Correlation Between Central Corneal Thickness, Corneal Curvature, Corneal Endothelial Cell Density and Intraocular Pressure Measurements among A Sample of Non-Glaucomatous Population in Jordan

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Abstract

Aim: To study the interrelationships between central corneal thickness (CCT), radius of corneal curvature (CC), Endothelial Cell Density (ECD) and intraocular pressure (IOP) measurement using Goldmann applanation tonometry in a sample of non-glaucomatous Jordanian population.

Methods: 195 eyes of 195 normal volunteers with a mean age of 37.4 years were included in the study, of which 60.5% were male. Both CCT and ECD were measured using a non-contact specular microscope (SP-2000p: Topcon Corporation, Japan) while the CC was measured using the Javal-Schiotz keratometer (Haag-Streit mires). The Goldmann applanation tonometer was used for IOP measurement. Only right eyes were used for statistical analysis. Multiple linear regression analysis were used to explore the relationships between the study variables.

Results: The mean (±SD) IOP, CCT and ECD were 13.09 mmHg (±2.87), 514.6µm (±36.3) and 3076 (±558) cell/mm², respectively. There was no statistically significant difference in IOP, CCT and ECD between genders (student t-test, P=0.45, P=0.83, P=0.57, respectively). The mean CC was 7.69mm (±0.28) in male subjects and 7.59mm (±0.24) in female subjects, with a statistically significant P value of 0.014. The change in CC with advancement of age showed a P value of 0.005. Neither CC nor ECD had a statistically significant relationship with IOP (P= 0.81 and P=0.15), respectively. But there was a significant relationship between CCT and IOP ($P < 0.001$).

Conclusion: The results of this study showed that in a sample of non-glaucomatous Jordanian population: IOP, CCT and ECD were sex independent while corneal curvature was steeper in the sampled females. There was a significant relationship between CCT and IOP, but not between CC or ECD and IOP.

Keywords: Applanation tonometry, central corneal thickness, corneal curvature, endothelial cell density and intraocular pressure.

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Introduction

Several reports have been published since the early 1970s describing the effect of CCT, CC and axial length on intraocular pressure (IOP) measurements using the Goldmann applanation tonometer. [1-4] After the wide spread of refractive surgery, in which variable thicknesses of the cornea are ablated, this issue was re-addressed. In the late 1990s several studies reported that thinner corneas cause artificially low IOP reading while thicker corneas cause artificially higher IOP reading, thus producing apparent normal tension glaucoma and ocular hypertension, respectively. [5-9] The overall conclusion that has been drawn is that tonometry values can be subjected to error as a result of differences in corneal thickness. [10] Some authors advocated that central corneal thickness should be taken into account when assessing risk for the development of glaucomatous damage in patients with ocular hypertension, [11] and many studies used empirical as well as manometric controlled closed system methods to find what would be the correction factor for applanation IOP readings. Some suggested a 0.11 to 1 mmHg correction factor per 10µm deviation from the average CCT. [12-22]

Mark [23] first pointed out that flatter corneal curvature might lead to lower IOP measurements, a finding supported by other studies. [14, 15, 21, 24] Up to this time no previous studies [6, 25, 26] have really identified a definite relationship between radius of corneal curvature (CC) and IOP. The relationship between ECD and endothelial cell function and IOP has been the focus of some promising research attempts.

This study attempts to examine the effect of CCT, CC and ECD on IOP measurements in a sample from Jordan, and to explore interrelationships among these parameters in the studied population.

Materials and Methods

This study was carried out at the Ophthalmology clinic at Jordan University Hospital in Amman, Jordan. The sample was composed of Jordanian individuals aged between 20 and 80 years.

Sample Participants were randomly selected from those presenting to the Ophthalmology clinic for evaluation of any kind of non-glaucoma related complaints. Based on their medical history, individuals having previous intraocular surgery, corneal surgery, corneal disease, contact lens wear, glaucoma or other conditions possibly affecting CCT, IOP, ECD or CC in one or both eyes were excluded from the study. The study protocol was reviewed and approved by Research and Ethics Committee at Faculty of Medicine/ University of Jordan.

The procedure was explained properly and a signed consent form was obtained from each participant. Both CCT and ECD were measured using the non-contact Topcon SP-2000p specular microscopy (Topcon Corporation, Japan). The CC was measured using the Javal-Schoitz keratometer (Haag-Sreit mires). The values, essentially for the flatter and steeper horizontal and vertical meridians, were averaged to give a single K reading for each cornea. Goldmann applanation tonometry was performed after standard topical anesthesia with one drop of oxybuprocaine 0.4% using the Haag-Streit tonometer with slit lamp. All measurements were taken in this specific order.

An average of two consecutive readings was taken regarding all examined parameters. Throughout the study, the same tonometer, pachometer and keratometer were used for all participants to avoid variations between different machines. Every device was properly calibrated and all measurements were obtained by two ophthalmologists (Dr. Younis and Dr. Abu-Yaghi) who were masked to other results.

Unpaired t-test was used to test the difference between means, while multiple linear regression analysis was used to find the relationships between the study variables. A P value of < 0.05 was considered to be statistically significant.

Analyses were applied separately to right and left eyes due to the inherent association between eyes in a subject. [27] The right eye was considered for the statistical analysis to eliminate the possible intra-subject effect that might appear if both eyes of the same patient had been included.

Results

Of the 195 patients that were included in the study, 118 (60.5%) were male while 77 (39.5%) were female. The mean age of the study sample was 37.39 ± 15.74 years ranging between 20 and 80 years. This is mainly because more than 50% of the study population was below the age of 33 years.

Table (1) shows the demographic data of the sample.

Table (1): Mean intraocular pressure, central corneal thickness, corneal curvature and endothelial mean cell density.

	Male	**Female**	**Total**
%	60.5%	39.5%	100%
Mean(±SD) IOP(mmHg)	13.22 ± 3.11	12.9 ± 2.47	13.09± 2.87
Mean (±SD) CCT(µm)	515.23 ± 36.20	513.19 ± 35.34	514.82± 35.77
Mean(±SD)CC (mm)	7.69 ± 0.28	7.59 ± 0.24	7.65± 0.27
MCD(±SD) (cell/mm²)	3095 ± 572	3045 ± 539	3076± 558

The mean (±SD) IOP (13.09 ± 2.87mmHg, range: 6-22 mmHg), CCT (514.82 ±35.77µm, range: 415-603 µm) and ECD (3076±558 cell/mm², range: 1707-4390 cell/mm²), were found to be higher in males than females but with no statistically significant difference (P= 0.373, P= 0.833 and P= 0.58, respectively). Also, the mean radius of CC was found to be lower in females (7.69mm) than that of males (7.59mm) but with a statistically significant P value of 0.014. In addition, CC was found to be significantly steeper with advancement of age (P= 0.005). (Figure 1)

We found a solid significant relationship between CCT and IOP in our sample (P <0.001), which means that thicker corneas tend to have higher IOP readings than thinner ones (Figure 2). No such relationship was found between CC or ECD and IOP (P= 0.81 and P= 0.15 respectively), (Figures 3 and 4). No significant relationships existed between CCT and of CC (P = 0.122) or endothelial Count (P= 0.4), (Figure 5 and 6). Both CCT and ECD were found to decrease with increasing age but with no statistical significance (P= 0.71, P= 0.06). No correlation was found between ECD and CC (P=0.94).

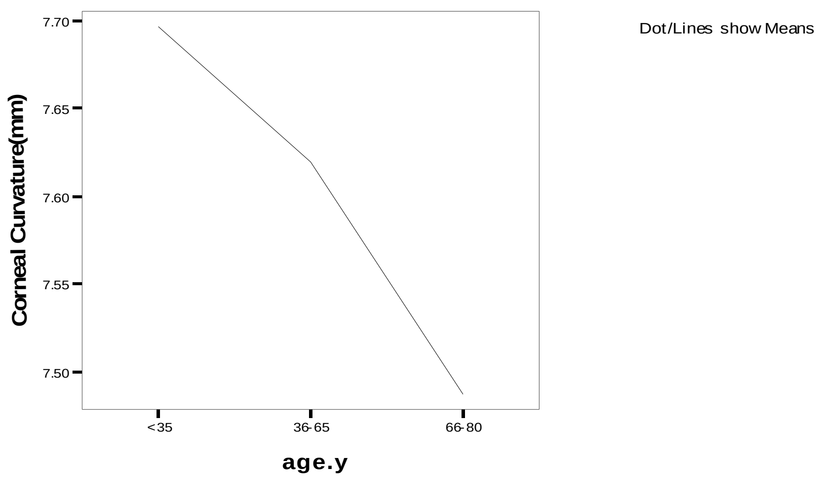

Figure (1): The relationship between Age (years) and CC (mm).

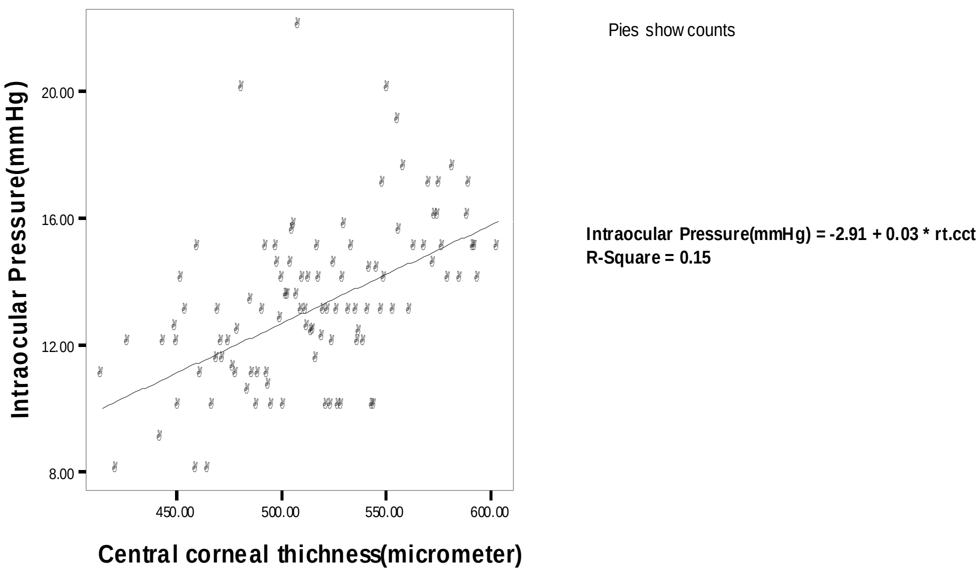

Figure (2): The relationship between CCT (µm) and IOP (mmHg).

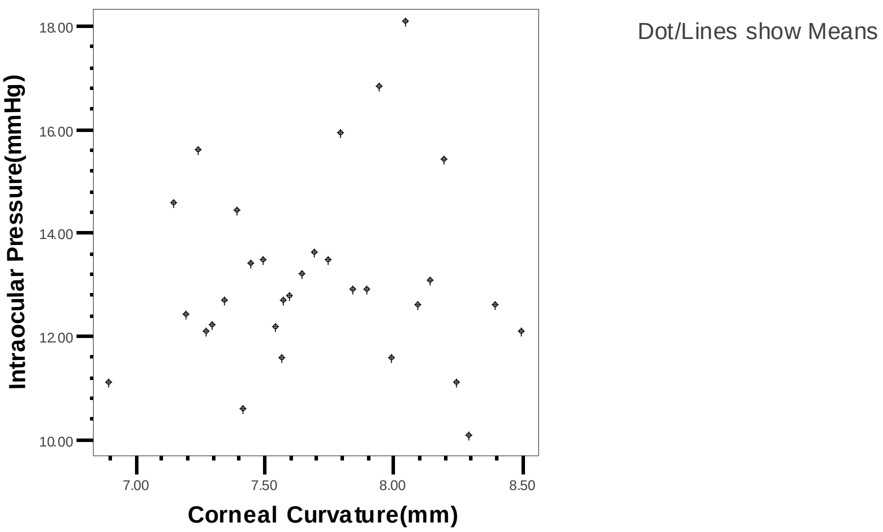

Figure (3)*:* ***The relationship between radius of CC (mm) and IOP (mmHg)***.

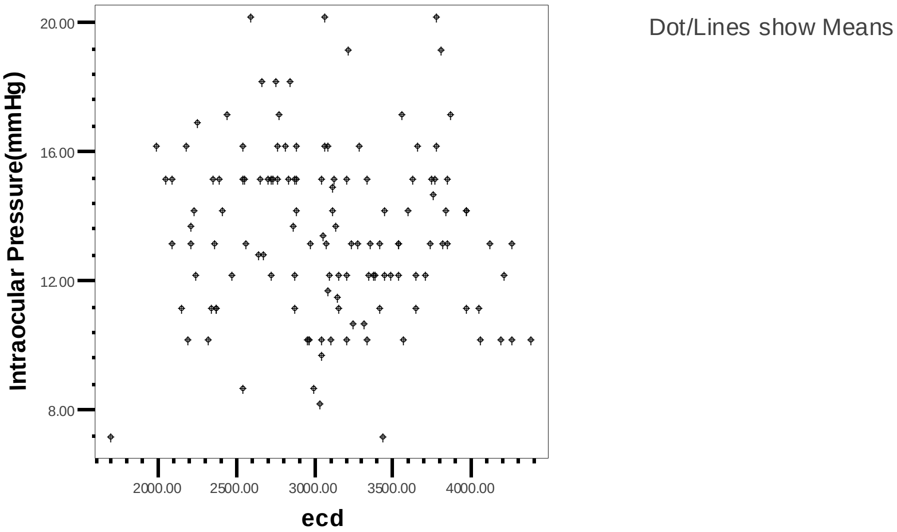

Figure (4): The relationship between ECD (cell/mm²) and IOP (mmHg).

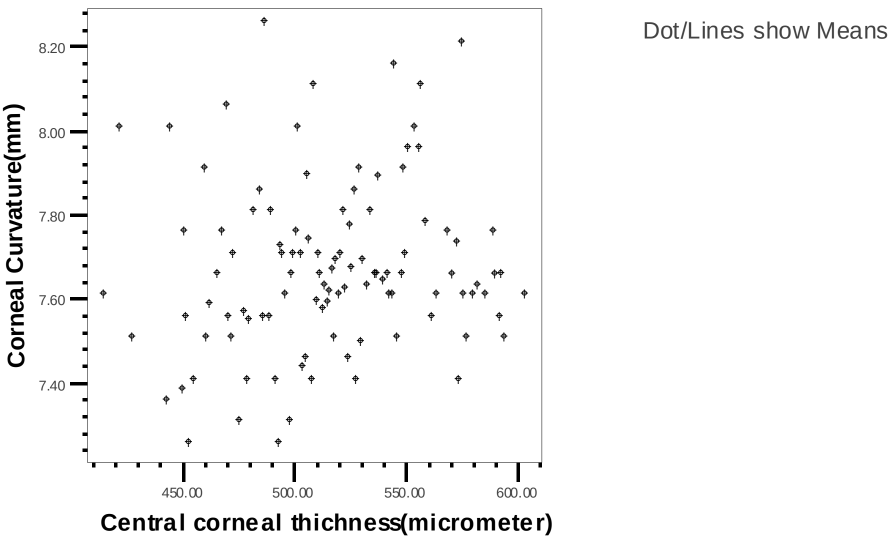

Figure (5): The relationship between CCT (μm) and Radius of CC (mm).

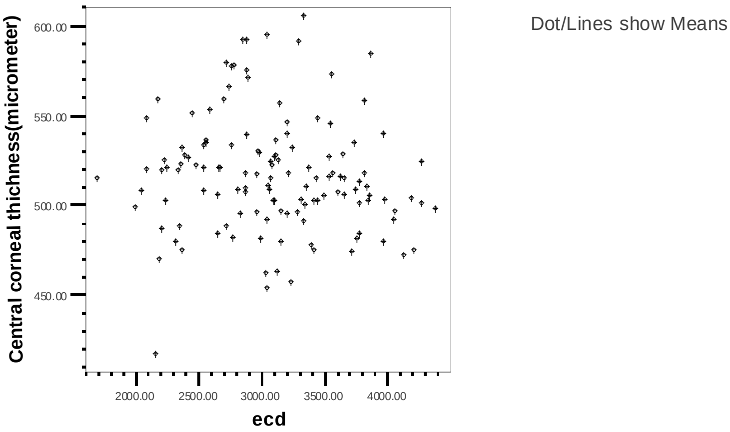

Figure (6): The relationship between ECD (cell/mm²) and CCT (μm).

Discussion

The mean CCT of our sample was comparable to others [26, 28-30] with no statistically significant difference between males and females. Although we did not find a significant relationship between age and CCT (P= 0.71), a finding consistent with other reports, [12, 26] Foster [31] and Alsbirk [13] found a significant decrease in CCT with advancement of age in Mongolian and Greenland populations, respectively, which might be attributed to environmental and/or genetic factors.

Our results demonstrated that CC was steeper in females, but this may be due to it being steeper with the advancement of age, or due to other factors such as body height or axial length. This is consistent with previous reports [28, 30] while one report by Eysteinsson [26] maintained that CC was found to be age-independent.

As it is well known, IOP measurement by Goldmann applanation tonometry is affected by CCT, CC and axial length. [3, 4] A margin of error ranging between 0.11 and 1 mm Hg for every 10μm of deviation from an average normal corneal thickness of 520μm has been suggested. [14-22] Our findings is in agreement with what was published previously and the relationship between the IOP and CCT was reproduced, reiterating the fact that a thin central cornea is a risk factor for a missed glaucoma as the IOP reading is underestimated. On the other hand, eyes with thicker corneas can be erroneously labeled with ocular hypertension. Doughty and colleagues [28] have pointed out that the magnitude of this effect did not provide any evidence that pachymetry needs to be integrated in glaucoma screening protocols based on tonometry. However they recommended that an unusually high or low reading should be investigated further. The scale of our study did not permit us to modify on this recommendation, although a larger sample can point out an exact relationship by providing tables of equivalent IOP readings for different CCT values.

Although many studies found that a change in the corneal curvature would affect the IOP readings, no relationship between CC and IOP was demonstrated in our sample (P= 0.15). CCT and CC appeared to be independent parameters as the relationship between them was not statistically significant (P= 0.122).

In 1988, Cheng et al. found a significant linear correlation between the increase in corneal thickness (delta CT) in the immediate postoperative period and the percentage of cell loss one and six months after cataract surgery. They concluded that the degree of endothelial cell loss can be predicted by how much the corneal thickness increased after surgery. [32]

Muller et al. suggested in 2004 that in an older population, lower ECD values would be expected in thinner and/or steeper corneas. [33] They recommended that future studies should focus on the investigation of the effects of corneal parameters on assessment of ECD within specific age groups.

In our study, we found no correlation between ECD and CCT (P =0.4) which is consistent with many previous articles. [33-37] Some authors found that endothelial cell numerical density within the physiological range is not correlated with CCT, and they suggested that endothelium morphology rather than the numerical density is more precise in evaluating the correlation between the endothelium and CCT. [38]

In our sample, we found that ECD is not correlated with CC (P= 0.94), and so we cannot predict that steeper corneas would be expected to have lower ECD. We found no significant relationship between ECD and IOP (P= 0.15). It may be useful to observe that our ECD values were way more than the minimal numerical cell density (physiological threshold, 400-500 cells/mm²) that is needed for a normal endothelial cell function.

In conclusion, this study aimed to explore the interrelationships between certain corneal parameters in a sample of non-glaucomatous Jordanian population and supported what was found previously that IOP tends to be artificially higher in thicker corneas. Pachymetry may be an essential parameter in following and treating glaucoma patients especially in extremes of CCT. Our study didn't prove a significant impact of CC or ECD on IOP measurements.

Future studies need to focus on what would be the effect of endothelial count and morphology on IOP measurements in different study populations including pre and post operative patients and in different ethnic groups.

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العلاقة ب اكة القرنية، و د ا، وكثافة ا لايا ا بطنة ا من جهة، وضغط الع من جهة أخرى عينة من الأردني

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ا لخص

ا دف: يهدف هذا البحث إ دراسة العلاقه ب اكة القرنية، و دبها، وكثافة ا لايا ا بطنة ا من جهة، وضغط الع من جهة أخرى عينة من الأردني ن لا يعانون ارتفاع ضغط الع (الزرق).

الطرق: ت دراسة 195 متطوعاً، معدل أعمارهم 37.4 سنة، ونسبة الذكور بينهم 60.5%. وحلّلت النتائج للمتغ ات أعلاه للع اليم فقط لغايات إحصائية.

النتائج: كان معدل ضغط الع 13.09 ملم زئبق، ومعدل كثافة ا لايا ا بطنة للقرنية 3076 خلية/ملم مربع، ومعدل اكة القرنية مركزيا 514.6 ميكرون.

ا لاصة: خلصت الدراسة إ وجود علاقه ذات أ ية إحصائية ب اكة القرنية وضغط الع ، ح أن العلاقة ب ضغط الع من جهة و دب القرنية وكثافة ا لايا ا بطنة ا من جهة أخرى تصل إ درجة الأ ية الإحصائية.

الكلمات الدالة: اكة القرنية، دب القرنية، كثافة ا لايا ا بطنة للقرنية، ضغط الع .