Correlations between Central Corneal Power, Axial Length, Anterior Chamber Depth and Central Corneal Thickness of near-Emmetropic Young University Students in Palestine

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Abstract

Purpose: To investigate the correlation between the central corneal power (CCP) and a panel of variables which include axial length (AL), axial depth of the anterior chamber (ACD), and the central corneal thickness (CCT) in emmetropic eyes in young students in the Optometry Lab of the Islamic University-Gaza (IUG), Palestine.

Methods: In a prospective analysis, 200 emmetropic students were examined from February to May 2019 by the Ultrasound Scanner (A-scan), Ultrasonic Pachymeter, and Visionix L79 Automated Refractometer Keratometer (ARK)-Topography machines. Only the data of one eye was randomly chosen for investigation. The age range was 18-23 years with spherical equivalent (SE) refractive error of less than ± 0.50 D.

Results: The means and standard deviations (SD) of the CCP, AL, ACD, and CCT of the near-emmetropic male students (n=97) were 43.19 ± 1.34 D, 23.54 ± 0.68 mm, 3.59 ± 0.26 mm, and 549 ± 33 µm, respectively. In addition, the means ± SD in female subjects in 103 near-emmetropic female students of CCP were 43.85 ± 1.43 D, AL 22.94 ± 0.69 mm, ACD 3.35 ± 0.25 mm, and CCT 543 ± 35 µm. There was a significant association between CCP and gender (p=0.00). However, there was no significant difference in CCP values between the age groups (p=0.49). There was a negative significant correlation between CCP and AL for both the males (r=-0.64; p=0.00) and the females (r=-0.71, p=0.00) participants. The values of the correlation (r) were 0.15 and 0.08 between CCP and ACD of the male and female participants respectively. Additionally, no significant correlation was found between CCP and CCT for male and female eyes (p=0.16, p=0.86, respectively).

Conclusion: This study provided information for CCP, AL, ACD, and CCT in near-emmetropic eyes in young students in the optometry lab at the IUG, Palestine. Scores of CCP was normally distributed. CCP was not significantly influenced by age, ACD and CCT. In male students CCP was flatter, and AL was longer when compared with female Palestinian young students.

Keywords: Central Corneal Power, Axial Length, Anterior Chamber Depth and Central Corneal Thickness, Emmetropic Eyes.
1. Introduction

Cowan defines emmetropia as “a state of refraction in which parallel rays of light are brought to focus on the retina when the eye at the resting state”1. Emmetropia is considered a feature of the normal eye2. Researchers have found that the refractive states of the eye are influenced by a variety of variables including central corneal power (CCP) axial length (AL), anterior chamber depth (ACD) and central corneal thickness (CCT)3-5. Previous reports have shown that the prevalence of near-emmetropia in Saudi Arabia is 54.1%, Nigeria 71.5%, Germany 37%, Brazil 15.9%, and Pakistan is 36.7%6,7,8,9,10.

Researchers have shown that the central corneal power is a vital indicator of corneal status which forms two thirds of the focusing power of the eye11-12. The same group of researchers found that the axial length is defined as the distance between the anterior corneal surface to an interference peak corresponding to the retinal pigment epithelium/Bruch’s membrane, and AL is usually measured in millimeters. There were previous reports that the ACD is vital in newer theoretical biometric formulas for intraocular lens (IOL) power calculations and for the implantation of phakic IOLs13 and the depth of the AC is approximately 3.17 mm8. According to Doughty and Jonuscheit14 and Ashwin et al15 the CCT is an indicator of corneal health status and influences applanation tonometry with decisions for refractive surgery dependent on sufficient CCT.

It is important for practitioners to know about normal values for ocular parameters in near-emmetropic students in order to initiate proper management and assessment for patients. To evaluate the ocular component values of near-emmetropic students, we performed a prospective analysis using A-Scan Ultrasound Biometry, Pachymetry, and Autorefractor Keratometer. The results of this investigation may enhance the understanding of the relationship between CCP, AL, ACD and CCT in a sample of normal Palestinian young eyes.

Materials and Methods

A prospective study was carried out using a convenience sampling method based on the assessment of near-emmetropic students attending the Optometry Lab of the IUG, Palestine. Only the data of one eye was randomly chosen for investigation. The study protocol received approved from the local Ethics Committee. In this study, 200 young students were examined from February to May 2019. The appropriate sample size was determined based on OpenEpi software (Sullivan, Atlanta, GA, USA)16.

The age group of the present study was 18-23 years with spherical equivalent (SE) refractive error of less than ± 0.50 D. The clinical examinations included CCP, AL, ACD, and CCT measurements. The CCP, AL, ACD, and CCT were measured with the Ultrasonic Pachymeter (Sonomed PacScan 300AP and Combination A-Scan Pachymeter) with topical anesthesia (0.1% HCL Localin). The technique was measured at the apical corneal position by adjusting the tip of probe with minimal corneal compression. Three consecutive readings were recorded and then the average was used in the current research. We measured the central corneal power by using the Visionix L79 Automated Refractometer Keratometer (ARK)-Topography device. For each participant, the chin was rested on a chin rest and forehead against forehead rest of L79ARK-Topography. Values of the CCP were obtained prospectively in the present research. In this study, all students had uncompensated visual acuities (VA) between 6/6 to 6/7.5. Individuals with previous ocular surgeries or laser treatment, contact lens wear and those who are taking any form of medications such as antihistamines, diuretics and drugs used to treat high blood pressure were excluded from the study.

Data analysis was conducted using IBM SPSS (Version 20, SPSS Inc., Chicago, Illinois, USA). Scores were reported as means and standard deviation (SD) in near-emmetropic students, and significance was calculated at p<0.05. In this study, the distribution of CCP variable was shown by using the histogram chart. Independent sample t-test was applied to compare CCP values between male and female groups, and one-way ANOVA was applied to compare CCP scores between the age groups.
In addition, Pearson’s correlation coefficient was used to evaluate the correlations between the CCP and a panel of variables. The dependent factors included AL, ACD and CCT.

**Results**
A total of 200 students were examined aged between 18 and 23 years in the Optometry Lab of the IUG, Palestine. The means and SD of the CCP, AL, ACD, and CCT of the near-emmetropic male students (n=97) were 43.19 ± 1.34 D, 23.54 ± 0.68 mm, 3.59 ± 0.26 mm, and 549 ± 33 µm respectively. In addition, the means ± SD in female students in 103 near-emmetropic female participants of CCP were 43.85 ± 1.43 D, AL 22.94 ± 0.69 mm, ACD 3.35 ± 0.25 mm, and CCT 543 ± 35 µm (Table 1). Based on the finding of normality test, scores of CCP was normally distributed, as can be presented in Figure 1.

| Variable | CCP (D) | AL (mm) | ACD (mm) | CCT (µm) |
|----------|---------|---------|----------|----------|
| Male     | Mean ± SD | 43.19 ± 1.34 D | 23.54 ± 0.68 mm | 3.59 ± 0.26 mm | 549 ± 33 µm |
| Range    | 48.25 – 40.25 | 20.66 – 24.96 | 2.80 – 4.31 | 475 – 644 |
| Female   | Mean ± SD | 43.85 ± 1.43 D | 22.94 ± 0.69 mm | 3.35 ± 0.25 mm | 543 ± 35 µm |
| Range    | 47.25 – 40.00 | 21.11 – 24.86 | 2.72 – 4.09 | 427 – 625 |

SD: standard deviation; CCP: central corneal power; AL: axial length; ACD: anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: Dioptre; µm: micrometers.

Figure 1. Histogram presenting the distribution of CCP of near-emmetropic (97 males and 103 females) students, aged 18-23 years
Mean CCP scores by gender and age were shown in Tables 2 and 3. There was a significant association between CCP and gender (p=0.00). However, there was no significant difference in CCP values between the age groups (p=0.49).

**Table 2. Distribution of CCP in near-emmetropic students from 97 males and 103 females**

| Age | Male Mean ± SD | Female Mean ± SD |
|-----|----------------|------------------|
| 18y | 43.35 ± 1.55 D | 43.94 ± 1.63 D   |
| 19y | 42.84 ± 1.21 D | 43.34 ± 1.50 D   |
| 20y | 42.82 ± 1.56 D | 43.64 ± 1.53 D   |
| 21y | 42.45 ± 0.99 D | 43.10 ± 1.30 D   |
| 22y | 42.72 ± 1.40 D | 43.20 ± 1.94 D   |
| 23y | 42.59 ± 0.66 D | 44.38 ± 1.24 D   |

CCP: central corneal power; D: dioptre; SD: standard deviation; y: year. * Independent sample t-test

**Table 3. Distribution of CCP in near-emmetropic students in the age range 18–23 years, mean 20.5 years**

| Variable | 18y (n=19) | 19y (n=60) | 20y (n=47) | 21y (n=32) | 22y (36) | 23y (n=6) |
|----------|------------|------------|------------|------------|---------|-----------|
| CCP* Mean ± SD | 43.75 ± 1.59 D | 43.01 ± 1.32 D | 43.07 ± 1.68 D | 42.90 ± 1.23 D | 42.97 ± 1.70 D | 43.18 ± 1.92 D |

CCP: central corneal power; D: dioptre; SD: standard deviation; n: number; y: year. * One way ANOVA test for mean difference of CCP due to age, P=0.49

There was a negative significant correlation between CCP and AL for both the males ($r$=-0.64; $p$=0.00) and the females ($r$=-0.71, $p$=0.00) subjects (Figures 2 and 3). The values of the correlation ($r$) were 0.15 and 0.08 between CCP and ACD of the male and female students respectively (Table 4). Additionally, no significant correlation was found between CCP and CCT for male and female eyes ($p$=0.16, $p$=0.86, respectively).

Figure 2. Negative significant correlation between CCP and AL in male students (n=97)
Table 4. Pearson's correlation between CCP and a panel of biometric variables in male and female participants

| Dependent variables | Male n= (97) | Female n= (103) |
|---------------------|-------------|-----------------|
| AL (mm)             | $r = -0.64; \ p = 0.00$ | $r = -0.71, \ p = 0.00$ |
| ACD (mm)            | $r = 0.15; \ p = 0.86$ | $r = 0.08; \ p = 0.25$ |
| CCT (µm)            | $r = -0.12; \ p = 0.16$ | $r = -0.14; \ p = 0.86$ |

Significant correlation at ($p<0.05$); $n$: indicates the number of subjects; $r$: Pearson’s correlation coefficient; CCP: central corneal power; AL: axial length; ACD: Anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: dioptres; µm: micrometers

Discussion

To our knowledge, this is the first prospective analysis on the normal central corneal power in Gaza Strip, Palestine. Results from the current study showed that the mean ± SD for corneal power values were 43.19 ± 1.34 D for males and 43.85 ± 1.43 D for females. All students were near-emmetropic, healthy volunteers. The present findings are comparable to Mallen et al.\textsuperscript{17} who determined the normal central corneal power in near-emmetropic subjects in Jordan, although with different population age, sample size, methodologies and clinical tests used (Table 5). In male students CCP was flatter, and AL was longer when compared with female Palestinian young students. This reason might be due to female corneas were significantly thinner than male corneas as observed in Table 5\textsuperscript{8,18}. The present study revealed that the results for ACD were 3.59 ± 0.26 mm in male and 3.35 ± 0.25 mm in female near-emmetropic subjects. This is consistent with a previous study from Denemark\textsuperscript{19}. Our mean CCT, 549 ± 33 µm in male and 543 ± 35 µm in female participants, are slightly lower than the earlier finding\textsuperscript{20}. This might be due to variations in demographics, race, lifestyles, and diagnostic criteria used.

Histogram found that the CCP of our participants was normally distributed (see Figure 1). The normal distribution of CCP had been previously reported\textsuperscript{20-21}. In the current study, a significant correlation was observed between CCP and AL in near-emmetropic subjects (see Table 4) and this is in agreement with previous reports\textsuperscript{17-18}. R. P. C. LIRA et al.\textsuperscript{9} have also demonstrated that steeper corneas tended to have shorter axial length. In our study, no correlation...
was found between CCP and ACD in near-emmetropic eyes. On the other hand, previous report from Taiwan found a significant relationship between CCP and ACD\textsuperscript{18}. Asian eyes tend to have tighter eyelids and narrow palpebral apertures that could perhaps explain the different results between the present study and previous clinical study. No significant correlation was obtained between CCP and CCT in our finding. This result was corroborated by a more recent study from Germany\textsuperscript{8}. In contrast, Shimmyo \textit{et al}\textsuperscript{22} reported that CCP had negatively correlated with CCT.

It can be concluded that this study provided information for CCP, AL, ACD, and CCT in near-emmetropic eyes in young health in the optometry lab at the IUG, Palestine. Scores of CCP was normally distributed. Steep cornea tended to have shorter AL. Male had flatter corneas and longer AL than female Palestinian young adults. In contrast, CCP was not significantly influenced by age, ACD and CCT.

The information about the prevalence of emmetropia and the three types of refractive error (RE) ([myopia, hypermetropia, and astigmatism] and the three severity of RE (mild, moderate, and severe)) were not available in the current study. This is a limitation of this present study which should be addressed in future research. Intraocular pressure test (IOP) was not carried out in this study. This is also a limitation of the study.

Table 5. Summary of reports presenting the correlation between CCP and a panel of variables which include AL, ACD, CCT, gender, and age

| Authors          | Country/Area | Gender       | Mean age/Range age (yrs) | No of subjects | CCP (D) | AL (mm) | ACD (mm) | CCT (µm) | CCP vs. AL | CCP vs. ACD | CCP vs. CCT | CCP vs. Gender | CCP vs. Age |
|------------------|--------------|--------------|--------------------------|----------------|---------|---------|---------|---------|-----------|-----------|------------|-------------|-------------|-------------|
| Mallen \textit{et al}\textsuperscript{17} | Jordan       | Males Females | 29.28 yrs/27.59 yrs      | 1093           | 43.49 D | 23.33 mm| 22.99 mm| 3.17 mm| N/A       | S         | N/A        | N/A         | S           | N/A         |
| M. J. Chen \textit{et al}\textsuperscript{18} | Taiwan       | Males Females | 61.30 yrs/60.50 yrs       | 500            | 43.50 D | 23.50 mm| 23.00 mm| 3.00 mm| 555 µm    | S         | S          | N/A         | S           | NS          |
| Olsen \textit{et al}\textsuperscript{19}    | Denmark      | Males Females | 67.90 yrs/68.10 yrs       | 723            | 43.41 D | 23.74 mm| 23.20 mm| 3.20 mm| N/A       | S         | N/A        | N/A         | N/A         | N/A         |
| Zocher \textit{et al}\textsuperscript{5}    | Germany      | Males Females | 43.00 yrs/44.00 yrs       | 245            | 42.88 D | 24.20 mm| 23.40 mm| 2.92 mm| 559 µm    | S         | S          | N/A         | S           | S           |
| R. P. C. LIRA \textit{et al}\textsuperscript{21} | Brazil       | Males Females | 6–17 yrs/6–17 yrs         | 1100           | 43.30 D | 16.70 mm| 16.30 mm| 3.17 mm| 539 µm    | S         | S          | S           | NS          | NS          |
| Iyamu and Osuobeni\textsuperscript{18}    | Nigeria      | Males Females | 48.22 yrs/47.15 yrs       | 130            | 42.83 D | N/A     | N/A     | 3.54 mm| 549 µm    | S         | NS         | NS          | NS          | NS          |
| Current study   | Palestine    | Males Females | 20.17 yrs/22.00 yrs       | 200            | 43.19 D | 23.54 mm| 22.94 mm| 3.59 mm| S         | NS        | NS         | NS          | NS          | NS          |

yrs: years; No: number; CCP: central corneal power; AL: axial length; ACD: Anterior chamber depth; CCT: central corneal thickness; mm: millimeters; D: dioptre; µm: micrometers; S: statistically significant association; NS: statistically insignificant association; N/A: not applicable; vs. versus
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العلاقة ما بين قوة القرنية المركزية، طول العين، عمق الغرفة الأمامية للعين، سماكة القرنية المركزية في الطلاب الجامعيين الطبيعيين في فلسطين

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الملخص

الهدف: تم إجراء الدراسة للتحقق من العلاقة ما بين قوة القرنية وطول العين، عمق الغرفة الأمامية للعين، وسمك القرنية المركزية في الطالبين في الأشراف الطبيعيين في جامعة الفسطاط- بغزء، فلسطين.

منهجية البحث: تم إجراء دراسة وصفية على 200 طالب جامعي من شهرين فبراير إلى مايو 2019 باستخدام كل من جهاز طول العين، عمق الغرفة الأمامية، قوة القرنية،みな سماكة القرنية، وقياسات القرنية. هذه الدراسة أجراها فقط لعين واحدة والمنشأة العمرية مابين (18 إلى 23) سنة.

نتائج البحث: قيمة الانحراف العشوائي في الطلاب الذكور مكترت قوة تجديد القرنية 1.34 ± 0.19، وطول العين 0.68 ± 0.12، عمق الغرفة الأمامية 3.95 ± 0.14، وسمك القرنية 43.85 ± 0.14.

الخاتمة: هذه الدراسة روت الباحثين معلومات متعلقة بمقدار الانحراف العشوائي لكل من طول العين، عمق الغرفة الأمامية، سماكة القرنية، وقوة القرنية، وتعتبرهما مكونات رئيسية للجينات، بينما لا تتأثر بالعمر أو الغرفة الأمامية أو مركز القرنية. أخيرًا، الطلاب الذكور يمكنهم أطول للعين أعلى من الطالبنان، بينما تجدر القرنية أقل من الطالبلاات الأنثى.

الكلمات المفتاحية: قوة سماكة القرنية، طول العين، عمق الغرفة الأمامية، سماكة القرنية.