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To Evaluate the Effect of Central Corneal Thickness, Intraocular Pressure and Visual Field Changes in Primary Open Angle Glaucoma Patients

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ABSTRACT

Aim: To correlate Central corneal thickness, Intraocular pressure & Visual field changes in patients diagnosed as the Primary Open Angle Glaucoma suspects.

Material and Methods: The present observational study was conducted from February 2021 to June 2022 (17 months) in the Department of Ophthalmology, Mahatma Gandhi Medical College and Hospital, Jaipur. 100 patients who attended the outpatient department of the Department of Ophthalmology were recruited during the study period. All patients underwent a complete ophthalmic examination.

Results: There was a statistically significant inverse correlation between age and CCT (r= -0.34, p<0.012). There was a statistically significant positive correlation between age and IOP (r= 0.32, p<0.028). There was a statistically significant positive correlation between VCDR and IOP (r= 0.31, p= 0.021).Visual field was abnormal in majority of subjects (87%).

Conclusion: Central corneal thickness is a significant predictor of glaucomatous damage as measured by vertical cup:disc ratio, intraocular pressure, mean deviation of visual field in patients with POAG. Measuring CCT in glaucoma patients my help identifies those patients who are at high risk for developing severe glaucomatous sequelae, thus enabling the ophthalmologist to treat their disease early. Age of the subject is also a predictor for glaucoma, so elderly subjects should be kept on regular check-up, to diagnose and treat disease early.

Keywords: Glaucoma, CCT, IOP

I. INTRODUCTION:

Glaucoma refers to a collection of diseases whereby increased intraocular pressure adversely impacts the optic nerve, and subsequently, the visual field.Glaucoma is the third leading cause of blindness in Indiaand accounts for 5.80% of total blindness in India. [1] It is theleading cause of irreversible blindness in general populationworldwide. [2,3] Glaucoma is a major cause of ocular morbidity andirreversible blindness. Globally till the year 2020, around65.5 million people have suffered from primary open angle glaucoma (POAG) and black populationhas the highest POAG prevalence in all age groups exceptthe Hispanics in over 80 years age group. [4]

A glaucoma suspect is an individual with clinicalfindings and/or a constellation of risk factors that indicatean increased likelihood of developing primary open-angleglaucoma (POAG). [5]Primary open angle glaucoma (POAG) is a type of glaucoma defined as open, normal appearing anterior chamber angle and raised intraocular pressure (IOP), with no other underlying disease. POAG is often diagnosed on routine ocular examination and in many instances in the late stage. It manifests mainly as peripheral visual field loss with central vision being preserved almost till the end stage. [6]

The 'normal' IOP is a statistical description of the range of IOP in the population, and is not applicable to the individual subject. [7] Different methods are available to measure the IOP. The most widely used instrument, considered the international gold standard, is the Goldmannapplanation tonometer. Hans Goldmann applied the Imbert–Fick principle which states: 'the existing pressure in a sphere containing a liquid, whose wall is constituted by a very thin and perfectly elastic membrane, can be measured by an external compression sufficient to transform a portion of spheric surface in a plain surface'. This theoretical sphere is dry, thin-walled, and readily flexible, all features not applicable to the cornea. The force necessary to flatten the cornea during tonometry can be influenced not only by the IOP but also by corneal characteristics such as central corneal thickness (CCT), corneal shape and hydratation, rigidity of the sclera and the globe. [8]

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Goldmann in his first report described some of the possible sources of measurement error. [8] He specifically outlined that the theoretical basis for his instrument was calculated for a mean CCT of 500 mm and that the accuracy could vary if CCT was significantly different from this value. Central corneal thickness (CCT) is considered as a possible explanation for glaucoma cases where clinical findings do not match. [9] A positive correlation between IOP readings and corneal thickness was found in patients attending a general clinic. [10]

Central corneal thickness has recently been recognized as a significant risk factor for progression of ocular hypertension to primary open-angle glaucoma in the Ocular Hypertension Treatment Study. [11] This study was the first to prospectively demonstrate that a thinner CCT predicts the development of POAG. They found that a decrease in CCT of 40µm added a 70% increase in risk.

In OAG, a thin cornea is more strongly associated with disease severity than IOP. [12] However, CCT has a significant effect on IOP measured by applanation tonometry. Some cannulation studies have shown tonometric estimates to be lower than actual IOP in eyes with thinner corneas and vice versa, indicating that CCT can have significant influence in the risk assessment for openangle glaucoma based on applanationtnometry measurement. [13]

The present study was undertaken with aim to correlate Central corneal thickness, Intraocular pressure & Visual field changes in patients diagnosed as the Primary Open Angle Glaucoma suspects so that patients at risk of progressing to glaucoma were identified and their progression to glaucoma can be prevented/delayed.

II. MATERIAL AND METHODS:

The present observational study was conducted from February 2021 to June 2022 (17 months) in the Department of Ophthalmology, Mahatma Gandhi Medical College and Hospital, Jaipur. Ethical approval for the study was obtained from institutional research ethics committee before the commencement of the study. 100 patients who attended the outpatient department of the Department of Ophthalmology during the study period were recruited.

Inclusion Criteria:
1. Patients aged between 40 to 70years.
2. Patients with open anterior chamber angles ongonioscopy.
3. Patients with consistently elevated IOP (>21mmHg) associated with normal appearance of the optic disc and retinal nerve fiber layer.
4. Patients with visual field indicative for glaucomatous damage in the absence of clinical signs of other optic neuropathies elevated IOP and optic disc changes.
5. Patients with optic disc or retinal nerve fiber layer that is indicative for glaucomatous damage in the absence of elevated IOP or visual fieldchanges.
6. Family history of primary open angle glaucoma

Exclusion Criteria:
1. Patients aged <40 yrs. or >70yrs.
2. Patients who have 2 or more of the following: Consistently elevated IOP, visual field suspicious for glaucomatous damage, optic disc or retinal nerve fiber layer that is suspicious of glaucomatous damage.
3. Patients with angle closure ongonioscopy.
4. Patients already on Glaucomatreatment.
5. Patients who have undergone Glaucoma surgery/Refractive surgery/Cataractsurgery.
6. Patients with secondary causes for open-angle glaucoma, such as pseudoexfoliation (exfoliation syndrome), pigment dispersion, and traumatic anglerecession.
7. Patient on steroids.
8. Patient having cataract.
9. Pregnant females
10. Patient having other systemic diseases like HTN, DM.
11. Cigarette smokers.

III. METHODOLOGY:

After taking consent of the patients; detailed ocular, systemic & family history was taken. Any history of refractive errors, use of corrective glasses or contact lenses, glaucoma, use of topical steroids & any previous records with respect to IOP, optic nerve head status or visual field was taken. Any history of ocular surgery like cataract/LASIK/ photorefractive keratectomy was noted. This is important as refractive error correction procedures are known to be associated with thinning of cornea & hence falsely low IOP and cataract surgery has been associated with lower IOP as compared to pre-surgery baseline.

Clinical assessment: All patients underwent a complete ophthalmic examination including the following:

- BCVA was assessed using an illuminated Snellen's chart, with the patient seated at 6 metersdistance.
- Near Vision was assessed using Jaeger's near

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visionchart.

- Color vision was checked using Ishihara's pseudo-isochromaticcharts.
- Slit Lamp Bio Microscopy Examination was performed to rule out any corneal/ anterior segment pathology orinfections.
- Gonioscopy was performed with Goldmann three-mirror lens. Only patients with open anterior chamber angles were included in thestudy.
- Detailed Fundus Examination was done by Indirect ophthalmoscopy, followed by Slit-lamp biomicroscopic evaluation with +90 Dlens.
- Intraocular pressure (IOP) was measured in both eyes using GoldmannApplanation Tonometer (GAT) after anaesthetising the eye with topical proparacaine 0.5% and using 2% Fluorescein strips.
- Central Corneal Thickness (CCT) was measured with NCT machine.

Statistical analysis: Statistical analysis was performed using SPSS Version 24. Pearson correlation test was used to evaluate the correlation between two variables.

IV. RESULTS:

Of the 100 subjects included in study, majority was of males (n=54, 54%) and 46% were females. Maximum subjects were from age group 51-60 years (49%), followed by 45% from age range 41-50 years and only 6 subjects were >60 years old. The mean central corneal thickness (CCT) was 522.07±34.98, majority (82%) of subjects had CCT ≤555µm, whereas only 18 subjects CCT was >555µm (Table 1).

Table 1: Baseline characteristics among the study subjects

Gender	**N=100**	**%**
Male	54	54
Female	46	46
Age Group (in years)		
41-50	45	45
51-60	49	49
>60	6	6
Co-morbidities		
Hypertension	14	14
Diabetes Mellitus	6	6
CCT (µm)		
≤555µm	82	82
>555µm	18	18
CCT,Mean±SD	522.07±34.98	
IOP,Mean±SD	17.51±4.96	
VCDR, Mean±SD	0.69±0.18	

According to Pearson correlation analysis there was a statistically significant inverse correlation between age and CCT (r= -0.34, p<0.012). There was a statistically significant positive correlation between age and IOP (r= 0.32, p<0.028) as mentioned in table 2.

Table 2: Correlation between age and CCT, IOPas well as VCDR

Variables	**CCT and Age**	**IOP and Age**	**VCDR and Age**
r value	-0.34	0.32	0.24
p value	0.012*	0.028*	0.11

*: statistically significant

According to Pearson correlation analysis there was a statistically significant positive correlation between VCDR and IOP (r= 0.31, p= 0.021). There was a statistically significant inverse correlation between CCT and IOP (r= -0.29, p= 0.033) and CCT and VCDR (r= -0.26, p=0.038). (Table 3)

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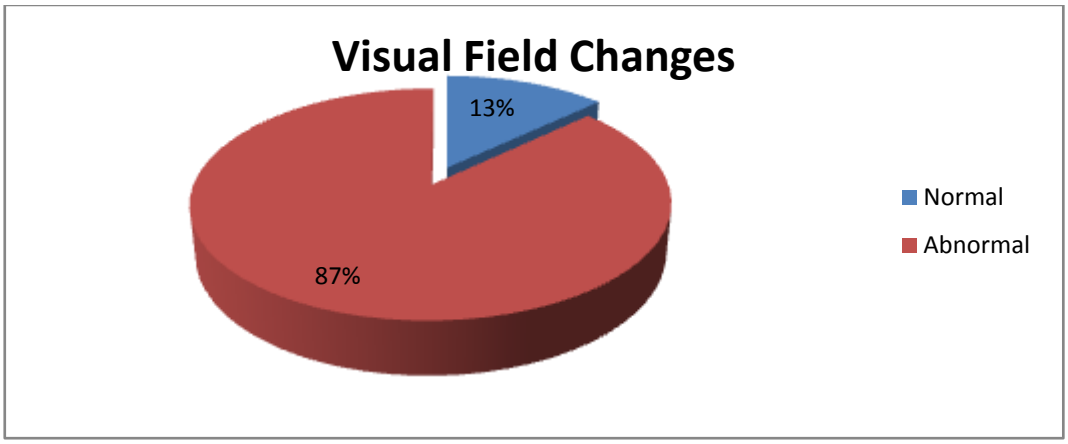
Table 3: Correlation between CCT, IOP and VCDR

Variables	r value	p value
CCT and IOP	-0.29	0.033*
CCT and VCDR	-0.26	0.038*
VCDR and IOP	0.31	0.021*

*: statistically significant

In present study, visual field was abnormal in majority of subjects (87%) with Primary Open Angle Glaucoma (POAG), but normal in only 13 subjects. (graph 1)



Graph 1: Visual field changes

V. DISCUSSION:

POAG suspect is diagnosed by the presence of one of the following conditions: consistently High IOP, a suspicious-appearing optic nerve head or abnormal visual fields. [14] IOP has been consistently recognized as the only modifiable risk factor for open angle glaucoma. [15] Accurate IOP measurements are of paramount importance in glaucoma diagnosis and management. Clinically, GAT is considered the gold standard for IOP measurement but even Goldmann and Schmidt accepted the fact that their technique was based on an average CCT of around 0.5 mm and accuracy varies when CCT deviated above or below this range. [8] So, the measurement of CCT helps in correct interpretation of IOP readings.

Of the 100 subjects included in study, majority was of males (n=54, 54%) and 46% were females. The male to female ratio was 1.17:1. So, according to findings of present study males to be more likely to have POAG. These findings were in accordance to result of Sujatha R and Patil R [16] who found that the patient population consisted of 42 females and 58 males. The male to female ratio of subjects was 1.38:1. Ramakrishnan Ret al [17] and Sharma R et al [18] in their studies too revealed similar male dominance. But in study done by Mitchell P et al [19], higher incidence of POAGwas found in females than males.

Maximum subjects were from age group 51-60 years (49%), followed by 45% from age range 41-50 years and only 6 subjects were >60 years old. This suggest that older age was one of the baseline factors that predicted the development of POAG. In The Ocular Hypertension Treatment Study, older age was one of the baseline factors that predicted the development of POAG in both univariate and multivariate analyses along with other factors. [11]Bindu S et al [20], Sharma R et al [18] and Ramakrishnan Ret al [17] too revealed similar age distribution.

The mean central corneal thickness (CCT) was 522.07±34.98, majority (82%) of subjects had CCT ≤555µm, whereas only 18 subjects CCT was >555µm.CCT is one of the most heritable traits and is known to vary with the ethnic identity. [21] It is a known fact that white race (Caucasians) have thicker corneas than African American dark races. [22] Further, mixed races in South Africa had mean CCT greater than Africans but thinner than Caucasians. A study done in rural central India (the central India eye & medical study) found a mean central corneal thickness to be 514 mm. [23] In south Indian population (The Chennai Glaucoma study) the mean CCT for the urban population was 520.7 ± 33.4 mm and in the rural group with glaucoma was significantly lower (505.9 ± 31.1 mm). [24]

In study done by Bindu S et al., [20] majority of patients in control as well as glaucoma group had CCT less than 555µm in either eye, but it was statistically significant only in the left eye. The mean CCT in glaucoma patients was 528.03±33.37µm in right eye and 529.69±34.14µmin the left eye. POAG group had thinner CCT than Normal. All these differences were statistically significant.According to Sujatha R and Patil R [16] mean CCT was 518.91 ± 24.26 mm, 522.19±21.56 mm among females, males respectively. They found that in Right Eye Normal CCT was present in 43% subjects, Low CCT in 30% and High CCT in 27% patients. In Left Eye Normal CCT was in 43% subjects, Low CCT in 26% and High CCT in 31% subjects. But Day AC et al, [25] found thatthere was no difference in CCT values in POAG patients.

According to Pearson correlation analysis there was a statistically significant inverse correlation between age and CCT (r= -0.34, p<0.012). This suggest that with increasing age central corneal thickness will reduce. Therefore, knowledge of CCT can help to attribute the likelihood of disease progression and assigning the risk can change clinical management decisions to reach a personalized target pressure.Day AC et al., [25] found a statistical significant inverse association of CCT with age.According to Gelaw Y (2012) [26] there is a statistically significant decline in CCT as age advances.In study done by Bindu S et al., [20] there was a reduction of CCT with advancing agein both groups but was significant only in glaucomapatients (P value 0.019 RE and 0.009 in LE).

But in study done by Sujatha R and Patil R [16] the mean age of subjects was 51.7 years. Thinner cornea reading in south Indian population especially when presenting at younger age should alarm the ophthalmologist to evaluate the patient thoroughly for glaucoma and monitored follow up to keep a check on the possible progression.

According to Pearson correlation analysis there was a statistically significant positive correlation between VCDR and IOP (r= 0.31, p= 0.021). This suggest that when VCDR will increase it will lead to increased IOP. But according to Pearson correlation analysis there was a statistically significant inverse correlation between CCT and IOP (r= -0.29, p= 0.033) and CCT and VCDR (r= -0.26, p=0.038). This suggest that when CCT will increase there will be a decrease in IOP and VCDR. Pakaravan M et al [27] found that CCT was inversely correlated with optic disc area According to his study, eyes with decreased CCT may have larger and more deformable optic discs. This was explained by the fact that both cornea and lamina cribrosa are ectodermal in origin and can be affected by the same pathology.According to findings of Bindu S et al [20], IOP had positive correlation with CCT and was statistically significant, and it was similar to findings of Day AC et al., [25] and Vijaya L et al [28]. Vertical cup-disc ratio had a negative correlation with CCT and had statistical significance.Mokbel TH and Ghanem AA [29] found that there was statistically significant inverse correlation between CCT and optic disc area (r = - 0.251, P = 0.031), and statistically significant positive correlation between CCT and vertical cup: disc ratio (r = 0.043, P = 0.014)

In present study, visual field was abnormal in majority of subjects (87%) with Primary Open Angle Glaucoma (POAG), but normal in only 13 subjects.Sujatha R and Patil R [16] found that corrected IOP reading of 21.43 mmhg for the 14 patient with abnormal visual fields on right side and was statisticallysignificant at P=0.01. They also found that highest percentage of abnormal visual field changes was seen in eyes with low CCT (<510).

VI. LIMITATIONS

Our research had few restrictions. It was a hospital-based study; to support the findings, a population-based investigation with larger sample sizes may be required. Even though GAT is regarded as the reference standard, measurement errors and intrinsic variability can still affect readings. The racial disparity in open angle glaucoma prevalence may be influenced by differences in CCT between different racial groups. Due to the fact that it would be challenging to determine the precise ethnicity of the patients in an urban setting, anthropologists play an important role in our profession. Therefore, to corroborate the findings of the current study, further information on ethnicity-specific CCT is needed, along with investigations including bigger groups of patients from other sites.

VII. CONCLUSION:

Glaucoma is a preventable cause of blindness making patient education crucial in managing and preventing the progression of open-angle glaucoma. Effective and successful treatment open-angle glaucoma can prevent the evolution of optic nerve atrophy and preserve patients vision. If not treated, open-angle glaucoma (OAG) leads to progressive loss of peripheral vision followed by central visual field loss. The present study leads to conclusion that according to Pearson correlation

analysis there was a statistically significant inverse correlation between age and CCT (r= -0.34, p<0.012), between CCT and IOP (r= -0.29, p= 0.033) and CCT and VCDR (r= -0.26, p=0.038) and statistically significant positive correlation between age and IOP (r= 0.32, p<0.028), between VCDR and IOP (r= 0.31, p= 0.021), between age and VCDR, though no significant difference was found (r= 0.24, p=0.11).

Central corneal thickness is a significant predictor of glaucomatous damage as measured by vertical cup:disc ratio, intraocular pressure, mean deviation of visual field in patients with POAG. Measuring CCT in glaucoma patients my help identifies those patients who are at high risk for developing severe glaucomatous sequelae, thus enabling the ophthalmologist to treat their disease early. Age of the subject is also a predictor for glaucoma, so elderly subjects should be kept on regular check-up, to diagnose and treat disease early.

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