Iran Red Crescent Med J. 2015 January; 17(1): e17873. DOI: 10.5812/ircmj.17873

Published online 2014 December 25. **Research Article**

Angle Kappa Measurements: Normal Values in Healthy Iranian Population Obtained With the Orbscan II

Hamid Gharaee [1]; Masoud Shafiee [2]; Rafie Hoseini [3]; Mojtaba Abrishami [2,4,*]; Yalda Abrishami [4]; Mostafa Abrishami [2]

[1]Cornea Research Center, Department of Ophthalmology, Mashhad University of Medical Sciences, Mashhad, IR Iran
[2]Eye Research Center, Department of Ophthalmology, Mashhad University of Medical Sciences, Mashhad, IR Iran
[3]Al-Zahra Eye Center, Zahedan University of Medical Sciences, Zahedan, IR Iran
[4]Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, IR Iran

*Corresponding Author: Mojtaba Abrishami, Eye Research Center, Farabi Eye Hospital, Tehran University of Medical Sciences, P.O.Box: 1336616351, Tehran, IR Iran. Tel: +98-2155400003, E-mail: mojtaba_abrishami@yahoo.com

Received: January 27, 2014; **Revised:** May 5, 2014; **Accepted:** May 31, 2014

Background: The angle kappa is important in proper centration of corneal ablation in keratorefractive surgery. Orbscan II device is widely used preoperatively in photoablation surgeries and can be used to measure the angle kappa.
Objectives: This study aimed to determine the mean angle kappa and its intercepts in healthy young Iranian adults.
Patients and Methods: In this cross-sectional study, orthotropic patients (age range, 18-35 years) who were referred to the Khatam Eye Hospital (Mashhad, Iran) were included. Exclusion criteria were as follows: history of any eye deviation or strabismus with or without orthoptic or surgical treatment; any intraocular, corneal, or keratorefractive surgery; contact lens use; any corneal anomaly; any ophthalmic or systemic drug consumption; and hyperopic spherical refraction > + 3.00 diopters (D), spherical refraction > -5.00 D, or cylindrical refraction > 2.00 D. All of the parameters were measured by the same operator through an Orbscan II device.
Results: A total of 977 healthy participants who aged 18 to 45 years were included consecutively. The study population consisted of 614 females and 363 males. The average angle kappa was 5.00° ± 1.36° at 240.21° ± 97.17° in males and 4.97° ± 1.30° at 244.22° ± 94.39° in females (P = 0.63). The average horizontal (x-axis) angle kappa was -0.02° ± 0.49°, with a mean of -0.02° ± 0.50° in males and -0.02° ± 0.49° in females (P = 0.93). The average vertical (y-axis) angle kappa was -0.09° ± 0.32°, with a mean of -0.09° ± 0.33° in males and -0.09° ± 0.32° in females (P = 0.74).
Conclusions: By using the normal angle kappa determined in this study, pseudodeviations can be identified more precisely in those who might undergo keratorefractive surgery.

Keywords: Normal Value; Population; Refractive Surgical Procedures

1. Background

Proper centration of corneal ablation is an essential goal in keratorefractive surgery. Decentration can lead to undesired complications such as decreased visual acuity, astigmatism, glare, and monocular diplopia, which would overcome the purposes of the surgery (1, 2). To minimize the risk of decentration, careful preoperative assessment must be done to measure the corneal center. Measurement of the angle kappa between the visual and papillary axes plays an important role in this process. Positive and negative angle kappa values correspond to the reflection of corneal light nasally and temporally, respectively (3). A positive angle kappa $\leq 5^\circ$ is physiologic, whereas values $> 5^\circ$ can lead to pseudostrabismus (4). Hyperopic eyes show large angle kappa in comparison to myopic eyes; therefore, a small decentration in these eyes can lead to severe complications. The angle kappa is commonly measured in cases of strabismus and plays an important role in the preoperative assessment. One method that can be used to measure the angle kappa is the Orbscan II device, which is widely used preoperatively in photoablation surgeries.

2. Objectives

The purpose of this study was to determine the mean angle kappa and its intercepts among normal young adults, who comprise the target population for keratorefractive surgery.

3. Patients and Methods

3.1. Patients

In a non-random simple sampling, a total of 977 cases among the patients, who were referred to the Khatam Eye Center (a specialized eye hospital in Mashhad, northeast of Iran) from March 2011 to February 2012 and claimed to be healthy, were enrolled in this observational cross-sectional study. All included cases were healthy, orthotropic

individuals who aged 18 to 35 years. Exclusion criteria were as follows: history of any deviation or strabismus, with or without orthoptic or surgical treatment; any intraocular, corneal, or keratorefractive surgery; using contact lens; any corneal anomaly; any ophthalmic or systemic drug consumption; and hyperopic spherical refraction > + 3.00 diopters (D), myopic spherical refraction < -5.00 D, or cylindrical refraction > 2.00 D. These criteria were defined to exclude cases with refractive errors that tend to induce pathologies. This study was registered with the Ethics Committee of Mashhad University of Medical Sciences, and clearance was obtained. All of the cases provided written informed consent before participating in the study. Considered ethical codes for this study were 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 17, and 20.

3.2. Examinations

Complete ophthalmologic and orthoptic examinations were performed, including slit lamp biomicroscopy and dilated pupil fundoscopy. The Orbscan II device (Bausch and Lomb, Technolas, NY) was used to measure the angle kappa in all participates. All measurements were done by the same operator. One acquisition was done per eye, unless an unacceptable result was obtained that would mandate repetition. For measurements with the Orbscan II device, all cases were educated for correct head position and straight gaze. The examiner used the joystick of the device to make adjustments such that the final result would be a sharply focused image of the eye. Then all the data were gathered in the predesignated questionnaire.

3.3. Statistical Analysis

Statistical testing was performed with SPSS 16.0 (SPSS, Inc., Chicago, IL). Shapiro-Wilk test was used to test the normal distribution of the data. Descriptive analysis was used to determine the mean values and the Student's t-test was used to compare differences. The variables are expressed as mean ± standard deviation (SD). Differences with a $P \leq 0.05$ were considered statistically significant.

4. Results

A total of 977 healthy young adults, aged 18 to 45 years, participated in this observational cross-sectional study. The study population consisted of 614 females and 363 males (P < 0.001). Table 1 shows the classification of cases according to five age groups. Figure 1 shows the distribution of angle kappa in degrees in different ages according to sex. The mean angle kappa was 4.97° ± 1.38°, with a mean of 5.00° ± 1.36° in males and 4.96° ± 1.30° in females (P = 0.63). The means of angle kappa in the right and left eyes were 5.16° ± 1.44° and 4.78° ± 1.31°, respectively (P = 0.007). The means of horizontal (x-axis) angle kappa were -0.44° ± 0.28° and 0.37° ± 0.25° in the right and left eyes, respectively (P = 0.012). The means of vertical (y-axis) angle kappa were -0.11° ± 0.31° and -0.07° ± 0.34° in the right and left eyes, respectively (P = 0.01). The mean of horizontal angle kappa was -0.02° ± 0.49°, with a mean of -0.02° ± 0.50° in males and -0.02° ± 0.49° in females (P = 0.93). The mean vertical angle kappa was -0.09° ± 0.32°, with a mean of -0.09° ± 0.33° in males and -0.09° ± 0.32° in females (P = 0.74) (Table 2). We measured the variables in the right and left eyes separately (Tables 3 and 4).

Table 1. The Distribution of Angle Kappa and Age [a]

Variables	Kappa of Arc, Degrees	Kappa Intercept, Degree
Males' Age, y		
< 20	5.32 ± 2.09	221.59 ± 106.64
20-25	5.06 ± 1.26	234.79 ± 99.93
25-30	4.95 ± 1.31	244.50 ± 94.96
30-35	5.01 ± 1.36	248.21 ± 93.80
> 35	4.76 ± 1.30	255.04 ± 85.65
Females' Age, y		
< 20	5.66 ± 1.32	230.71 ± 109.18
20-25	4.94 ± 1.45	231.61 ± 101.70
25-30	4.91 ± 1.66	234.55 ± 98.52
30-35	5.12 ± 1.37	244.70 ± 89.84
> 35	4.77 ± 1.40	244.48 ± 91.66
All Participants' Age, y		
< 20	5.53 ± 1.65	227.15 ± 107.41
20-25	5.02 ± 1.33	233.70 ± 100.46
25-30	4.93 ± 1.45	240.64 ± 96.39
30-35	5.05 ± 1.36	248.76 ± 91.78
> 35	4.76 ± 1.29	250.44 ± 88.35
Males	5.00 ± 1.36	240.21 ± 97.17
Females	4.97 ± 1.30	244.22 ± 94.39
All	4.96 ± 1.38	241.28 ± 96.02

[a] Data are presented in mean ± SD.

Table 2. Horizontal and Vertical Angle Kappa [a]

Variables	Horizontal, mm	Vertical, mm
Males' Age, y		
< 20	-0.02 ± 0.54	-0.15 ± 0.40
20-25	-0.03 ± 0.50	-0.13 ± 0.37
25-30	-0.02 ± 0.48	-0.07 ± 0.30
30-35	-0.03 ± 0.49	-0.09 ± 0.30
> 35	-0.01 ± 0.49	-0.30 ± 0.27
Females' Age, y		
< 20	-0.01 ± 0.63	-0.20 ± 0.35
20-25	-0.04 ± 0.51	-0.11 ± 0.32
25-30	-0.02 ± 0.49	-0.12 ± 0.34
30-35	-0.03 ± 0.50	-0.06 ± 0.29
> 35	-0.02 ± 0.48	-0.01 ± 0.32
All Participants' Age, y		
< 20	-0.01 ± 0.60	-0.18 ± 0.37
20-25	-0.03 ± 0.50	-0.12 ± 0.35
25-30	-0.02 ± 0.48	-0.09 ± 0.32
30-35	-0.03 ± 0.50	-0.08 ± 0.30
> 35	-0.01 ± 0.47	-0.02 ± 0.29
Males	-0.02 ± 0.49	-0.09 ± 0.32
Females	-0.02 ± 0.50	-0.09 ± 0.33
All	-0.02 ± 0.49	-0.09 ± 0.32

[a] Data are presented in mean ± SD.

Table 3. The Measurements in Right Eye [a,b]

Variables	OD			
	Kappa	Kappa Angle	Kappa X	Kappa Y
Males' Age, y				
< 20	5.58 ± 2.01	191.07 ± 18.00	-0.47 ± 0.25	-0.12 ± 0.38
20-25	5.23 ± 1.23	193.42 ± 32.81	-0.44 ± 0.28	-0.14 ± 0.32
25-30	5.13 ± 1.37	191.72 ± 27.37	-0.43 ± 0.25	-0.08 ± 0.31
30-35	5.14 ± 1.38	192.64 ± 14.53	-0.43 ± 0.32	-0.13 ± 0.29
> 35	4.89 ± 1.25	194.21 ± 23.82	-0.41 ± 0.26	-0.06 ± 0.25
Females' Age, y				
< 20	5.54 ± 1.23	188.88 ± 14.10	-0.55 ± 0.29	-0.13 ± 0.21
20-25	5.17 ± 1.43	192.22 ± 18.71	-0.47 ± 0.27	-0.13 ± 0.29
25-30	5.14 ± 1.93	193.85 ± 23.08	-0.42 ± 0.31	-0.14 ± 0.33
30-35	5.38 ± 1.39	191.55 ± 15.88	-0.47 ± 0.23	-0.08 ± 0.31
> 35	4.93 ± 1.36	192.29 ± 28.48	-0.42 ± 0.32	-0.04 ± 0.34
All Participants' Age, y				
< 20	5.69 ± 1.55	187.88 ± 15.42	-0.53 ± 0.27	-0.16 ± 0.28
20-25	5.14 ± 1.30	193.14 ± 28.76	-0.45 ± 0.28	-0.13 ± 0.31
25-30	5.14 ± 1.61	192.56 ± 27.24	-0.42 ± 0.27	-0.09 ± 0.32
30-35	5.26 ± 1.38	192.37 ± 25.89	-0.44 ± 0.29	-0.11 ± 0.30
> 35	4.90 ± 1.30	193.30 ± 25.89	-0.41 ± 0.28	-0.04 ± 0.29
Males	5.15 ± 1.33	192.27 ± 26.23	-0.43 ± 0.27	-0.10 ± 0.30
Females	5.18 ± 1.66	192.52 ± 23.42	-0.45 ± 0.29	-0.40 ± 0.31
All	5.16 ± 1.44	192.67 ± 25.45	-0.44 ± 0.28	-0.11 ± 0.31

[a] Data are presented in mean ± SD.
[b] Abbreviation: OD, Right Eye.

Table 4. The Measurements in Left Eye [a, b]

Variables	OS			
	Kappa	Kappa Angle	Kappa X	Kappa Y
Males' Age, y				
< 20	5.06 ± 2.23	251.95 ± 146.39	0.43 ± 0.35	-0.13 ± 0.44
20-25	4.88 ± 1.26	276.60 ± 124.69	0.38 ± 0.28	-0.13 ± 0.41
25-30	4.77 ± 1.21	297.02 ± 108.31	0.40 ± 0.27	-0.07 ± 0.30
30-35	4.83 ± 1.31	303.02 ± 104.70	0.37 ± 0.24	-0.06 ± 0.31
> 35	4.63 ± 1.14	315.22 ± 82.23	0.38 ± 0.22	-0.01 ± 0.28
Females' Age, y				
< 20	5.49 ± 1.42	277.55 ± 143.56	0.35 ± 0.33	-0.27 ± 0.45
20-25	4.71 ± 1.48	270.20 ± 131.14	0.34 ± 0.26	-0.09 ± 0.36
25-30	4.67 ± 1.31	276.18 ± 124.53	0.34 ± 0.26	-0.10 ± 0.34
30-35	4.87 ± 1.31	306.95 ± 95.83	0.40 ± 0.27	-0.03 ± 0.28
> 35	4.60 ± 1.45	296.67 ± 102.82	0.37 ± 0.23	-0.05 ± 0.30
All Participants' Age, y				
< 20	5.32 ± 1.75	264.57 ± 142.58	0.50 ± 0.34	-0.23 ± 0.44
20-25	4.81 ± 1.33	274.37 ± 126.77	0.38 ± 0.28	-0.11 ± 0.39
25-30	4.73 ± 1.25	289.10 ± 115.01	0.39 ± 0.23	-0.07 ± 0.31
30-35	4.89 ± 1.30	304.94 ± 101.26	0.38 ± 0.25	-0.04 ± 0.30
< 35	4.62 ± 1.28	307.17 ± 91.93	0.38 ± 0.23	-0.01 ± 0.29
Males	4.80 ± 1.26	293.96 ± 110.42	0.39 ± 0.25	-0.08 ± 0.34
Females	4.74 ± 1.38	283.41 ± 119.43	0.40 ± 0.26	-0.06 ± 0.34
All	4.78 ± 1.31	289.90 ± 114.32	0.37 ± 0.25	-0.07 ± 0.34

[a] Data are presented in mean ± SD.
[b] Abbreviation: OS: Left Eye.

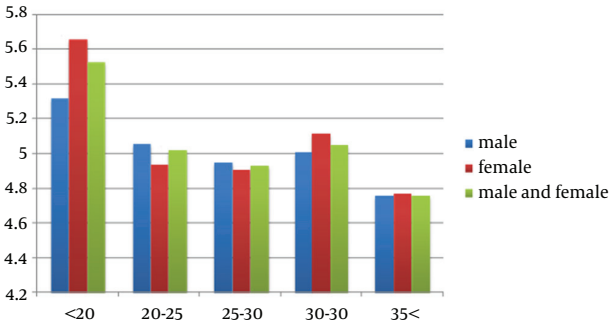

Figure 1. The Distribution of Angle Kappa in Degrees in Different Ages in Males and Females and in Both Sexes

5. Discussion

The angle kappa plays an important role in refractive surgery, and inaccurate preoperative measurements of this angle can lead to serious surgical complications associated with decentration (1, 5). In patients with strabismus, precise measurement of the angle kappa prevents the under-calculation or over-calculation of the degree of deviation (3). In patients with a large angle kappa, the lens of prescription glasses can result in a large prismatic effect, which can disturb the best-corrected visual acuity (6). Angle kappa is increased with age (7).

To achieve more accurate results in the preoperative assessment, we measured the angle kappa in a large sample of a normal population. Hashemi et al. previously measured the angle kappa distribution in a population of Tehran residents with a wide age range (6). Their findings encouraged us to restrict our sampling to the population that was most likely to undergo refractive surgery (age range, 18-35 years). Therefore, our results might be more reliable for estimating the angle kappa in this population (8). We used the Orbscan II device because of its very precise measurements and excellent reproducibility with only one acquisition per eye. To reduce the risk of systematic bias, a single operator used the Orbscan II.

The Orbscan II finds the center of the pupil and finds where the perpendicular axis to the pupil center intercepts the cornea. In the reports, the plus or cursor sign (+) shows the corneal apex and the small "k" shows the intercept of the pupillary axis. The Orbscan documents the pupillary axis by four dimensions. First dimension is the deviation by the degree (4.59° in our example). The second is the geometrical locus of the axis according the 360° scale. The cornea periphery is assumed 360°, initiating at the 3-o'clock position and rotate counterclockwise. For example, the locus is at 346.47°. Therefore, the kappa angle is 4.59° at (@) 346.47°. The third and fourth are the intercepts in x-axis and y-axis, respectively. The dimension of the intercept is divided into x-axis (horizontal) and the y-axis (vertical). In our example, it is + 0.19 mm in the left of the corneal apex and -0.11 mm below the corneal apex.

Among the 977 individuals (1954 eyes) who were examined, there were more women than men ($P < 0.001$), and the values obtained from women would have more effect on the overall results. The angle kappa for both men and women decreased with age, according to the linear regression test. We observed a significant difference between the mean angle kappa in the right and left eyes. No previous study had obtained this result, which did not seem to be accidental due to the large number of cases. Further investigations are needed to resolve this difference.

In comparison to the reported value of 4.96° ± 1.38° in this study, Hashemi et al. reported a mean angle kappa of 5.46° previously (6); however, we used a different age range with a smaller refractive error than they did. Because a higher refractive error can result in larger angle kappa, lower angle kappa results were expected in our study. Basmak et al. (4) used an age range similar to ours (20-40 years) and observed an average angle kappa of 5.22°. In Wachler et al. the angle kappa was reportedly greater in patients with hyperopia (8) while Hashemi et al. (6) found higher values in patients with emmetropia. Unfortunately, we did not divide patients into groups on the basis of their refraction and hence, we could not comment on the angle kappa distribution among different refractive groups.

In another recently published study, performed in our center, the angle kappa changes after photorefractive surgery were evaluated in a population different from this study's and it was found that in 96 eyes, the angle kappa had not changed significantly after the surgery (4.97° ± 1.24° preoperatively and 4.99° ± 1.10° at six months postoperation). Findings of the current study were the same as our previous population (9).

Moreover, we found just another document about the measurement of kappa angle in normal population. Basmak et al. in 100 normal individuals, compared synaptophore with the Orbscan, and the effect of refraction on the kappa angle. They found that a correlation exists between positive refractive errors and large positive angle kappa values. Moreover, data gathered by Orbscan showed a little bit higher values in comparison to synaptophore; however, the Orbscan system provides angle kappa values with quantitatively established precise measurements (10).

Park et al. have reviewed the concept of angle kappa, its measurement and distribution in normal populations, and its implications in refractive surgery and concluded that evidences about the kappa angle effects on refractive surgery were growing. Decentered treatment might be induced by ignoring it and visual symptoms might aggravate the vision. In treating refractive errors in modern era, compensating kappa angle is important in achieving optimal correction (11).

Although a large sample size in this study could as-

sume a good evaluation of the amount of angle kappa in refractive surgery cases, one of our limitations was ignoring the spherical equivalent of patients for more precise classification of angle kappa, which is known to be affected by this variable.

Acknowledgements

The authors would like to thank Ms. Pardis Eghbali, and Maryam Kadkhoda, for their kind assistance with optometric and Orbscan measurements and Ms. Parisa Eghbali for her kind assistance in statistical analysis.

Authors' Contributions

Hamid Gharaee and Masoud Shafiee designed and coordinated the study and participated in clinical examinations and final editing of the manuscript. Rafie Hoseini and Yalda Abrishami assisted in the study design, Orbscan measurements, data gathering, and manuscript editing. Mostafa Abrishami participated in design and planning study, statistical analysis, and manuscript preparation. Mojtaba Abrishami participated in design, formation, and preparing manuscripts and editing. All authors read and approved the content of the manuscript.

References

1. Uozato H, Guyton DL. Centering corneal surgical procedures. *Am J Ophthalmol.* 1987;**103**(3 Pt 1):264–75.
2. Pande M, Hillman JS. Optical zone centration in keratorefractive surgery. Entrance pupil center, visual axis, coaxially sighted corneal reflex, or geometric corneal center? *Ophthalmology.* 1993;**100**(8):1230–7.
3. Scott WE, Mash AJ. Kappa angle measures of strabismic and nonstrabismic individuals. *Arch Ophthalmol.* 1973;**89**(1):18–20.
4. Basmak H, Sahin A, Yildirim N, Saricicek T, Yurdakul S. The angle kappa in strabismic individuals. *Strabismus.* 2007;**15**(4):193–6.
5. Moshirfar M, Hoggan RN, Muthappan V. Angle Kappa and its importance in refractive surgery. *Oman J Ophthalmol.* 2013;**6**(3):151–8.
6. Hashemi H, KhabazKhoob M, Yazdani K, Mehravaran S, Jafarzadehpur E, Fotouhi A. Distribution of angle kappa measurements with Orbscan II in a population-based survey. *J Refract Surg.* 2010;**26**(12):966–71.
7. Choi SR, Kim US. The correlation between angle kappa and ocular biometry in Koreans. *Korean J Ophthalmol.* 2013;**27**(6):421–4.
8. Wachler BS, Korn TS, Chandra NS, Michel FK. Decentration of the optical zone: centering on the pupil versus the coaxially sighted corneal light reflex in LASIK for hyperopia. *J Refract Surg.* 2003;**19**(4):464–5.
9. Zarei-Ghanavati S, Gharaee H, Eslampour A, Abrishami M, Ghasemi-Moghadam S. Angle kappa changes after photorefractive keratectomy for myopia. *Int Ophthalmol.* 2014;**34**(1):15–8.
10. Basmak H, Sahin A, Yildirim N, Papakostas TD, Kanellopoulos AJ. Measurement of angle kappa with synoptophore and Orbscan II in a normal population. *J Refract Surg.* 2007;**23**(5):456–60.
11. Park CY, Oh SY, Chuck RS. Measurement of angle kappa and centration in refractive surgery. *Curr Opin Ophthalmol.* 2012;**23**(4):269–75.