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Assessment of the Role of Central Corneal Thickness in Measuring the Intra-ocular Pressure in the Screening for Glaucoma amongst People Residing in a Sub-Himalayan Territory of North India

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To find out the average central corneal thickness (CCT) and intraocular pressure (IOP) and to determine the prevalence of ocular hypertension in the study group.
Methods: It was a cross sectional study conducted on subjects with age more than 30 years. These respondents were subjected to Visual acuity, IOP measurement using hand held Perkins applanation tonometer (PAT), measurement of central corneal thickness using ultrasonic hand held pachymeter and fundus evaluation was done using direct ophthalmoscope.
Results: A total of 2603 subjects participated in the study. 628 subjects (24.1%) were males and 1975(75.8%) were females. The ages ranged from 30 to 91 years (mean=53, median=60 and mode=60). The average CCT in the study population was 528.72±34.40 µm in the right eye and

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529.26±35.17 µm in the left eye. The mean IOP for right eye was 13.73±2.89 mm Hg while for the left eye was 13.86±2.86 mm Hg. The mean corrected IOP was 14.71±3.41 mmHg for the right eye and 14.87±3.34 mmHg for the left eye.

Conclusions: Average CCT in the study population was lesser in comparison to the mean CCT among Caucasians resulting in underestimation of the IOP measured by PAT, inducing a Type II error in making the diagnosis of glaucoma with a potential to reduce the sensitivity, increase in false negative rate, and reducing the diagnostic odds ratio for glaucoma.

Keywords: Cornea; intra-ocular pressure; Glaucoma.

1. INTRODUCTION

Intraocular pressure is the most important parameter involved both in diagnosis and management of glaucoma. Goldmann applanation tonometry (GAT) is the gold standard in measurement of IOP. The reliability of any particular tonometer in correctly estimating the IOP is of paramount importance since false estimation of IOP, both under or overestimation will have direct consequence on the diagnosis and on subsequent management of glaucoma. It was previously thought that corneal thickness variation does not occur and a fixed value of 520 microns was assumed in all patients. In a study by Ehlers et al [1] it was found that GAT most accurately reflected the IOP when the CCT was 520 microns and deviations from this value resulted in over or underestimation by as much as 7 mm Hg. Whitacre et al. [2] found that with Perkin's applanation tonometer underestimation of IOP was 4.9 mmHg in thin corneas and overestimation of IOP was 6.8 mmHg in thick corneas. The GAT measures the force required to applanate the eye to 3.06 mm diameter. The force required is a combination of opposition to IOP plus the force needed to bend the cornea. Therefore, the thicker the cornea the greater is the force needed to bend and the thinner the cornea, lesser is the force needed to bend, resulting in incorrect estimation of IOPs in eyes with variations in CCTs. One of the findings of the Ocular Hypertension Treatment Study (OHTS) [3] was the impact of CCT on the development of glaucoma. CCT has been found to have direct relationship with the intraocular pressure as thinner corneas result in an underestimation of the IOP and thicker corneas an overestimation. Various studies have shown that CCT varies in different populations.

1.1 Aims and Objectives

1. To find out the average central corneal thickness (CCT) and intraocular pressure (IOP) in the study group.
2. To determine the prevalence of ocular hypertension in the study group.

2. MATERIALS AND METHODS

The study was conducted in a Sub-Himalayan territory of North India at Block level in state of Himachal Pradesh, on subjects of the age group of 30 years and above. Demographic and health related information of the respondents was collected by the Field Investigators. Assuming the prevalence of Glaucoma among population of 30 years and above @ 2.5%, sample size was calculated to be 2900. It was a cross-sectional study with sampling technique of simple random sampling. Two field investigators were recruited for the study. They conducted house to house survey of the villages falling under the selected sub center along with local health worker and health educator/ Medical Social Worker. They enlisted all eligible persons for the study and also collected the relevant information on the pre designed performa. The enlisted respondents consenting to participate in the study were called for detailed examination at the sub center on a predetermined fixed date. These respondents were subjected to visual acuity, IOP measurement using hand held PAT as it was easy to carry for outreach camps, measurement of central corneal thickness and corrected IOP was done using ultrasonic hand held pachymeter (Pac Scan 300P). The formula used for the IOP correction for CCT was CCTØ =0.545mm (Avg.CCT) in Pac Scan 300P pachymeter. Fundus evaluation was done using direct ophthalmoscope.

The continuous variables were presented as means and numbers as proportions. Chi square test was applied to test the significance difference in proportions and student t-test for means. Coefficient of correlation was used to determine the strength of association. Level of significance was set at 5%.

3. RESULTS

A total of 2603 subjects participated in the present study of which 1975 (75.8%) were female and 628 (24.1%) were male. The age range was 30-91 years (Mean: 53, Median: 60, & Mode: 60) (Table.1). Mean IOP in the study population for right and left eye was 13.73±2.89 mmHg and 13.86±2.86 mmHg respectively (Table 1). The mean CCT in the subjects was 528.72±34.40 µm for the right eye and 529.26±35.17 µm for the left eye. The mean CCT in the subjects >60 years of age was 523.81 µm and 523.77µm respectively for the right eye and left eye (Table 2). There was no statistical difference in the mean CCT in the males and females (Table 3). The mean corrected IOP (corrected for CCT) was 14.71±3.41 mmHg for the right eye and 14.87±3.34 mmHg for the left eye. It was observed that corrected IOP increased with the age, which was the result of decrease in CCT as the age increased (Table.4). In subjects with CCT <560 µm and > 560 µm a statistically significant difference between measured and corrected IOP was noted but in former group it was underestimated and in later group it was overestimated (Table 5). No statistically significant difference in the mean CCT was noted between diabetics and non-diabetics. In this study, the mean Optic-cup disc ratio (OCD) was 0.294±0.129 for right eye and 0.297±0.106 for the left eye and the mean difference was statistically non significant (p=0.33). On the basis of IOP >21 mmHg in one or both eyes, it was found that 39 subjects were diagnosed as ocular hypertensive. However when we took into account the CCT values the number substantially increased to 129.

Table 1. Mean IOP in both the eyes distributed over different age groups

Age	Right eye	Left eye	P value
	Mean IOP ±SD	Mean IOP±SD	
30-40	13.83±2.83	13.80±2.71	0.17
41-50	13.69±2.73	13.91±2.73	<<0.05*
51-60	13.81±2.88	14.36±4.86	0.02*
>60	13.70±3.14	13.80±3.08	0.26
Total	13.73 ±2.89	13.86 ±2.86	<<0.05*

SD: Standard deviation

4. DISCUSSION

A total of 2603 subjects participated in the study. Six hundred and twenty eight (24.1%) subjects were male and 1975 (75.8%) were female. The ages ranged from 30 to 91 years (mean=53, median=60 and mode=60). The difference in the recruitment of the male and female was because at the time of survey male subjects were usually outdoor working in the fields or in jobs and female subjects were present in their homes, therefore large number of female subjects were enrolled for the study and when the camps were being held more female subjects turned up for examination, which reflects that health seeking behavior is more among female subjects than in male.

Table 2. Mean CCT of both eyes in different age groups

Age	Right eye	Left eye	P value
	Mean CCT±SD	Mean CCT±SD	
30-40	534.23±35.97	530.99±34.67	0.29
41-50	532.97±253.87	531.57±31.99	0.19
51-60	530.68±32.90	528.86±37.54	0.33
>60	523.81±36.50	523.77±34.80	0.59
Total	528.72 ±34.40	529.26 ±35.17	0.23

In the present study it was observed that the mean IOP for right eyes was 13.73 ±2.89 mm Hg while for the left eyes was 13.86±2.86 mmHg which found to be statistically significant in some of the age groups (Table 1) and the mean Corrected IOP (after taking CCT into consideration) for the right eyes was 14.71±3.41 mmHg and for the left eyes was 14.87±3.34 mmHg. Jonas JB et al. [4] in their study on Indian eyes in central India found the mean IOP to be 13.6±3.4 mm Hg. Our study results are similar to this study and the reason may be relatively thin corneas in our population. The mean CCT in the present study was 528.72±34.4 µm in right eyes and 529.17±35.17 µm in the left eyes (Table 2). Results of various studies (Eballe AO et al. [5], Hassan M et al. [6], Hoffmann EM et al. [7], Foster et al. [8], Kunert et al. [9], La Rosa et al. [10], Nemesure et al. [11] and Herndon et al. [12]) shows that the black population have thinner corneas in comparision to Caucasians (Table 3).

In the present study we found that difference in CCT among males and females was not statistically significant (Table 4). Godar et al. [13] found that CCT was significantly correlated with age and intra ocular pressure but not with gender.

Table 3. Mean CCT in various studies

S. No.	Study/Authors	Place	Race	Mean CCT	Subjects/eyes
1.	Eballe AO et al. [5]	Cameroon	Black race	529.29±35.9 µm 528.19±35.9 µm in the left eye	970 subjects
2	Hassan M et al. [6]	Pakistan	Black race	529.5±33.6 µm and 524.1±33.3 µm in females	250 subjects
3.	Hoffmann EM et al. [7] Gutenberg health study	Germany	Caucasians	557.3±34.3µm in males and 551.6±35.2µm in females	4698 subjects
4.	Kunert et al. [9]	India	Black race	520 µm	615 eyes
5.	La Rosa et al. [10]	USA	African Americans and Caucasians	African Americans:531±36.3µm in the right eye & 530.0±34.6µm in the left eye Caucasians: 558.0±34.5µm in right eye & 557.6±34.5µm in the left eye	82 subjects-African Americans 83 subjects-Caucasians
6.	Nemesure et al. [11] Barbidose eye suvey	Barbidose	Black and white race	530µm in blacks 545µm in whites	Black- 2120 eyes White-50 eyes
7.	Herndon et al. [12]	Durham	Black and white race	537 µm in blacks 556 µm in whites	184 eyes
8.	Present study Chauhan A et al.	India	Black race	528.72±34.40 µm in the right eye 529.26±35.17µm in the left eye	2603 subjects

In the present study it was observed that the CCT decreases with increasing age (Table 5). Subjects in older age groups were found to have thinner corneas as compared to young subjects. This study matched with the various studies done in different populations. Godar et al. [13] studied the factors affecting the CCT in Nepalese population and they found that CCT decreases with increasing age. Lyamu E et al. [14] studied to investigate the relationship between age, gender, corneal diameter, central corneal curvature, CCT and IOP in Nigerians with normal IOP. They concluded that CCT of normotensive Nigerian adults decreases with age. Wolf RC et al. [15] performed a cross-sectional study (The Rotterdam study) in their Caucasians population on the distribution of CCT and its association with IOP in 395 subjects aged 55 years and more. They found that mean CCT in their study population is 537.4 µm. Lam AK et al. [16] in their study of corneal thickness in central and all four quadrants of cornea in Hong Kong Chinese concluded that there was a general thinning of corneal thickness at all regions from aging but no difference between the genders was found. The mean corneal thickness in their study population varied from 541.7 µm to 560.8 µm. Shafiq Irfan [17] studied influence of CCT on IOP measured with GAT in normal healthy 500 eyes of 250 subjects in the age range 11-54 years from general population in Pakistan. The mean IOP was 15.35 mmHg and mean CCT value was 531.50 µm. Soatiana JE et al. [18] in their review article stated that the CCT is naturally thin in Sub-Saharan Africans and also observed that the CCT is thicker for younger than the older age.

The average IOPs in different CCT ranges was calculated and it was found that in CCTs < 500 µm the difference between the mean IOP and the mean Corrected IOPs was 3.82 mmHg and 3.88 mmHg for right and left eyes respectively (underestimated). In CCTs between 500-560 µm the difference was 3.15 mmHg and 3.28mmHg respectively in the right eyes and left eyes respectively (under-estimated); in CCT>560 µm the difference was 2.01 mmHg and 1.97 mmHg in the right eyes and left eyes respectively (over-estimated). The difference in the means was statistically significant with the p-value <0.05 (Table 6). In our study we had used Perkin's applanation tonometer which showed maximum underestimation in thin corneas where CCT was <500 µm. Browing AC et al. [19] stated that Goldman in 1957 first suggested that IOP measurement by applanation tonometry could be affected by CCT. Since then the workers have confirmed this and defined the effect. They found that measurement of IOP in patients with thin corneas tended to be underestimated, while with thick corneas the opposite occurred. Thomas R et al. [20] in their study in Vellore (India) measured CCT in 50 normal, 25 Glaucoma, and 23 ocular hypertensive patients. They concluded that increased CCT in ocular hypertensive may lead to an overestimation of IOP. Kniestedt et al. [21] found that the IOP recording with GAT was more dependent on the CCT as compared to Dynamic Contour Tonometer (DCT) and Pneumotonometer (PTG).

It was observed that mean optic-cup disc ratio (OCD) was 0.294±0.129 for the right eyes

Table 4. Mean CCT (µm) in different sex and age groups (n=2603)

Age	Right eye			Left eye		
	Mean CCT(M)	Mean CCT(F)	P value	Mean CCT(M)	Mean CCT(F)	P value
30-40	538.13±36.81	530.33±35.85	0.16	540.65±36.05	530.89±34.47	0.08
41-50	535.08±34.57	530.87±277.53	0.65	535.46±35.47	532.00±31.26	0.28
51-60	534.12±32.39	527.24±32.93	0.02	536.98±51.09	528.39±32.15	0.10
>60	524.24±36.85	523.39±36.22	0.90	523.05±37.55	522.33±32.34	0.30
Total	529.79±35.89	528.40 ±33.93		529.51±39.82	529.21±33.56	

CCT: Central corneal thickness, M: Male F: Female, R: Right eye L: Left eye

Table 5. Correlation between age with CCT (µm) (n=2603)

Age	Total number of subjects	Mean CCT_R±SD	Coefficient of correlation	Mean CCT_L±SD	Coefficient of correlation
30-40	513	534.23±35.97	-0.04	535.77±34.67	-0.08
41-50	736	532.97±253.87	**P value**	533.73±31.99	**P value**
51-60	685	530.68±32.90	0.08	532.68±37.54	<<0.05*
>60	669	523.81±36.50		522.69±34.80	

Table 6. Relationship among mean CCT, mean IOP & mean Corrected IOP (n=2603)

CCT Range (µm)	Mean IOP_R±SD (mmHg)	Mean Corrected IOP_R ±SD (mmHg)	P value	Mean IOP_L±SD (mmHg)	Mean Corrected IOP_L ±SD (mmHg)	P value
<500	13.16±2.65	16.98±2.89	<<0.05*	13.39±2.74	17.27±2.95	<<0.05*
500-560	13.82±2.91	16.97±4.19	<<0.05*	13.92±2.76	17.20±3.02	<<0.05*
>560	14.21±2.98	12.20±3.17	<<0.05*	14.59±5.83	12.62±3.42	<<0.05*

**the difference in means is statistically significant at p value<0.05*

and 0.29±0.106 for the left eyes. On the basis of IOP >21 mmHg in one or both eyes, it was found that 39 subjects were labeled as of ocular hypertension. However when we took into account the CCT values, the number of subjects with ocular hypertension, substantially increased to 129.

5. CONCLUSION

We found that the average CCT in study population was lesser in comparison to the mean CCT among Caucasians resulting in underestimation of the IOP measured by PAT, inducing a Type II error in making the diagnosis of glaucoma with a potential to reduce the sensitivity, increase in false negative rate, and reducing the diagnostic odds ratio for glaucoma. Higher age groups tend to have lower CCT values.

We may be underestimating the IOP because of thinner corneas in our population and consequently under diagnosing glaucoma. Keeping the results of the study in mind we suggest that patients suspected of glaucoma should have CCT measured at least once. The target pressures should be modified based on the CCT values for a particular patient. We hope that the knowledge generated by the present study will go a long way in preventing irreversible blindness due to glaucoma as a result of early diagnosis and management.

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ETHICAL APPROVAL

Authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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