

## Original Research Article

# A comparative study of central corneal thickness, mean keratometry and astigmatism in persons with and without refractive errors in Taif

Afnan H. Alqurashi<sup>1</sup>, Omayma K. Afifi<sup>2</sup>, Hatim F. Jabr<sup>1</sup>, Hanan A. Aljuaid<sup>3\*</sup>

<sup>1</sup>Department of Ophthalmology, King Abdul Aziz Specialist Hospital, Taif, KSA

<sup>2</sup>Department of Histology, <sup>3</sup>Department of Medicine, College of Medicine, Taif University, Taif, KSA

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### \*Correspondence:

Dr. Hanan A. Aljuaid,

E-mail: [moon002011@gmail.com](mailto:moon002011@gmail.com)

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## ABSTRACT

**Background:** Corneal topography is an important parameter in the evaluation of corneal disease, but there is no average value of normal corneal geometry in Saudi individuals is known. So, this study aimed to establish a standard normal value for central corneal thickness (CCT), mean keratometry (km), and astigmatism in Saudi individuals to be used as a reference value, and to compare these results with the same parameters in patients who have refractive errors.

**Methods:** This study was performed from January 2016 to July 2017 at King Faisal Hospital in Taif, KSA, and included a current group of 105 eyes without refractive errors, and 250 eyes with refractor errors.

**Results:** The mean CCT value was 551.681  $\mu$ m, km value was 43.426 D, and astigmatism was 0.784 D for all eyes with normal visual acuity. However, these values are the statistically significant difference between different ages, but no significant differences according to sex. Regarding the eyes with refractive error, it was found that the mean CCT was 509.66  $\mu$ m, km was 46.79 D, and for astigmatism was 3.97 D. When the results of two groups were compared, there was a significant difference between them except for km in the group a; (12-20 years).

**Conclusions:** The standard value of central corneal thickness, mean keratometry, and astigmatism in Saudi individuals is differing according to the age but it is the same in both genders. These values are differing statistically in patients with refractor error.

**Keywords:** Central corneal thickness, Mean keratometry, Astigmatism, Taif, KSA

## INTRODUCTION

The anterior corneal surface is the major refractive element of the human eye, contributing about 80% of the dioptric power of the whole eye in the non-accommodated state.<sup>1,2</sup> The structure of the human cornea has a non-uniform curvature with variable thickness throughout. It is thinner at the centre and thickens towards the edges. The viscous fluid in the anterior chamber of the eye exerts pressure on the cornea that inflates it and gives its shape.<sup>3</sup>

Corneal thickness is an important indicator of corneal health, and its alteration may be indicative of different pathologies.<sup>4</sup> Its measurement is the essential factor to assign to the corneal status, endothelial pump mechanism and in wide range of disorders; as ectatic dystrophies, contact lenses related complication, dry eye, and diabetes mellitus. In addition, it is an increasingly important procedure in the evaluation of patients with ocular hypertension or glaucoma. The curvature of the internal and external surfaces significantly affects its refractive power but the influence of the refractive error on corneal thickness has not yet been clearly established. There are

controversial results concerning this topic that requiring further study to clarify.<sup>5,6</sup>

As a LASIK (Laser in situ keratomileusis) has recently become the most popular refractive surgical procedure, the preoperative corneal keratometry and central corneal thickness is very important nowadays to ensure the success of the corneal refractive surgery. Accurate measurement of these parameters is important in decreasing the incidence of postoperative iatrogenic keratoconus. Also, such measurement provides guidance and serves a preventive function in reducing the occurrence of curvature negative pressure suction ring selection during surgery and in preventing the formation of free.<sup>7</sup>

Astigmatism is an important cause in determining the uncorrected visual acuity. It is caused by some combination of the external or corneal surface and internal optical properties (posterior corneal surface, human lens, fluids, retina, and eye-brain interface).<sup>8</sup> Cornea is a large contributor of the refractive astigmatism and also considers a significant factor in determining the axis and amount of intraoperative correction of refractive astigmatism. Both the anterior and posterior corneal surfaces contribute to the total corneal astigmatism. Astigmatism may be combined with other types of refraction; myopic astigmatism, hyperopic astigmatism or mixed astigmatism.<sup>9,10</sup> Keratometry, central corneal thickness and astigmatism can be measured using a number of modalities including optical pachymetry, pentacam, ultrasound pachymetry, Scheimpflug imaging, optical coherence tomography, and even magnetic resonance imaging.<sup>11</sup>

Pentacam is a newly developed three-dimensional analysis system that can accurately scan the surfaces of the cornea and the other anterior segment of the system. It takes a photo of the cornea and displays a topographic analysis of the front and back surfaces of it.<sup>12,13</sup> It is a fast, non-contact method, which uses a rotating Scheimpflug camera that provides a 3-dimensional scanning of the anterior segment of the eye. From the images acquired, information regarding the corneal topography, corneal pachymetry, anterior chamber depth, angle, and lens density can be evaluated.<sup>13,14</sup>

Several studies have reported different parameters among different populations as, Caucasians and African Americans, Indian, Nigerians.<sup>15-17</sup> It is found that there is a difference in the corneal parameters between patients from the different country. This difference might alter the measurement of intraocular pressure and potentially the assessment and management of glaucoma in these populations.

To the best of our knowledge, no such data are available for eye parameters in healthy Saudi persons. So, due to the lack of the detailed about corneal topography in Saudi individuals, this study, aimed to evaluate the corneal topography of healthy Saudi in different ages and sex by

Pentacam device and compare them with persons with refractor error.

## METHODS

### *Participants and setting*

The present study was carried out on (355) eyes of Saudi individuals; divided into two groups. Group 1; included (105) eyes with normal visual acuity (49 males, 56 females) and group 2 included (250) eyes with an error of refraction (116 males, 134 females). The participants of with normal visual acuity were chosen after a detailed history and visual exam. All had no previous ocular surgery, no ocular diseases or medication, and no history of contact lens wear for at least one week. The participants in each group were divided according to their age into three subgroups; group a; from (12-20) years, group b; from (21-40) years and group c; (above 41) years. This study was performed from Jan-2016 to Jul-2017, in the ophthalmology out-clinic of King Faisal Hospital in Taif, KSA.

### *The measured parameters*

Central corneal thickness (CCT), mean keratometry (km), and astigmatism (Astig) were measured by Pentacam HR device.

### *Pentacam examination technique*

All measurements were done at the same time of the day, between 9:00 am and 2:00 pm. Before the parameters were measured the Visual Acuity and Auto-Refractometer were done to be sure that the participants of the first group had normal visual acuity. During measurements, the subject was positioned with his or her chin in a cup and forehead against a headband. The patient was asked to look at fixation target, automated mode low flash intensity pictures from the center of the cornea were taken while the subject focused on a fixation light. The measurement automatically started whenever correct alignment with the corneal apex and focus was achieved. The picture was captured and printed out with only if the endothelial cells were in clear focus. If the image captured didn't clearly outline the endothelial cells, patients were asked to remove their head, blink, and a second measurement was performed.

### *The retrospective part (group 2)*

The recorded data of patients with an error of refraction were retrospectively collected for (250) eyes examined over a period of one year excluding those who have had a prior refractive surgery. The collected data were compared with that of the normal eyes.

### *Statistical analysis*

Data were presented as Mean $\pm$ SD. Statistical differences between different groups were assessed by Student's t-test

and ANOVA from the SPSS statistical package version 17. The value of  $p < 0.05$  was considered statistically significant.

### Ethical Considerations

The study was approved by the Medical Ethics and Research Committee of King Faisal Hospital. The written informed consent was obtained from all subjects involved in the study. Confidentiality was maintained throughout the data collection process.

## RESULTS

### Group 1: subjects with normal visual acuity

This part of study enrolled 105 eyes with normal visual acuity; 49 (46.7%) for male and 56 (53.3%) for female.

The number, percentage, and means of ages to all participates are shown in (Table 1). In the total sample of this group (N=105) the mean of central corneal thickness (CCT) was 551.681  $\mu\text{m}$ . However, this value differed according to the age of the subject, it decreased with age. It was the highest (573.769  $\mu\text{m}$ ) in subgroup a; lesser in subgroup b (543.377  $\mu\text{m}$ ) and the lowest was in subgroup c (537.897  $\mu\text{m}$ ). Regarding the mean keratometry (km), it was found that the mean in the total sample was 43.426 D. However, it was found that the Km value increased with age. The values in three subgroups was (43.069 D) in subgroup a, (43.079 D) in subgroup b and was (44.13 D) in subgroup c.

Concerning to astigmatism, the mean value in the total sample of Saudi individuals with normal visual acuity was 0.784 D. Meanwhile, its mean value was the highest in subgroup b (0.98 D), lesser in the subgroup a (0.723 D), and was the lowest in subgroup c (0.651 D).

**Table 1: Showing number, percentage, range of years, means and SD in the two main groups and the three age subgroups.**

Groups	Subgroup a (12-20 years)			Subgroup b (21-40 years)			Subgroup c (>41 years)		
	No	%	Mean $\pm$ SD	No	%	Mean $\pm$ SD	No	%	Mean $\pm$ SD
1 (Normal visual acuity)	13	12.4	15.76 $\pm$ 2.58	53	50.5	28.28 $\pm$ 5.16	39	37.1	50.2 $\pm$ 6.31
2 (Error of refraction)	55	21.9	16.21 $\pm$ 2.56	156	62.7	29.38 $\pm$ 5.71	39	15.7	52.2 $\pm$ 9.62

**Table 2: The means $\pm$ SD values of CCT, km and astigmatism of respondents with normal visual acuity in the three age groups.**

	Subgroup (a) (12-20 years)	Subgroup (b) (21-40 years)	Subgroup (c) >41 years	P and Sig.
CCT ( $\mu\text{m}$ )	573.769 $\pm$ 24.836	543.377 $\pm$ 31.848	537.897 $\pm$ 28.027	0.001*
Km (D)	43.069 $\pm$ 1.488	43.079 $\pm$ 1.382	44.13 $\pm$ 1.205	0.001*
Astigmatism (D)	0.723 $\pm$ 0.356	0.98 $\pm$ 0.469	0.651 $\pm$ 0.34	0.00*

\* $p < 0.05$  (significant)

**Table 3: Mean $\pm$ SD values of CCT, km and astigmatism in male and female respondents with normal visual acuity in the three age groups, comparison between male and female.**

Group	Number	CCT ( $\mu\text{m}$ )	Km (D)	Astigmatism (D)
Subgroup (a) (12-20 years)	Male (N=5)	588.4 $\pm$ 23.3	43.3 $\pm$ 1.21	0.82 $\pm$ 0.455
	Female (N=8)	567 $\pm$ 23	42.69 $\pm$ 1.69	0.671 $\pm$ 0.32
	P value	0.153 NS	0.481 NS	0.553 NS
Subgroup (b) (21-40 years)	Male (N=24)	547.9 $\pm$ 34.2	42.93 $\pm$ 1.03	0.936 $\pm$ 0.418
	Female (N=29)	541.7 $\pm$ 29.4	43.2 $\pm$ 1.62	1.048 $\pm$ 0.494
	P value	0.504 NS	0.48 NS	0.386 NS
Subgroup (c) >41 years	Male (N=20)	531.9 $\pm$ 25.2	43.83 $\pm$ 1	0.665 $\pm$ 0.258
	Female (N=19)	544.3 $\pm$ 30	44.45 $\pm$ 1.34	0.637 $\pm$ 0.418
	P value	0.172 NS	0.115 NS	0.803 NS

\* $P < 0.05$  (significant)

On comparing the means of all these different normal parameters between different age subgroups by ANOVA, there was a significant difference between them (Table

2). On the other hand, there was no statistically significant difference between male and female in each subgroup when comparing by t-test (Table 3).

### Group 2: subjects with an error of refraction

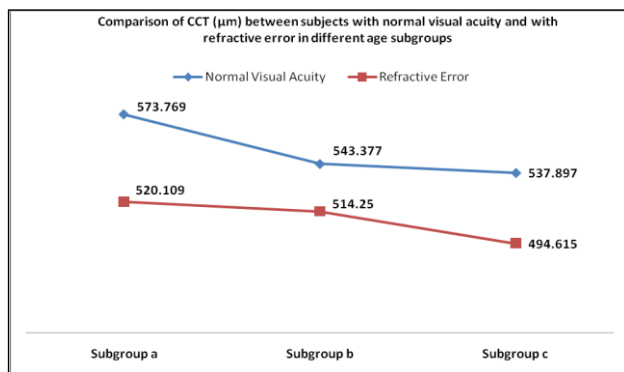
This part of the study was retrospective and recorded 250 eyes with refractive error; 116 (46.4%) for male and 134 (53.6%) for female. The number, percentage, and means of ages to all participates are shown in (Table 1). In the total sample of this group (N=250) the mean of central corneal thickness (CCT) was decreased to be 509.66  $\mu\text{m}$ , the mean keratometry (km) was increased to be 46.79 D and the astigmatism was increased to be 3.97 D. On

comparing these different parameters in patients with refractive error with the corresponding subjects with normal visual acuity as all (male and female), there was a significant difference between them except for km in subgroup a (12-20 years) (histograms 1, 2, 3). However, on comparing each sex with the corresponding one in two groups, there was a statistically significant difference between all subgroups except km in males of subgroup a and c in which the difference was non-significant (Table 4).

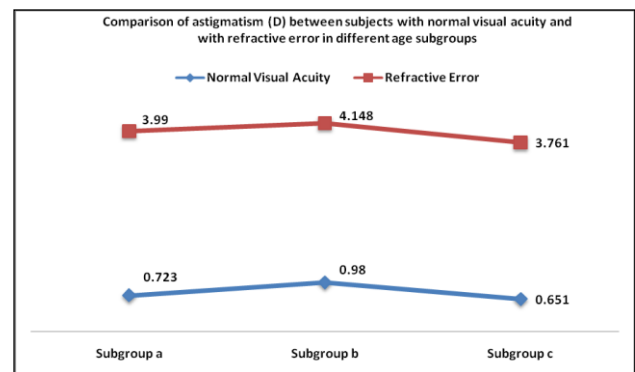
**Table 4: Mean $\pm$ SD values of CCT, km and astigmatism in male and female respondents with error of refraction, and Comparison with corresponding group with normal VA.**

	Number	CCT ( $\mu\text{m}$ )	P value	Km	P value	Astigmatism	P value
<b>Subgroup (a)</b> <b>(12-20 years)</b>	Male (N=21)	537.7 $\pm$ 63.4	0.008 *	44.62 $\pm$ 4.3	0.234	3.73 $\pm$ 2.07	0*
	Female (N=34)	508.4 $\pm$ 45.2	0*	47.32 $\pm$ 4.45	0*	4.16 $\pm$ 1.85	0*
<b>Subgroup (b)</b> <b>(21-40 years)</b>	Male (N=77)	508.4 $\pm$ 43.9	0*	47.14 $\pm$ 7.45	0*	3.95 $\pm$ 1.93	0*
	Female (N=79)	507.3 $\pm$ 49.4	0*	47.45 $\pm$ 5.22	0*c	4.35 $\pm$ 2.9	0*
<b>Subgroup (c)</b> <b>&gt;41 years</b>	Male (N=18)	489.9 $\pm$ 61.3	0.013*	46.18 $\pm$ 5.34	0.083	3.18 $\pm$ 1.86	0*
	Female (N= 21)	498.6 $\pm$ 60	0.004*	49.52 $\pm$ 5.87	0.001*	4.33 $\pm$ 1.74	0*

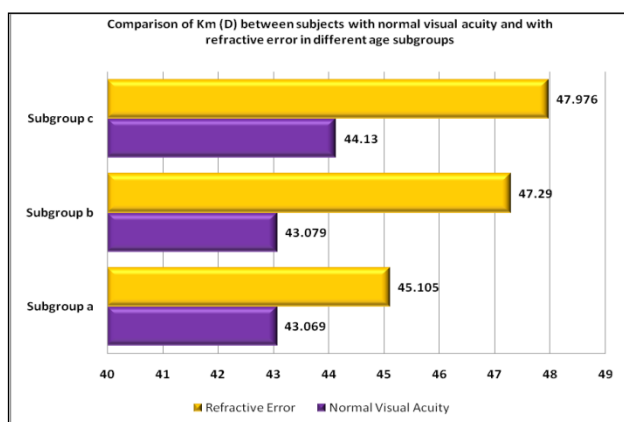
\*P<0.05 (significant), non-significant= p>0.05



**Figure 1: Showing comparison of CCT between subjects with normal visual acuity and those with refractor error.**



**Figure 3: Showing comparison of astigmatism between subjects with normal visual acuity and those with refractor error.**



**Figure 2: Showing comparison of km between subjects with normal visual acuity and those with refractor error.**

## DISCUSSION

Globally, LASIK is the treatment of choice for the surgical correction of refractive errors.<sup>18</sup> The precise measurement of corneal topography is essential for preoperative evaluation, postoperative measurement particularly for patients who require future enhancement procedure or cataract surgery and also for detection of post-refractive keratectasia.<sup>19,20</sup>

Ethnic variations in corneal topography have been reported in many racial groups. Different parameters among different populations have been reported, but there is no standard value of in Saudi individuals is known.<sup>15-17</sup> This study reports the normal standard values of CCT, km, and astigmatism in Saudi individuals to use as reference values and compare them with that of refractive error.



The results of this study indicate that in eyes of Saudi individual with normal visual acuity, the mean CCT is 551.681  $\mu\text{m}$ . However, when the CCT was studied in different age groups, it was found that it is significantly decreased with aging. These results are in agreement with the previous results of Hahn et al, who found that older subjects had significantly thinner CCTs compared with younger participants.<sup>21</sup> They also are partially in parallel with the results of Rushood et al, who found that the average CCT in full-term Saudi newborns was thicker (616  $\mu\text{m}$ ) than in older aged participants of this study.<sup>22</sup>

Otherwise, gender-related differences were also observed in this work; but, they were not statistically significant. This non-significantly gender variation in this work is in agreement with Gelawet al, and are in contrary to some previous findings in which higher mean was found in males.<sup>17,23-25</sup> So, there remains a need for more studies focusing on gender differences in CCT in different race groups in order to establish the reality of gender variation in CCT.<sup>16</sup> These conflicting results among different studies were attributed to differences in measuring methods.<sup>26</sup>

When compared these values in different ages with the corresponding eyes with refractive errors, it was found that the cornea became thinner in all age groups and in total sample (509.68  $\mu\text{m}$ ). This result is in parallel with the previous finding which found a relationship between refraction and CCT and the cornea became thinner in more myopic eyes.<sup>27,28</sup>

They added that a decrease in the corneal thickness was a result of a change in the anterior segment as the eyeball elongated in myopic progression. On the other hand, it was found that there was no statistical difference in CCT between emmetropes and myopes.<sup>29</sup>

Regarding the mean keratometry (km) in this study, it found that the relation of Km value with age was reverse to the CCT relation with age. It was increased significantly with age while CCT decreased significantly with age. On comparing with the corresponding groups with refractor errors, there was a significant difference between them except for km in 12-20 years old persons, especially in males.

These results have coincided partially with other authors who found that the Km and CCT were inversely proportional to the myopic group while they did not correlate with each other in hyperopes.<sup>30</sup> So, the non-significant differences in some subgroup in this study may be returned to the type of refractive errors.

Concerning to the corneal astigmatism in this study, the mean value was the highest in subgroup b (21-40 years), lesser in the subgroup a (12-20), and was the lowest in subgroup c (more than 41). It has been shown that the astigmatism axis (of the anterior corneal surface) turns to "against-the-rule" with age, while others have found that

the prevalence of astigmatism increases with age.<sup>9,10</sup> On comparing with the corresponding groups with refractor errors, the corneal astigmatism was significantly increased. This means that the CCT was decreased while Km and corneal astigmatism were increased in the group with refractive errors. This coincided with other results who concluded that the Km showed a close correspondence with corneal astigmatism and an inverse relationship with CCT in the myopia patients.<sup>30</sup> In conclusion, the standard values of CCT, km, and astigmatism in Saudi individuals with normal visual acuity are differed according to the age but it is the same in both male and female. These parameter values are differing statistically in patients with refractor errors. It is recommended to study the same parameters in a greater sample size in all regions of Saudi Arabia to draw a firm conclusion in eyes with normal visual acuity and also in each type of refractor errors separately.

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