Correlation Between Myopic Refractive Error, Corneal Power and Central Corneal Thickness in the Egyptian Population

This article was published in the following Dove Press journal:
Clinical Ophthalmology

Purpose: To find out the correlation between myopic refractive error, corneal power and central corneal thickness (CCT) in the adult Egyptian population.

Methods: A retrospective observational cross-sectional study in which we analyzed the preoperative data of 1401 Egyptian myopic patients (1401 eyes) who underwent keratorefractive procedures between 2016 and 2019 in a private eye surgery center.

Results: Mean age of patients was 28.1± 5.79 years (range 18–40). Mean CCT in the Egyptian population sample in our study was 539.23± 32.24. Only the corneal power parameters (flat K, steep K and average K) showed a statistically significant difference (p-value <0.001) between males and females. A statistically significant and weak positive correlation of average K with the absolute value of refractive astigmatism (r = 0.063, p-value = 0.018), and between myopic error with average K (r = 0.136, p-value <0.001) was found.

Conclusion: Among the myopic adult Egyptian population, the greater the myopic error measured, the steeper the cornea, with a weak positive correlation between refractive error and corneal power.

Keywords: myopia, cornea, central corneal thickness, corneal power, Egyptian

Introduction
Laser in situ keratomileusis (LASIK), since its introduction by Pallikaris and his team in 1990,1 has become the most frequently performed corneal refractive procedure all over the world, with millions of LASIK procedures completed to date.2

Assessment of corneal power parameters, especially the central corneal thickness (CCT) and the corneal curvature (the corneal power), is crucial before proceeding with laser vision correction (LVC) procedures. Decision making before LVC procedure and calculation of percentage of tissue altered (PTA) should rely on cut-off values like CCT that vary among different population groups.3

Conventionally, corneal thickness normally ranges between 537 μm and 550 μm. Five hundred microns has been accepted as a cut-off value for safe refractive surgery. Thinner corneas are at risk for ectasia, haze and less predictable refractive outcomes.3

Analysis of causes of post-LASIK ectasia revealed that thin CCT (below 500 μm) and anterior corneal topographic irregularities are among the most important risk factors.4,5

In addition, measurement of CCT has become very important in assessment of glaucoma patients, as intraocular pressure (IOP) was found to be positively
correlated with CCT. Thin corneas result in false low IOP while thicker corneas tend to show false high IOP.\(^5\,^7\)

Assessment of CCT and corneal power has been made easier and more accurate by the introduction of Pentacam with the Scheimpflug camera system, being a very rapid, non-contact, accurate, reproducible and user-friendly method.\(^8\,^9\)

As myopia has been identified as the most prevalent refractive error all over the world,\(^10\,^{11}\) the correlation between myopia and axial length of the eye was extensively discussed, revealing a positive correlation between the absolute value of myopia and axial length.\(^12\,^{13}\)

The correlation between refractive error and corneal parameters has been previously studied in different regions and populations.\(^3\,^{14}\,^{15}\) The purpose of this work is to find out if there is any correlation between corneal parameters (namely, central corneal thickness and corneal power) and the refractive error in the myopic adult Egyptian population.

**Patients and Methods**

This study is a retrospective study in which we analyzed the preoperative data of 1401 patients (1401 eyes) who underwent keratorefractive surgery (LASIK and photorefractive keratectomy (PRK) procedures) between 2016 and 2019 at Nour Eloyon Specialty Eye Center, Egypt. We only retrieved the data of the right eye of every patient. The study was performed according to the Declaration of Helsinki, and adhered to the regulations of the Institutional Review Board and ethical committee at Cairo University. The study was approved by the ethical committee of the Egyptian Society of Keratoconus and Corneal Transplants. Patient consent to review their medical records was not required by the ethical committee of the Egyptian Society of Keratoconus and Corneal Transplants in this retrospective study as patients’ names were masked and their privacy respected.

Inclusion criteria were patients between 18–40 years old, with myopic error of spherical equivalent less than ±8.00 D who had provided written informed consent to undergo the LVC procedure.

Exclusion criteria were previous corneal refractive procedure or intraocular surgery, corneal scarring, and definite or suspect keratoconus patients.

Data of these patients was retrieved from the hospital filing system; these data included age, sex, manifest and cycloplegic refraction, central corneal thickness, keratometric measures and type of surgery performed. Data of patients revealed that manifest refraction was done using an automated refractometer (Topcon KR 8000, Japan). The patients were examined using a slit lamp for examination of the anterior segment. Manifest refraction was validated with trial correction using a lens set. Cycloplegic refraction was taken after instillation of Tropicamide drops (1% Mydriacyl; Alcon Inc., Switzerland) for 30 minutes to exclude any significant difference between manifest and cycloplegic refraction. Fundus examination was done using slit lamp biomicroscopy to exclude any retinal problems like myopic choroidal neovascular membranes or peripheral retinal tears or breaks.

Central corneal thickness and corneal power were measured using the Pentacam Scheimpflug system (Oculus Optikgerate GmbH, Germany). This system was designed with a camera that rotates 360 degrees around the optical axis of the examined eye to capture 25 Scheimpflug images per second and provide a three-dimensional image of the anterior segment with 25,000 height values. The printout included anterior and posterior corneal surface topography maps and a detailed pachymetric map.

We calculated the spherical equivalent (SE) value by adding the value of the sphere to the half of the refractive astigmatism value in diopters. Central corneal thickness was collected from the Pentacam images as the corneal thickness at the corneal apex. Keratometric measures were also retrieved from the Pentacam images as K1, the flat keratometric value, and K2, the steep keratometric value; the average K was used in the statistics and was calculated by the sum of flat and steep K divided by two. Keratometric astigmatism was calculated by the difference between the steep and the flat K.

Taking into consideration that we were dealing only with myopic refractive errors, we chose to use the absolute value of spherical equivalent and refractive astigmatism and to omit the negative sign in statistics to make it easier and to show real correlation between the refractive error and corneal parameters.

**Statistics**

Data were coded and entered using the Statistical Package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Data was summarized using means, standard deviations, median, minimum and maximum for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical
variables. Comparisons between groups were done using unpaired t-tests.\textsuperscript{17} Correlations between quantitative variables were done using the Pearson correlation coefficient.\textsuperscript{16} P-values of less than 0.05 were considered to be statistically significant.

**Results**

Retrospective analysis of preoperative data of 1401 eyes of 1401 patients scheduled for LVC procedures was done. Mean age of patients was 28.1 ± 5.79 years (ranging from 18 to 40 years); 958 patients were aged between 18–30 years (68.38%), while 443 patients were aged between 30–40 (31.62%). Study subjects included 496 males (35.4%) and 905 females (64.6%); 1355 eyes (96.7%) underwent LASIK and 46 eyes (3.3%) underwent PRK.

Mean value and range of spherical equivalent (SE), refractive astigmatism, corneal power parameters and central corneal thickness (CCT) are shown in Table 1. Table 2 categorized patients’ data into two age groups (18–30 years and 30–40 years).

Comparing the data of males and females, there was no statistically significant difference in SE, refractive astigmatism (RA), keratometric astigmatism (KA) or CCT. Only the corneal power parameters (flat K, steep K and average K) showed a statistically significant difference (p-value < 0.001), as shown in Table 3.

By correlating the spherical equivalent of a myopic refractive error in its absolute value to different corneal parameters, we found a statistically significant but weak positive correlation with average K, meaning that the greater the myopic error, the steeper the cornea (r = 0.136, p-value < 0.001), as shown in Figure 1. Also, a statistically significant but weak positive correlation was found with both refractive and keratometric astigmatism (r = 0.0957, p-value < 0.001 and r = 0.089, p-value < 0.001, respectively), as shown in Table 4.

The central corneal thickness showed a weak non-significant negative correlation with the absolute value of SE, meaning that the greater the myopic refractive error, the thinner the cornea (r = -0.027, p-value = 0.314), as shown in Table 4.

In addition to being correlated to SE, Table 4 shows a statistically significant and weak positive correlation of average K with the absolute value of refractive

| Table 1 Statistical Values of Refractive Errors and Corneal Parameters |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Mean | Standard Deviation | Median | Minimum | Maximum |                |
| SE              | -3.60 | 1.85            | -3.25 | -0.75    | -8.0    | -8.0           |
| Sphere value    | -3.09 | 1.87            | -2.75 | 0        | -8.0    | -8.0           |
| RA              | -1.03 | 0.95            | -0.75 | 0        | -4.5    | -4.5           |
| CCT             | 539.23 | 32.24         | 537.00 | 470.00  | 638.00  | 638.00         |
| Flat K          | 42.89 | 1.59            | 42.84 | 38.09    | 47.86   | 47.86          |
| Steep K         | 44.14 | 1.58            | 44.10 | 38.41    | 48.01   | 48.01          |
| KA              | 1.25  | 1.08            | 1.02  | 0        | 5.25    | 5.25           |
| Average K       | 43.52 | 1.49            | 43.46 | 38.25    | 47.93   | 47.93          |

**Abbreviations:** SD, standard deviation; SE, spherical equivalent; RA, refractive astigmatism; CCT, central corneal thickness; KA, keratometric astigmatism.

| Table 2 Comparison of Patients’ Data Between Two Age Groups | 18–30 Years | 30–40 Years | p-value |
|-----------------------------------------------------------|------------|------------|--------|
|                                                            | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum |        |
| SE                                                         | -3.71 | 1.84 | -3.25  | -0.75   | -8.0    | -3.44 | 1.7 | -3.12  | -0.75   | -8.0    | 0.009  |
| Sphere value                                              | -3.2   | 1.83 | -2.75  | 0       | -8.0    | -2.92 | 1.76 | -2.75  | 0       | -7.75   | 0.006  |
| RA                                                        | -1.01  | 0.75 | -0.75  | 0       | -4.5    | -1.06 | 0.97 | -0.75  | 0       | -4.5    | 0.42   |
| CCT                                                       | 541.08 | 30.76 | 541.00 | 470.00  | 625.00 | 535.51 | 34.18 | 528    | 470.00  | 638.00  | 0.004  |
| Flat K                                                    | 42.95  | 1.43 | 42.9   | 38.3    | 47.2    | 42.77 | 1.52 | 42.72  | 38.09   | 47.86   | 0.048  |
| Steep K                                                   | 44.19  | 1.54 | 44.15  | 38.7    | 47.2    | 44.05 | 1.64 | 44.00  | 38.41   | 48.01   | 0.15   |
| KA                                                        | 1.24   | 0.84 | 1.00   | 0       | 5.25    | 1.27  | 0.89 | 1.07   | 0.01    | 5.22    | 0.46   |
| Average K                                                  | 43.57  | 1.43 | 43.55  | 38.5    | 47.6    | 43.41 | 1.52 | 43.34  | 38.25   | 47.93   | 0.077  |

**Abbreviations:** SD, standard deviation; SE, spherical equivalent; RA, refractive astigmatism; CCT, central corneal thickness; KA, keratometric astigmatism.
Table 3 Comparison Between Data of Males and Females

|                | Male         |              |                | Female        |              | p-value |
|----------------|--------------|--------------|----------------|---------------|--------------|---------|
|                | Mean  | SD    | Median | Minimum | Maximum | Mean  | SD    | Median | Minimum | Maximum |
| SE             | −3.54 | 1.85  | −3.25  | −0.75   | −8.0    | −3.64 | 1.85  | −3.25  | −0.75   | −8.0    | 0.347   |
| Sphere value   | −2.99 | 1.87  | −2.75  | 0       | −8.0    | −3.14 | 1.86  | −2.75  | 0       | −8.0    | 0.149   |
| RA             | −1.09 | 0.98  | −0.75  | 0       | −4.5    | −1.00 | 0.94  | −0.75  | 0       | −4.5    | 0.073   |
| CCT            | 538.94| 31.40 | 539.00 | 470.00  | 627.00  | 539.39| 32.71 | 536.00 | 470.00  | 638.00  | 0.800   |
| Flat K         | 42.61 | 1.43  | 42.58  | 38.09   | 46.60   | 43.05 | 1.66  | 43.00  | 39.11   | 47.86   | <0.001  |
| Steep K        | 43.86 | 1.60  | 43.82  | 38.41   | 47.87   | 44.30 | 1.54  | 44.25  | 40.02   | 48.01   | <0.001  |
| KA             | 1.25  | 0.91  | 1.00   | 0       | 5.22    | 1.26  | 1.17  | 1.04   | 0       | 5.25    | 0.867   |
| Average K      | 43.24 | 1.45  | 43.23  | 38.25   | 47.13   | 43.67 | 1.49  | 43.63  | 39.56   | 47.93   | <0.001  |

**Abbreviations:** SD, standard deviation; SE, spherical equivalent; RA, refractive astigmatism; CCT, central corneal thickness; KA, keratometric astigmatism.

astigmatism ($r = 0.063$, p-value = 0.018). Also, CCT was found to be negatively correlated to average K, to a weak statistically significant value, meaning that the steeper the cornea, the thinner the central corneal thickness ($r = −0.089$, p-value = 0.001) (Figure 2).

A non-statistically significant negative correlation was also found between average K and the keratometric astigmatism ($r = −0.015$, p-value = 0.582).

Keratometric astigmatism showed a strong statistically significant positive correlation with the absolute value of refractive astigmatism ($r = 0.651$, p-value <0.001) (Figure 3) (Table 4).

By analyzing the age of the study subjects, a statistically significant but weak negative correlation was found with the CCT ($r = −0.094$, p-value <0.001), meaning that the older the patient, the thinner the cornea (Figure 4) (Table 4).

Age also showed a statistically significant correlation with keratometric astigmatism ($r = 0.087$, p-value = 0.001). But its correlations with spherical equivalent ($r = 0.036$, p-value =0.175) and average K ($r = −0.018$, p-value = 0.508) were not significant (Table 4).

Mean CCT in the Egyptian population in our study was $539.23 ± 32.24$.

Figure 1 Correlation between spherical equivalent in absolute value and average K showing a statistically significant but weak positive correlation ($r = 0.136$, p-value <0.001).
Table 4 Correlation Value Between Different Parameters

|                          | Spherical Equivalent (SE) by Absolute Value | Refractive Astigmatism (RA) by Absolute Value | Average K | Keratometric Astigmatism (KA) by Absolute Value | CCT |
|--------------------------|---------------------------------------------|-----------------------------------------------|-----------|-----------------------------------------------|------|
| Refractive astigmatism (RA) by absolute value | r 0.0957 p-value <0.001 N 1401 |                                    |            |                                              |      |
| Average K                | r 0.136 p-value <0.001 N 1401 | 0.063 p-value 0.018 N 1401 |            |                                              |      |
| Keratometric astigmatism (KA) by absolute value | r −0.089 p-value 0.001 N 1401 | 0.651 p-value <0.001 N 1401 | −0.015 p-value 0.582 N 1401 |                                              |      |
| CCT                      | r −0.027 p-value 0.314 N 1401 | 0.035 p-value 0.187 N 1401 | −0.089 p-value 0.001 N 1401 | −0.018 p-value 0.512 N 1401 |      |
| Age                      | r 0.036 p-value 0.175 N 1401 | 0.018 p-value 0.491 N 1401 | −0.018 p-value 0.508 N 1401 | −0.087 p-value 0.001 N 1401 | −0.094 p-value <0.001 N 1401 |

Abbreviations: SD, standard deviation; SE, spherical equivalent; RA, refractive astigmatism; CCT, central corneal thickness; KA, keratometric astigmatism.

Discussion

The primary outcome of our work is evaluating the correlation between corneal parameters measured with Pentacam and the myopic refractive error in the adult Egyptian population.

Although correlation between axial length and myopic refractive error has been thoroughly studied and proven by different studies showing a positive correlation between the absolute value of myopia and axial length,12,13 the
**Figure 3** Correlation between absolute value of keratometric and refractive astigmatism showing a statistically significant strong positive correlation ($r = 0.651$, p-value $<0.001$).

**Figure 4** Correlation between age and central corneal thickness showing a statistically significant but weak negative correlation ($r = -0.094$, p-value $<0.001$).
correlation between SE and corneal power has not been fully studied yet.

In the current study we retrieved data from a large sample which included 1401 eyes of 1401 patients. To our knowledge, this is the largest sample among all the studies that assessed the correlation of corneal parameters with myopic refractive error. AlMahmoud et al, in 2011, used the same retrospective pattern with a larger sample of 3395 eyes but they included all types of emmetropia with a wide range of refractive errors from +6.75 to −14.0 diopters. Arora et al, in 2015, studied 1000 eyes of 500 candidates with different types of refractive errors.

The mean age of our study subjects was 28.1±5.79 years, with a range from 18 to 40 years. In contrast, the study by AlMahmoud et al included patients with a mean age of 40±10 years, ranging from 19 to 84. Kadhim et al, in 2016, recruited patients with a mean age of 40.1±14.6 years, ranging from 20 to 75 years.

In our study we used the Pentacam (Oculus Optikgerate GmbH, Germany) for assessment of corneal power and CCT; AlMahmoud et al and Ucakhan et al used the same instrument. Kadhim et al used the autorefracto-keratometry (RC-5000; Tomey Corporation) for assessment of corneal power and the contact ultrasound pachymeter (SP-3000; Tomey Corporation, Nagoya, Japan) for CCT measurement. Arora et al also used the autokeratometer for assessment of corneal power. The use of Pentacam made it easier to assess all the corneal parameters needed, in a rapid, reproducible non-contact way.

Regarding the correlation between myopic refractive error in its absolute value and corneal power, we found a weak statistically significant correlation in the present study (r = 0.136, p-value <0.001). AlMahmoud et al studied this correlation in a large sample with different types of refractive errors and, in the whole study sample, found a weak correlation between average K and SE; in the myopic group, the correlation was also weak but statistically significant (r = −0.185, p-value <0.001). They stated that there was a 0.11 diopter change in average K for every diopter change in SE in the whole study sample. AlMahmoud et al also found that the cornea in males was significantly flatter than that in females (average K: males 43.54; females 44.21, p-value <0.001). This finding was consistent with our results in this point (average K: males 43.24; females 43.67, p-value < 0.001), even though there was no statistically significant difference in SE between males and females in either study.

In a sample of 500 eyes, from subjects aged between 20 and 40 years, Arora et al, in 2015, found a statistically significant correlation between SE and corneal curvature (CC) (r = 0.159, p <0.01 and r = 0.184, p <0.01) in the right eye and left eye, respectively.

Mashige et al, in 2017, studied the corneal parameters and their correlations with refractive error in a sample of 600 black South African participants. Their mean age was 28.15 ±13.1 years, which was close to the mean age in our study. They found no correlation between SE and corneal power (referring to it as anterior corneal curvature (ACC) (r = −0.03, p-value = 0.48).

In addition, Chen et al, in 2009, found no significant correlation between SE and corneal power (r = −0.016, p-value = 0.723) in a sample of 500 Taiwanese Chinese patients aged 40–80 years (mean age = 60.9±11.2 years).

In 2019, Krishnan et al identified no significant correlation between SE and corneal power in terms of base curve (BC) (r = 0.070, p = 0.383) in a sample of 156 subjects in South India with an average age of 29.27 years.

In the present study, we found a statistically significant but weak correlation between average K and the absolute value of refractive astigmatism (r = 0.063, p-value = 0.018); however, the correlation between average K and keratometric astigmatism was not significant (r = −0.015, p-value = 0.582). Keratometric astigmatism showed a strong statistically significant correlation with the absolute value of refractive astigmatism (r = 0.651, p-value <0.001).

AlMahmoud et al found in the myopic group of their study a significant correlation between corneal power and keratometric astigmatism (r = 0.082, p-value = 0.0003) but not with refractive astigmatism (r = 0.039, p-value = 0.103). However, like our study, they found a strong correlation between KA and RA (r = 0.784, p-value <0.001).

Multiple studies tried to describe the relationship between the SE and the central corneal thickness. In our work we found the mean SE (−3.6± 1.85) and the mean CCT (539.23± 32.24), the correlation between absolute value of SE and CCT was non-significant negative correlation meaning that the more the myopic refractive error the thinner the cornea (r = −0.027, p value = 0.314).

In a study by Lazreg and Colin, in 2011, Pentacam pachymetry was performed in refractive surgery centers in Algeria, Tunisia and Morocco on 1615 eyes of patients originating from North Africa. Most of the patients (70%
were aged between 20 and 35 years. Thirty-eight percent had a CCT between 450 and 500 microns and 40% between 500 and 550 microns.

In agreement with the present study, AlMahmoud et al described a non-significant correlation between SE and CCT in their myopic group dataset (r = −0.018, p-value = 0.427), while this correlation was statistically significant in the whole study dataset (r = −0.067, p-value = 0.003). In addition, Chen et al found a non-significant correlation between SE and CCT in Taiwanese Chinese people (r = −0.034, p-value = 0.445). In another study on Chinese people, Fam et al studied CCT in a sample of 714 myopic patients with a mean age of 32.9 years (range 15–59 years) and found the mean CCT to be 534.5±38.1 µ; they found no significant correlation between CCT and SE (r = −0.13, p-value = 0.72).

In South India, Krishnan et al found a negative weak correlation between SE and CCT (r = −0.172, p-value = 0.03) and, in a black South African population, Mashige et al found a non-significant correlation between SE and CCT (r = 0.05, p-value = 0.25).

Ucakhan et al, in 2008 in Turkey, prospectively evaluated corneal elevation and thickness in relation to the refractive status measured with the Pentacam Scheimpflug system. They examined 215 patients with different types of refractive errors. They found no correlation between SE and CCT in the whole sample (r = 0.149, p-value >0.05). However, when comparing the high myopia group to other groups (low myopia, myopic astigmatism, hyperopia and emmetropia), they found CCT to be significantly lower in this group than in other groups.

In 2010, Nangia et al evaluated CCT and its association with ocular and general parameters in Indians (the Central India Eye and Medical Study). This study included 9370 eyes of 4711 participants. Mean CCT was 514±33µ, mean age was 49.1±13.2 years (range = 30–100 years) and mean refractive error was 0.19±1.50 diopters (rang = 20.0 to +6.00 diopters). In contrast to our results, they stated that, according to univariate analysis, there was a significant correlation between CCT and SE (r = 0.07, p-value <0.001); following multivariate analysis (including CCT, age, gender, and body mass index), CCT was no longer significantly correlated with SE (p-value = 0.54).

In contrast, Kadhim et al studied the distribution of CCT and its relation to age, SE and corneal power in a sample of the Iraqi population. They studied 418 eyes from 209 subjects ranging in age from 20 to 75 years and with different types of refractive errors. They found a statistically significant correlation between CCT and SE (r = 0.153, p-value = 0.002), which they attributed to the inclusion of a wide range of refractive errors in their study.

An earlier study by Mourad et al, in 2019, found that CCT was significantly lower in myopic and hyperopic patients (mean = 531 and 523.5, respectively) than in emmetropic people (mean = 555) in a sample of 84 eyes in Egyptian people.

In our work, CCT was found to be negatively correlated to average K to a weak statistically significant value, meaning that the steeper the cornea, the thinner the central corneal thickness (r = −0.089, p-value = 0.001). This was consistent with AlMahmoud et al's results in their myopic group (r = −0.113, p-value <0.001) and the whole dataset (r = −0.105, p-value <0.001). Kadhim et al also reported a significant negative correlation in the Iraqi population (r = −0.097, p-value = 0.048). In contrast, Mashige et al reported no significant correlation between CCT and average K in South African people (r = 0.16, p = 0.08). Chen et al also reported a non-significant correlation in Taiwanese Chinese patients (r = 0.013, p = 0.77).

Wirbelauer et al, in 2009, studied the influence of corneal curvature on central and paracentral pachymetry using Optical Coherence Tomography (OCT). That prospective study included 77 eyes of 77 patients with a mean age of 61±17 years (range 14–87 years) and reported that the correlation between corneal thickness and corneal power was non-significant in the center (r = −0.009, p = 0.935). However, it became significant in the paracentral areas measured in 4 points (r = 0.131, p = 0.021).

Age in our study was significantly correlated with CCT and non-significantly correlated with average K, in agreement with AlMahmoud et al regarding the myopic group in their study.

To conclude, among the myopic adult Egyptian population, the greater the myopic error measured, the steeper the cornea, with a weak positive correlation between refractive error and corneal power.

Limitations of this work include its retrospectiveness and its lack of assessment of axial length to differentiate between axial and index myopia. However, the fact that our study subjects were young candidates for refractive corneal surgery means that there was no place for index myopia. Also,
the age range from 18–40 years did not offer a chance for
other age groups to be represented in the study.

A multi-continental study on a larger number of
patients must be conducted in order to confirm the
relationship between CCT and ethnic origin.

Data Sharing Statement
All the data included in this study are available on request.

Ethics Approval
The study was performed according to the Declaration of
Helsinki, and adhered to the regulations of the Institutional
Review Board and ethical committee of Cairo University.
The study was approved by the ethical committee of the
Egyptian Society of Keratoconus and Corneal Transplants.

Patient Consent to Review Their
Data
Patient consent was not required by the ethical committee
of the Egyptian Society of Keratoconus and Corneal
Transplants in this retrospective study as patients’ names
were masked and their privacy respected.

Consent to Participate
Written consent was gained from all patients undergoing
LASIK and PRK procedures after the surgical techniques
and indications had been thoroughly explained to them.

Funding
We received no funding throughout the study. No financial
disclosure.

Disclosure
Mohamed S. Kotb states no conflicts of interest. Sherif
A. Eissa states no conflicts of interest.

References
1. Pallikaris I, Papatzanaki M, Statthi E, et al. Laser in situ keratomileusis.
Lasers Surg Med. 1990;10:463–468. doi:10.1002/lsm.1900100511
2. Sandoval H, Donnenfeld E, Kohnen T, et al. Modern laser in situ
keratomileusis outcomes. J Refract Surg. 2016;42(8):1224–1234.
doi:10.1016/j.jrs.2016.07.012
3. Lazreg S, Colin J. Central corneal thickness of North African
population. Invest Ophthalmol Vis Sci. 2011;52(14):5182.
4. Bohac M, Koncarevic M, Pasalic A, et al. Incidence and clinical
characteristics of post LASIK ectasia: a review of over 30,000
LASIK cases. Semin Ophthalmol. 2018;33(7–8):869–877. doi:10.1080/08820538.2018.1539183
5. Santhiago M, Giacomini N, Smadja D, et al. Ectasia risk factors in
refractive surgery. Clin Ophthalmol. 2016;10:713–720. doi:10.2147/
OPTH.S51313
6. Singh R, Goldberg I, Graham S, et al. Central corneal thickness,
tonometry, and ocular dimensions in glaucoma and ocular
hypertension. J Glaucoma. 2001;10(3):206–210. doi:10.1097/000
61198-200106000-00011
7. Damji K, Muni R, Munger R. Influence of corneal
variables on accuracy of intraocular pressure measurement.
J Glaucoma. 2003;12(1):69–80. doi:10.1007/00061198-2003020
0-00015
8. Lackner B, Schmidinger G, Pich, S, et al. Repeatability and reproduc-
cibility of central corneal thickness measurement with Pentacam,
Orbscan, and ultrasound. Optom Vis Sci. 2005;82(10):892–899.
doi:10.1097/01.ops.0000180817.46312.9a
9. Barkana Y, Gerber Y, Elbaz U, et al. Central corneal thickness
measurement with the Pentacam Scheimpflug system, optical
low-coherence reflectometry pachymeter, and ultrasound
pachymetry. J Cataract Refract Surg. 2005;31(9):1729–1735.
doi:10.1016/j.jcrs.2005.03.058
10. Cha J, Wong T. Myopia-the silent epidemic that should not be
ignored. JAMA Ophthalmol. 2016;134(12):1363–1364. doi:10.1001/
jamaophthalmol.2016.4008
11. Holden B, Fricke T, Wilson D, et al. Global prevalence of myopia
and high myopia and temporal trends from 2000 through 2050.
Ophthalmology. 2016;123(5):1036–1042. doi:10.1016/j.ophtha.20
16.01.006
12. Gonzalez Blanco F, Sanz Fernandez J, Munoz Sanz M. Axial length,
corneal radius, and age of myopia onset. Optom Vis Sci. 2008;85
(2):89–96. doi:10.1097/OPX.0b013e3181622602
13. Ip JM, Huyhn SC, Killey A, et al. Variation of the contribution from
axial length and other oculometric parameters to refraction by age
and ethnicity. Invest Ophthalmol Vis Sci. 2007;48(10):4846–4853.
doi:10.1167/iovs.07-0101
14. AlMahmoud T, Priest D, Munger R, et al. Correlation between
refractive error, corneal power, and thickness in a large population
with a wide range of ametropia. Invest Ophthalmol Vis Sci. 2011;52
(3):1235–1242. doi:10.1167/iovs.10-5449
15. Arora J, Anjea P, Mehta P, et al. Relation of refractive error with
corneal curvature of the eye in adult subjects with refractive error.
J Evol Med Dent Sci. 2015;4(51):8846–8855. doi:10.14260/jemds/
2015/1282
16. Kadhim Y, Farhood Q. Central corneal thickness of Iraqi population
in relation to age, gender, refractive errors, and corneal curvature:
a hospital-based cross-sectional study clinical. Ophthalmology. 2016;
10:2369–2376.
17. Chan YH. Biostatistics102: quantitative data – parametric & non-
parametric tests. Singapore Med J. 2003a;44(8):391–396.
18. Chan YH. Biostatistics 104: correlational analysis. Singapore Med J.
2003b;44(12):614–619.
19. Ucakhan ÖÖ, Gesoglu P, Ozkan M, et al. Corneal elevation and
thickness in relation to the refractive status measured with the
Pentacam Scheimpflug system. J Cataract Refract Surg. 2008;34
(11):1900–1905. doi:10.1016/j.jcrs.2008.07.018
20. Mashige K, Oduntan O. Corneal parameters and their correlations
with refractive error, axial length, anterior chamber depth and lens
thickness in black South Africans. Guoji Yanke Zazhi. 2017;17
(4):597–603.
21. Chen M, Liu Y-T, Tsai -C-C, et al. Relationship between central
corneal thickness, refractive error, corneal curvature, anterior cham-
der depth and axial length. J Chin Med Assoc. 2009;72(3):133–137.
doi:10.1016/S1726-4901(09)70038-3
22. Krishnan V, Jayalatha K, Vijayakumar C. Correlation of central
corneal thickness and keratometry with refraction and axial length:
a Prospective Analytic Study. Cureus. 2019;11(1):e3917. doi:10.77
59/cureus.3917
23. Fam H, How A, Baskaran M, et al. Central corneal thickness and its
relationship to myopia in Chinese adults. Br J Ophthalmol. 2006;90
(12):1451–1453. doi:10.1136/bjo.2006.101170
24. Nangia V, Jonas J, Sinha A, et al. Central corneal thickness and its association with ocular and general parameters in Indians: the Central India Eye and Medical Study. *Ophthalmology*. 2010;117(4):705–710. doi:10.1016/j.ophtha.2009.09.003

25. Mourad M, Rayhana R, Moustafaa M, et al. Correlation between central corneal thickness and axial errors of refraction. *J Egypt Ophthalmol Soc*. 2019;112(2):52–60. doi:10.4103/egos. ejos_18_19

26. Wirbelauer C, Thannhauser C, Pham D. Influence of corneal curvature on central and paracentral pachymetry with optical coherence tomography. *Cornea*. 2009;28(3):254–260. doi:10.1097/ICO.0b013e3181861ef0