliable value for the evaluation of normal corneal diameter, with this population. In addition, we have defined the cutoff values of 10.93 and 12.34 mm for micro- and megalocornea, measured with the Orbscan II.

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