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ORIGINAL ARTICLE

Central Corneal Thickness and Corneal Hysteresis Together with Corrected Intraocular Pressure in Normal Population

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Abstract

Background: **Cornea is the transparent window on the front of the eye with a dome shape. The cornea forms the anterior part of the eye outer coat. This coat's primary function is to protect the intra ocular components. The cornea serves as a structural barrier and guards the eye against infections. It offers the eye's anterior refractive surface with the tear film. Two-thirds of the eye's refractive power contributed by the cornea.**

Objective: **The study aims to report and correlate central corneal thickness (CCT) by Pentacam, .corneal hysteresis (CH), corneal resistance factor. (CRF), corneal-compensated intraocular pressure. (IOP cc), and Goldenmann-correlated intraocular pressure. (IOP g) by ocular response analyser. (ORA) to know the average of the normal Egyptian population in Alsharquia government.**

Methodology: **This study was cross-sectional observational non-interventional study including 300 eyes of 150 persons randomly selected from the outpatient clinic of Alfath Private Eye Hospital, Zagazig, Alsharqia.**

Results: **Our study sees that there is statistically significant decrease on central corneal thickness with increase the age. Age was statistically significant negative correlated with CH and CRF. In our study there was statistically significant positive correlation between CCT with, CRF and IOP g among the normal population. While regarding IOP cc, there was no statistically significant correlation with CCT and statistically significant positive correlation with CRF.**

Conclusion: **CCT has a significant correlation with CH., CRF and IOP g and no significant correlation with IOP cc, sex or the type of the eye, however CCT was significantly decrease with increase the age.**

Keywords: Central corneal thickness, Corneal hysteresis, Intraocular pressure

1. Introduction

The transparent window on the front of the eye with a dome shape is called the cornea. The cornea forms the anterior part of the eye outer coat. This coat's primary function is to protect the intra ocular components. The cornea serves as a structural barrier and guards the eye against infections. It offers the eye's anterior refractive surface with the tear film. Two-thirds of the eye's refractive power is contributed by the cornea.[1]

Numerous ophthalmology applications require an understanding of the biomechanical characteristics of the cornea. The accurate measurement intraocular pressure (IOP) is known to be impacted by differences in the cornea's biomechanical properties. Improved diagnosis and staging of numerous corneal diseases may be achieved by a good acknowledging of the biomechanical behaviour of the cornea.[2]

Since its release in 2004, the Pentacam has gained popularity as a tool for assessing the anterior segment of the eye. The corneal surface is regularly examined using corneal tomography and Scheimpflug imaging. The technology can produce a three-dimensional map of the cornea using a rotatable Scheimpflug camera.[3]

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After delivering a metered collimated air pulse, the Ocular Response Analyzer (Reichert Ophthalmic Instruments) records corneal inward and outward applanation actions and gives an indicator of the viscoelastic behaviour of the cornea.[4]

The four initial parameters can be presented via the ORA. The corneal viscoelastic damping is represented by CH, which is the difference between those two pressure values. The Goldmann-correlated IOP is the average of these two pressures (IOP g). A pressure measurement known as the corneal-compensated IOP (IOP cc) uses the CH to calculate an IOP value that is less influenced by the characteristics of the cornea, like the central corneal thickness (CCT). The corneal resistance factor, or CRF, is a measure of overall corneal resistance that is determined using a proprietary algorithm.[5]

The Ocular Response Analyzer (ORA) signals contain properties that are not recorded by CH and the CRF can offer more details on the biomechanical variations between healthy and pathological corneas. Some researchers go into detail about the pressure, applanation signal intensity, and temporal response. Compared to the usual Ocular Response Analyzer variables, Some of these factors have demonstrated stronger keratoconus diagnostic utility. Additionally, recent research has demonstrated that ORA can play a significant role in expanding our knowledge of the glaucoma pathogenesis.[6]

The study aims to report and correlate central corneal thickness by Pentacam, corneal hysteresis, corneal resistance factor, corneal-compensated intraocular pressure, and Goldenmann-correlated intraocular pressure by ocular response analyzer (ORA) to know the average of the normal Egyptian population in Alsharquia government.

2. Patients and methods

Study design: This study was cross-sectional observational non-intervential study **Place of study:** This study was performed at Alfath Private Eye Hospital, Zagazig, Alsharqia **Period of study:** From January 2020 to September 2022 **Population of study:** 150 persons (300 eyes) of normal population.

2.1. Inclusion criteria

All persons who are within age from 16 to 50 years old, all persons who are with no other ocular disease like glaucoma or corneal scars, all persons who are with no history of VKC and all persons who are with no history of previous corneal or intraocular surgeries.

2.2. Exclusion criteria

Persons who are aged less than 16 or more than 50 years old, persons who are with other ocular disease like glaucoma or corneal scars, persons who have history of VKC and persons who are with history of previous corneal or intraocular surgeries.

2.3. Sample size

The sample will be 150 persons (300 eyes).

2.4. Study tools and procedures

History taking (name, sex, age, occupation, past ophthalmic history and medical history) and full ophthalmic examination, which includes:

Snellen's chart visual acuity, autorefractometer readings for refractive state, best corrected visual acuity (BCVA), slit-lamp microscopic examination: All participants underwent a thorough examination of the anterior segment, including examinations of the cornea, sclera, anterior chamber, iris, pupil, and lens, as well as fundus inspection by slit-lamp biomicroscopy utilising 90+ lenses. And all participant were photographed with (OCULUS-PENTACAM HR).

They sit in front of *pentacam*, no drops were added, no blinking or eye deviation until process of photography completed. 4 maps refractive display were printed and Central Corneal thickness (CCT) measurement were recorded.

They sit in front of ***Ocular Response Analyzer*** no drops were added, no blinking or eye deviation until process of photography completed. to measure.

Corneal Hysteresis, corneal Resistance Factor, corneal-Compensated IOP and Goldenmann-correlated IOP by ocular response analyzer (ORA) Tonometer

2.5. Ethical consideration

Each participant in this study provided written informed consent after being told of its objective and prior to participating in the study, which was authorised by the ethical council of the Faculty of Medicine for Girls at AL-Azhar University.

2.6. Statistical analysis

SPSS version 23 was used for data processing, data checking, data entry, and data analysis. The

Table 1. This table demonstrates the average value of corneal hysteresis. (CH), corneal resistance factor. (CRF), corneal-compensated intraocular pressure. (IOP cc), goldenmann-correlated intraocular pressure. (IOP g), BAD and Y-corrdinate among the normal population.

Eye examination	Total number of eyes (n = 300)
	mean ± SD (Range)
CRF	11.1 ± 2.7 (6.1–19.6)
IOP g	13.7 ± 3.2 (8–20.5)
IOP c	14.4 ± 3.3 (7.9–21.8)
CH	11.3 ± 2.8 (6.7–22.2)
BAD	1.02 ± 0.56 (−0.3–3.08)
Y-corrdinate	−0.3 ± 0.22 (−0.97–3.34)

results of this investigation were analysed using the following statistical techniques.

The data were presented as mean +standard deviation (SD) for quantitative factors and as number and percentage for qualitative variables.

Level of significance: The level of significance for all of the aforementioned statistical tests was set at 5%. (P-value).

When the *P* value is less than 0.05, the findings are considered significant. When the *P* value exceeds 0.05, the results are declared non-significant.

3. Results

Tables 1–6.

Oppositely CCT was statistically significantly negatively correlated with BAD. While regarding IOP cc, there was no statistically significant correlation with CCT Tables 7 and 8.

4. Discussion

In our study, CCT mean value was 543.7 ± 31.2 μm, Our study's findings were in agreement with **Prasad *et al.***[7] They performed research on 5158 consecutive patients who visited a practise for cornea and refractive surgery between August 4, 2000, and April 20, 2009. The Sonagage ultrasonic pachymeter was used to measure CCT. The mean corneal thickness was 544 34 m (range, 415–695 m).

Table 2. Average central corneal thickness among the normal population on Sharqia region.

Variable	Total number of eyes (n = 300)
	mean ± SD (Range)
Average central corneal thickness	543.7 ± 31.2 (481–634)
Average central corneal thickness	
400–500	27 (9.0%)
500–600	255 (85.0%)
≥600	18 (6.0%)

Table 3. Classes of ORA among the studied group This table shows that about half of the normal population (53.0%)) had suspected ORA, (36.0%) was normal ORA and (11.0%) was mild ORA according to keratoconus match index.

Classes of ORA	Total number of eyes (n = 300) Number (%)
Normal	108 (36.0%)
Suspect	159 (53.0%)
Mild	33 (11.0%)

Table 4. This table demonstrates that the central corneal thickness decreased with age in a statistically significant way, as age group ≥40 years had the lowest central corneal thickness than other age groups.

Age groups	CCT (n = 300)	F-test	*P* value
	mean ± SD (Range)		
≤20 years	545.9 ± 30.7 (501–607)		
20–30 years	552.2 ± 37.2 (494–634)		
30–40 years	542.4 ± 27.7 (488–619)	6.09	0.001**
≥40 years	511.5 ± 30.8 (481–542)		

**: Highly statistically significant different.

Table 5. This table shows that there was statistically significant increase in central corneal thickness among normal than suspected than mild ORA classes of the normal population.

ORA class	CCT (n = 300)	F-test	*P* value
	mean ± SD (Range)		
Normal	555.1 ± 33.5 (481–634)		
Suspected	543.9 ± 31.1 (507–630)	13.1	0.001[a]
Mild	535.9 ± 27.2 (483–619)		

[a] Highly statistically significant different.

But these results have disagreed with **Feltgen *et al.***[8] who conducted a study on 73 patients, In his study the CCT value ranged from 448 to 713 μm (mean 580 μm (SD ± 54 μm).

In Correlation between central corneal thickness and sex, our study stated that Males and females did not differ statistically significantly from one another.

Table 6. This table shows that there was statistically significant positive correlation between CCT with CH, CRF, IOP g and Y-corrdinate among the normal population.

Variables	Central corneal thickness		SIG
	r	*P* value	
Corneal hysteresis (CH)	0.2	0.001[a]	HS
Corneal resistance factor (CRF)	0.3	0.001[a]	HS
Corneal-compensated intraocular pressure (IOP cc)	0.04	0.4	NS
Goldenmann-correlated intraocular pressure (IOP g)	0.3	0.001[a]	HS
BAD	−0.4	0.001[a]	HS
Y-corrdinate	0.2	0.001[a]	HS

HS, highly significant; NS, non-significant; S, significant.
[a] Highly statistically significant different.

Table 7. This table shows that there was statistically significant increase on CH, CRF and IOP cc among normal than suspected than mild ORA classes of the normal population. While regarding BAD, there was statistically significant decrease on BAD among normal than suspected than mild ORA classes. On the other hand, IOP g wasn't statistically significant different among the different ORA classes.

Variable	Normal (number = 108)	Suspected (number = 159)	Mild (number = 33)	F-test	*P* value
	mean ± SD	mean ± SD			
CH	12.3 ± 2.6	11.1 ± 2.9	10.8 ± 2.8	10.4	0.001[a]
CRF	12.2 ± 2.7	10.9 ± 2.2	10.5 ± 2.6	13.6	0.001[a]
IOP cc	15.1 ± 4.3	14.9 ± 3.3	13.6 ± 2.9	5.8	0.003[b]
IOP g	13.7 ± 3.1	13.6 ± 3.2	13.7 ± 3.7	0.02	0.9
BAD	0.91 ± 0.5	1.07 ± 0.6	1.1 ± 0.4	3.3	0.04[b]

[a] Highly statistically significant different.
[b] Statistically significant different.

regarding the central corneal thickness like **Saulius *et al.***[9] who conducted a study in which no statistically significant difference was found between the sexes ($P > 0.05$).

In the correlation between CCT and Age, our study stated that there is statistically significant decreases in central corneal thickness value with the increase in the age which has agreed with **Saulius *et al.***[9] who conducted a study on 211 Caucasian patients (358 eyes) and has disagreed with **Prasad *et al.***[7] who conducted a study that found no correlation between age and CCT (r2 = 0.00645) This disagreement may be due to the large number of sample, and different instruments.

In the correlation between CH and CRF with Age, Age was negatively correlated with corneal hysteresis (CH) and corneal resistance factor (CRF) this has agreed with **Sharifipour *et al.***[10] They studied 302 healthy people throughout 6 age decades (10–69 years) in Iran and found that corneal hysteresis and corneal resistance factor both significantly decreased with age and has agreed also with **Ali**[11] They studied 195 Egyptians across various age groups. According to the study, there is a strong correlation between age and both CH and CRF. As people get older, and the mean CRF as well decreases with increasing the age. Like also **El Massry *et al.***[12] who carried out a study on 997 healthy people in Alexandria, Egypt. The corneal biomechanical properties CH and CRF decrease with the increase in the age. IOP g and IOP cc change slightly with the increase in the age.

Table 8. This table shows that there was statistically significant positive correlation between CRF with CH, IOP g and IOP cc. While age and BAD were statistically significant negatively correlated with CRF. In regard to Y-corrdinate, it was not statistically correlated with CRF among the normal population.

Variables	Corneal resistance factor (CRF)		
	R	*P* value	SIG
Age	−0.2	0.001[a]	HS
Corneal hysteresis (CH)	0.9	0.001[a]	HS
Corneal-compensated intraocular pressure (IOP cc)	0.5	0.001[a]	HS
Goldenmann-correlated intraocular pressure (IOP g)	0.18	0.001[a]	HS
BAD	−0.12	0.02[b]	S
Y-corrdinate	0.03	0.9	NS

HS, highly significant; NS, non-significant & S, significant.
[a] Highly statistically significant different.
[b] Statistically significant different.

Corneal hysteresis and corneal resistance factor results in our study were: CH mean value was 11.3 ± 2.8 range (6.7–22.2) and CRF mean value was 11.1 ± 2.7 range (6.1–19.6) of mean age 25.8 ± 6.1 range (18–43). Like **Chen *et al.***[13] who conducted a study on 20 healthy individuals in Hong Kong of mean age 24.1 ± 2.6 CH mean value 11.1 ± 1.1 CRF mean value 10.7 ± 1.3. However in **Ali**[11] who conducted a study in which The mean CRF measurement was 10.25 0.15 mm Hg (range, 4.9–14.2) and the mean CH measurement was 10.25 0.12 mm Hg (range, 6.5–14.4), with a mean age of 45.

Corneal-compensated intraocular pressure (IOP cc) result in our study was 14.4 ± 3.3 which has agreed with **Ouyang *et al.***[14] They did a study on 296 randomly selected eyes from 158 healthy subjects' eyes to assess IOP. IOP readings were 15.21 2.77 mm Hg with ORA (IOP cc) and 14.95 2.99 mm Hg with ORA (IOP g) in normal participants; in our study, IOP g was 13.7 3.2.

In correlation between CCT and corneal biomechanics our study stated that there was statistically significant positive correlation between CCT with CH, CRF and IOP g among the normal population.

That has agreed with **Mangouritsas *et al.***[15] who carried out a study on 74 non-glaucoma patients with IOP 21 mm Hg and found that CCT was substantially correlated with corneal biomechanical reaction in non-glaucoma subjects.

While regarding IOP cc, It has no statistically significant correlation with central corneal thickness (CCT) but it has statistically significant positive correlation with corneal resistance factor (CRF).

That has agreed with Ouyang *et al.*[14] who carried out a study in which the correlation between CH and IOP cc as evaluated by ORA was better than that between CCT and CH.

4.1. Conclusion

Our study is first study to measure all corneal biomechanics by ORA in correlation with CCT, age and sex among Egyptian adults in the same study. Our study seeks to know the average data (normal values) of each parameter on each own and to correlate each one to the other.

It could be concluded from this study that CCT has a significant correlation with CH., CRF and IOP g and no significant correlation with IOP cc, sex or the type of the eye, however CCT was significantly decrease with increase the age.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

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Conflicts of interest

The authors declared that there were NO conflicts of Interest.

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