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Correlation between Refractive Errors and Intraocular Pressure after Adjusting by Central Corneal Thickness

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ABSTRACT

Background: There is a significant correlation between myopia and intraocular pressure as an increase in the intraocular pressure (IOP) was on a higher side in high and moderate myopias in comparison to emmetropic and low myopic patients indicating higher degrees of myopia as an important risk factor for ocular hypertension.

Objective: To investigate the correlation between refractive status and intraocular pressure after adjusting for central corneal thickness.

Patients and Methods: This study was conducted in the Ophthalmology Department at Zagazig University Hospitals on patients with refractive errors within 20-40 years with no detectable systemic or ocular pathologies that could affect the outcome of the study. The spherical equivalent of refractive errors ranges in myopia from -1 to -6 and in hypermetropia from +1 to +6. The sample was (50) eyes to be divided into two groups. It was calculated using Open Epi Program with a Confidence level of 95% and power of 80%

Results: The mean CCT of the studied myopic group was 544.68 ± 29.62, while among the studied hypermetropic group it was 548.9 ± 32.5, there was no statistically significant difference between both groups regarding central corneal thickness. The mean IOP of the studied myopic group was 17.44 ± 2.41. While among the studied hypermetropic group it was 13.92 ± 1.8, there was a highly statistically significant difference between both groups regarding IOP.

Conclusion: There was a statistically significant correlation between intraocular pressure and myopia with intraocular pressure being higher in the moderate myopic patient than in low myopia, thereby increasing the risk of glaucoma in these patients.

Keywords: Central corneal thickness, Intraocular pressure, Spherical equivalent refractive error.

INTRODUCTION

Accurate measurement of intraocular pressure is an important parameter in ophthalmic examinations, for the diagnosis and the follow-up of glaucoma. Goldmann applanation tonometer (GAT) is considered the standard for measurement of IOP. However, measurement with GAT depends on many factors, such as curvature and central corneal thickness. Higher IOP values were detected by Rebound tonometry (RT). The IOP readings exceed the GAT values usually in a range of less than 1 mmHg generally in the myopic eye. The (RT–GAT) discrepancy is related to the refractive error, but not to central corneal thickness (CCT) [(1)].

Han *et al.* [(2)], reported that IOP is positively correlated with refractive errors. Myopes have higher IOP than the Emmetropes and the IOP of hyperopes is less compared to Emmetropes. Also raised IOP is the modifiable major risk factor for the development of glaucoma is influenced by other systemic parameters such as blood pressure and pulse pressure. Glaucoma is the second commonest cause of irreversible blindness and visual impairment.

The relationship between refractive error and IOP is an area of a discrepancy. myopia may be associated with the risk of primary open-angle glaucoma and hyperopia with a possible risk of ocular hypertension. Considering this variability in IOP in different populations and the inconsistencies in relation to IOP with age, gender, and refractive error [(3)].

The myopic refractive error and the intra-ocular pressure seem to have a significant correlation as such that with the increase of myopic refractive error there was an increase of the IOP. The myopic refractive error and the CCT seem to have a significant correlation as such that with the increase of myopic refractive error there was a decrease of the central corneal thickness [(4)].

Fern *et al.* [(5)]**,** confirmed the relationship between central corneal thickness manifest refractive errors and intraocular pressure. The cornea of myopic eyes was significantly thinner than that of control and hyperopic eyes.

Central corneal thickness plays an important role in understanding the risk of glaucoma. The corneal thickness of less than 555µm provides false results of low intraocular pressure, whereas, the corneal thickness of more than 555µm provides a false result of raised intraocular pressure when measured with GAT where IOP measurement is altered by the corneal thickness [(6)]**.**

Central corneal thickness and IOP have an independent effect on the risk of developing POAG.

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When GAT was introduced in the 1950s, the thickness of the cornea was recognized as a potential confounder to IOP measurement. Several investigators have developed formulae to "adjust" IOP as measured by GAT for CCT. These formulae have been based on cannulation studies of the eyes during cataract surgery [(7)]. The present study aimed to investigate the correlation between refractive status and intraocular pressure after adjusting for central corneal thickness.

PATIENTS AND METHODS

This Prospective cross-sectional study was conducted in the Ophthalmology Department at Zagazig University Hospitals. Fifty patients with refractive errors, divided into 2 groups 25 are myopic eyes and 25 are hypermetropic eyes. During the period from May to December 2019.

Ethical Considerations

Written informed consent was obtained from all children's parents, **the study was approved by the research ethics committee of the Faculty of Medicine, Zagazig University.** The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: The patients are between 20-40 years old with no detectable systemic and ocular pathologies that could affect the outcome of the study. The spherical equivalent of refractive errors ranges in myopia from -1 to -6 and in hypermetropia from +1 to +6.

Exclusion criteria: Patients with significant corneal pathology, such as scarring, edema, keratoconus, or dystrophy, were excluded. Additionally, those with a history of recent contact lens wear, ocular surgery, ocular trauma or glaucoma, or cataract were excluded. also, patients who will have evidence of systemic disease or pregnancy will be excluded. Lastly, patients with astigmatism more than +3 or -3 are excluded too.

All patients were subjected to the following:

Data collection: Data collected for all patients at the time of hospital visit, the data-collection sheet

Full History taking from the patient including demographic characteristics, such as name, age, sex, and gender.

Ophthalmological examination including external examination of eyebrows and eyelids as well as Visual acuity by Snellen's Vision-Box. Full Slit-lamp examination to the anterior and posterior segment of the eye. Also, Tear break up time and Ocular Surface Dye Staining with Fluorescein Green dye to assess the extent of ocular surface damage was done.

Measurement of the intraocular pressure: The IOP was assessed with the Slit-lamp mounted Goldmann applanation tonometer after sterilizing the tonometer probe with hydrogen peroxide and applying tetracaine Hcl 0.1% and staining the eye with a wetted fluorescein strip. Three consecutive readings are taken, and the average recorded as measured IOP (mIOP) in mmHg, and the IOP measurements were taken 10 minutes after pachymetry.

Measurement of central corneal thickness by Sirius Topography with Scheimpflug Camera.

Sirius (Costruzione Strumenti Oftalmici, Florence, Italy) topography consists of a combination of rotating Scheimpflug camera and Placido disk and allows full analysis of the topography and elevation of the anterior and posterior corneal surface and full corneal thickness [(8)]. All measurements of CCT and IOP were taken between 9 am and 12 noon to avoid diurnal variation [(9)].

Regarding the adjusted IOP reading it was calculated following variable, GAT reading, and CCT. The calculation by using a software of Sirius Topography with Ehllars Formula**.**

Assessment of the refractive error Objectively with Topcon KR.800 Computerised auto refractometer, made in Japan, and subjectively by Trial Box containing different lenses and trial frame.

Refractometry:

Refractometry (Optometry) is an objective method of finding out the error of refraction by use of equipment called a refractometer. Refractometry utilizes the principles of indirect ophthalmoscopy. Presently, the computerized auto refractometer, both objective as well as subjective modern auto refractometer are available commercially; which are being used increasingly. The computerized, auto refractometer quickly gives information about the refractive error of the patient in terms of a sphere, cylinder with an axis, and interpupillary distance. This method is a good alternative to retinoscopy by busy practice. It is also advantageous for mass screening, research programs, and epidemiological studies. The subjective verification of refraction is a must even after auto refractometry [(10)].

Statistical Analysis

The collected data were analyzed by computer using Statistical Package of Social Services version 24 (SPSS), Continuous Quantitative variables were expressed as the mean ± SD & median (range), and categorical qualitative variables were expressed as absolute frequencies (number) & relative frequencies (percentage). The results were considered statistically significant when the significant probability was less than 0.05 ($P < 0.05$).P-value < 0.001 was considered highly statistically significant (HS), and P-value ≥ 0.05 was considered statistically insignificant (NS).

RESULTS

Table (1), showed that the mean age of the studied myopic group was32.3± 5.61years old, with a range from 23 to 40 years old.

And 38.5% of them were males, while 61.5 % were females, while the mean age of the studied hypermetropic group was 35± 6.59 years old, with a range from 20 to 40 years old.

And 46.2 % of them were males, and 53.8 % were females, there was no statistically significant difference between both groups regarding sex and age.

Table (1): Demographic data of the studied groups

Demographic data	Myopic patients		Hypermetropic patients		MWt/χ^2	p-value
	No.25	%	No.25	%		
Age (years)						
Mean ± SD	32.3± 5.61		35± 6.59		59.50	0.193 (NS)
Median (Range)	33(23-40)		38(20-40)			
Sex						
Male	10	38.5	12	46.2	Fisher's	1.000 (NS)
Female	15	61.5	13	53.8		

MWT: Mann- Whitney test **Chi-square test** **P-value <0.05 is significant**
S: Statistically significant **NS: Non-significant**

Table (2), showed that among the studied myopic group BCVA was 1.0 in 88 % of the studied eyes also among the studied hypermetropic group BCVA was 1.0 in 88% of the studied eyes, with no statistically significant difference between both groups.

Table (2): Best-corrected visual acuity (BCVA) among the studied eyes (N=50)

BCVA	Myopic eyes (N=25)		Hypermetropic eyes (N=25)		χ^2	p-value
	No.	%	No.	%		
1.0	22	88.0	22	88.0	0.667	0.717 (NS)
0.8	2	8.0	1	4.0		
0.6	1	4.0	2	8.0		

Chi-square test **P-value <0.05 is significant** **NS: Non-significant**

Table (3), showed that the mean IOP of the studied myopic group was 17.44± 2.41 mmHg, while among the studied hypermetropic group it was 13.92± 1.8 mmHg, there was a highly statistically significant difference between both groups regarding IOP.

Table (3): Intraocular pressure(IOP)among the studied eyes before adjustment

IOP	Myopic eyes (N=25)	Hypermetropic eyes (N=25)	MWt	p-value
Mean ± SD mmhg	17.44± 2.41	13.92± 1.8	84.000	0.000* (HS)
Median	18	14		

MWT: Mann- Whitney test **P-value <0.05 is significant** **HS: highly significant**

Table (4), showed that the mean Spherical equivalent (SE) of the studied myopic group was -2.56± 1.6 D while among the studied hypermetropic group it was +3.35± 1.23 D, there was a highly statistically significant difference between both groups regarding Spherical equivalent (SE).

Table (4): Spherical equivalent (SE) among the studied eyes

SE	Myopic eyes (N=25)	Hypermetropic eyes (N=25)	MWt	p-value
Mean ± SD (D)	-2.56± 1.6	3.35± 1.23	0.000	0.000* (HS)
Median	-2.25	+2.75		

MWT: Mann- Whitney test **P-value <0.05 is significant** **HS: highly significant**

Table (5), showed that there was a statistically significant negative correlation between Spherical equivalent and IOP and AIOP (r=-0.728 and r=-0.499, P-value <0.05), regarding central corneal thickness, there was a statistically significant negative correlation between AIOP and CCT(r=-0.419, p-value <0.05) but there was a positive correlation between CCT and IOP(r=0.521, p-value<0.05).

Table (5): Correlation matrix between SE, IOP, AIOP, and CCT among the studied myopic eyes

Correlation Coefficient		SE	AIOP	IOP
AIOP	**R**	**-0.728****		
	p-value	**0.000**		
IOP	**R**	**-0.499***	**0.472***	
	p-value	**0.011**	**0.017**	
CCT	**R**	**0.099**	**-0.419***	**0.521****
	p-value	**0.638**	**0.037**	**0.008**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table (6), showed that there is a statistically significant positive correlation between Spherical equivalent and AIOP (r=0.447, P-value <0.05), regarding central corneal thickness, there was a statistically significant negative correlation between AIOP and CCT(r=-0.681, p-value <0.05) but there was a positive correlation between CCT and IOP(r=0.804, p-value<0.05).

Table (6): Correlation matrix between SE, IOP, AIOP, and CCT among the studied hypermetropic eyes.

Correlation Coefficient		SE	AIOP	IOP
AIOP	**R**	0.447*		
	p-value	0.025		
IOP	**R**	0.089	-0.201	
	p-value	0.674	0.336	
CCT	**R**	-0.134	-0.681**	0.804**
	p-value	0.524	0.000	0.000

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

It is generally accepted that there is an increased prevalence of glaucoma among myopic eyes. Myopic eyes had 1.6 to 3.3 times increased risk of glaucoma. One of the reasons why glaucoma should be more frequent in myopic eyes seems to be higher intraocular pressure (IOP) in myopic eyes compared with non- myopic eyes. This causal relationship can be rationalized by the knowledge that IOP is still considered an important risk factor for the development of glaucoma [(11)].

The Visual Impairment Project in Australia showed that the mean IOP among patients with newly developed glaucoma over 5 years was significantly higher than that among the non- incident cases. Furthermore, it has been suggested that myopic eyes are more susceptible to the effects of elevated IOP. It has been also proposed that myopic eyes have abnormal connective tissue that could predispose to glaucoma [(12)].

There is evidence from the literature that a correlation exists between refractive status and IOP [(11)]. Even after adjusting for age, sex, diabetes, and blood pressure, the mean IOP higher in myopic eyes compared with IOP were approximately 0.5 non- myopic eyes in the Blue Mountains Eye Study [(13)]. However, little is known about the true relationship between refractive status and IOP taking into account the central corneal thickness (CCT), as the CCT has a significant influence on IOP measurement.

As regarding our results, the study showed that the mean age of the studied myopic group was 32.3 ± 5.61 years old, with a range from 20 to 40 years old. And 38.5% of them were males, and 61.5 % were females, while the mean age of the studied hypermetropic group was 35 ± 6.59 years old, with a range from 20 to 40 years old. And 46.2 % of them were males, and 53.8 % were females, there was no statistically significant difference between both groups regarding sex and age. Which in agreement with the study of **Mourad *et al.***[(14)]**,** who reported that the mean age of all patients was 33.75±7.56 years. Regarding sex of the patients, 53.6% of patients were females, whereas 46.4% were males with no statistically significant difference between studied groups and study of **McGhee *et al.***[(15)], who found that hypermetropic patients who come to refractive surgery are older than myopic patients with a statistically significant difference.

The current study showed that among the studied myopic group BCVA was 1.0 in 88 % of the studied eyes also among the studied hypermetropic group BCVA was 1.0 in 88% of the studied eyes, with no statistically significant difference between both groups and among the studied myopic group VA was 0.33, 0.1 and 0.6 in 32%, 24% & 20% respectively while among the studied hypermetropic group VA was 0.3, 0.1 and 0.6 in 32%, 16% & 4% respectively, with no statistically significant difference between both groups. Which in agreement with the study of **Karthikeyan and Meenakshi [16],** who found that a final visual acuity of 0.8 or better was achieved by 51% (34/66) of myopic amblyopes and 52% (18/34) of hypermetropic amblyopes. Visual acuities of 0.6–0.4 were achieved in 34% (23/66) of myopes and 41% (14/34) of hyperopes. Final visual acuities of 0.3 were achieved in 13% (9/66) of myopes and 5% (2/34) of hypermetropes.

The current study showed that the mean IOP of the studied myopic group was 17.44 ± 2.41 mmHg., while among the studied hypermetropic group it was 13.92 ± 1.8 mmHg, there was a highly statistically significant difference between both groups regarding IOP, which in agreement with the study of **Jarade *et al.* [17],** who reported that the mean IOP was 14.22 ± 2.56 mmHg and 13.70 ± 2.09 mmHg in the hyperopic and myopic groups respectively with a highly significant difference (P < .001). Also, the study of **Osaiyuwu and Edokpa [18]**, who demonstrate that in the Nigerian population recently diagnosed with POAG, myopes had a higher mean intraocular pressure as compared to hypermetropes. The myopes also had a mean IOP value higher than normal when contrasted with hyperopes

The current study showed that the mean Spherical equivalent (SE) of the studied myopic group was -2.56 ± 1.6 D While among the studied hypermetropic group it was +3.35 ± 1.23 D, there was a highly statistically significant difference between both groups regarding Spherical equivalent (SE), which in agreement with the study of **Iyamu *et al.* [19]**, who reported a high significant difference between myopic group and hypermetropic group.

The current study showed that there was a statistically significant negative correlation between Spherical equivalent and IOP and AIOP (r=-0.728 and r=-0.499, P-value <0.05), regarding Central corneal thickness, there was a statistically significant negative correlation between AIOP and CCT(r=-0.419, p-value <0.05) but there was a positive correlation between CCT and IOP(r=0.521, p-value<0.05). Our results agreed with the study of **Wei *et al.* [6],** who found that the mean CCT and IOP were 554.19±35.46 µm and 15.31±2.57 mmHg respectively. There were significant correlations between the CCT and IOP values. Linear regression analysis revealed a positive correlation between CCT and IOP (r = 0.44, P<0.05).

This study showed that there is a statistically significant positive correlation between spherical equivalent and AIOP (r=0.447, P-value <0.05), regarding central corneal thickness, there was a statistically significant negative correlation between AIOP and CCT(r=-0.681, p-value <0.05) but there was a positive correlation between CCT and IOP(r=0.804, p-value<0.05). Our findings agreed with the study of **Nomura *et al.* [20],** who investigated the relationship between intraocular pressure (IOP) and refractive errors after adjusting for age, central corneal thickness (CCT), and other related factors.

There was a positive correlation between IOP and increasing degrees of myopia [11]. Nevertheless, it has also been reported that no difference in IOP was detected between the two eyes in anisometropic subjects with unilateral myopia. Therefore, the relationship between IOP and myopia has been inconclusive. However, little or no evidence considering the influence of CCT on this relationship has been reported, although the influence of CCT on IOP measurement seems critical. The data reported here show that there is a positive significant association between IOP and advancing degrees of myopia, even after adjusting for CCT, and other relevant factors.

CONCLUSIONS

The myopic refractive error and the intra-ocular pressure seem to have a significant correlation as such that with the increase of myopic refractive error there was an increase of the intraocular pressure. These findings support the hypothesis that the relationship between glaucoma and myopia might be pressure mediated.

RECOMMENDATIONS

Further studies with a larger sample size are recommended which can shed more light on the relation between refractive error and adjusted intraocular pressure. Performing other studies using additions of axial length to differentiate between refractive and axial refractive error and which type more correlated with IOP.

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