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Distribution of central corneal thickness in North Indian population.

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Abstract:

AIM: To find the distribution of central corneal thickness (CCT) in the North Indian population and to find out the relationship between CCT and intraocular pressure (IOP) and to co-relate CCT with IOP and its effect on systemic diseases.

METHODOLOGY: In this population-based cross-sectional study, 1635 subjects were monitored. Patients aged 10 years and above were included in the study. Systemic diseases such as diabetes mellitus, hypertension, thyroid, cardiac artery disease and asthma were taken after proper history and laboratory examination. CCT was measured using a Zeiss IOL Master 700 0 1.70. IOP was measured with a Goldmann applanation tonometer. Any kind of post-surgical ocular pathology, corneal pathology or any refractive surgery done were excluded from the study. All these measurements were taken by study investigators only.

RESULT: The mean CCT of the entire population was 525.2766 µm, with a standard deviation of 38.99679. The p- value of the data was 0.00871 using one sample Kolmogorov-Smirnov test and 0.000131 using Shapiro-Wilk normality test.

CONCLUSION: From this study, it was concluded that CCT and IOP are directly proportional to each other as the increase in CCT also leads to an increase in IOP also. If CCT increases by 1-micron, IOP will also increase by 0.025 mm Hg. Systemic diseases like DM and HTN also showed a significant relationship with CCT, but we did not find any significant impact of HTN with CCT in this study. On a gender basis, we can say that males have thicker corneas compared to females.

KEY WORDS
CCT, IOP, DM, HTN, CAD

ABBREVIATIONS
CCT – Central Corneal Thickness
IOP-Intra Ocular Pressure
HTN- Hypertension
DM- Diabetic Mellitus
CAD- Coronary Artery Disorder

1. Introduction:

The cornea is the clear front surface of the optical system of the eye, which allows light to enter the eye for vision. It provides approximately 65 to 75% of the focusing power of the eye. The thickness of the cornea is related to the function of the endothelium, and it can be measured indirectly by pachymetry. Measurement of central corneal thickness (CCT) is important when undertaking a functional and morphological evaluation of the cornea for various diagnostic purposes or before any surgical intervention. The central corneal thickness (CCT) of a normal and healthy cornea ranges from 450 to 650 µm [1]. It can be thinner in ecstatic corneal diseases such as keratoconus, pellucid marginal degeneration, and iatrogenic keratectasia and after surgical tissue ablation. CCT increases in cases of corneal edema (e.g, endothelial dystrophy), cornea plana, and other corneal dystrophies. In addition, after lamellar and penetrating keratoplasty, CCT can be increased. The measurement of corneal thickness is called pachymetry. Given that applanation tonometry estimates the intraocular pressure (IOP) by measuring the force required to flatten an area of the cornea, a thinner cornea may lead to underestimation of the true IOP and a thicker cornea may lead to overestimation of the true IOP [1], [2]. In addition, a thinner central corneal measurement is associated with the development of glaucoma, increased risk of visual field progression and more advanced glaucoma damage [2]. Some drugs such as anti-glaucoma medication and topical prostaglandin can also reduce CCT, thus making the cornea thin and giving over or underestimated IOP reading, thus resulting in false diagnosis [3].
Measurement of CCT is particularly important before any kind of refractive surgery. Doing any kind of refractive surgery in a thin cornea can result in postoperative complications i.e. corneal ectasia. CCT must be more than 500 µm before any refractive surgery [4].

While CCT affects the prognosis of ocular hypertension, its value in patients diagnosed with glaucoma is less certain. There are several biological and genetic factors that may influence glaucoma progression, which have been associated with thinner CCT. The CCT itself can be affected by several factors, including ethnicity, age, sex, glaucoma medications, genetics, and the sub type of glaucoma. In addition, there is variability in the measurement of CCT between different types of devices. These factors need to be considered in the evaluation of patients with glaucoma. CCT and its effect on interpretation of intraocular pressure levels and risk stratification [5].
CCT is associated with higher IOP, longer axial length, and greater radius of corneal curvature as well as higher BMI, metabolic syndrome, and CKD [6].
Awareness of these ethnicity-related and age-related physiologic changes enables us to assess the influence of disease and surgical procedures more accurately. The purpose of this study is to understand the distribution of CCT in the North Indian population.

2. Methodology:

This study is a population-based cross-sectional study done at a tertiary eye hospital, Delhi. A total of 1635 patients were included in the study. All patients underwent a complete ophthalmic examination before inclusion in the study. Patients aged 10 years and above were included in the study. The age of each patient was confirmed during OPD procedures.
The gender of the patient was also included in the study. Any systemic, oral, or tropical medication taken by the patient that would make any variation in the CCT was excluded from the study. Systemic diseases such as diabetes mellitus (DM), hypertension (HTN), coronary artery disease (CAD) and thyroid were taken after proper history and laboratory examination. CCT was measured using a Zeiss IOL Master 700 0 1.70. (Carl Zeiss Meditec AG, Jena, Germany). Any ophthalmic surgical process done on the patient was confirmed through patient's history taking and proper ophthalmic examination of both anterior and posterior segments of the eye. Any patient wearing contact lenses was not included in the study because wearing contact lenses for too long may affect CCT. Any kind of post-surgical ocular and corneal pathology or any refractive surgery done before would lead to variation in the CCT and thus were excluded from the study. IOP was measured with a Goldmann applanation tonometer only by proper clinical optometrists. Patients with glaucoma or taking any kind of anti-glaucoma medications were excluded from the study. All these measurements were taken by studying investigators only.

3. Results:

I. Male and Female Ratio:

771 patients were female, while 863 patients were male in our study (Figure 1). It is seen in our study that male has mathematical -0.407 value low IOP than female for every 1 mm change in CCT. The p-value of the data is 0.00429, which is very significant. The mean age of males was 46.40 years, while that of females was 47.23 years with an SD of 17.23522.

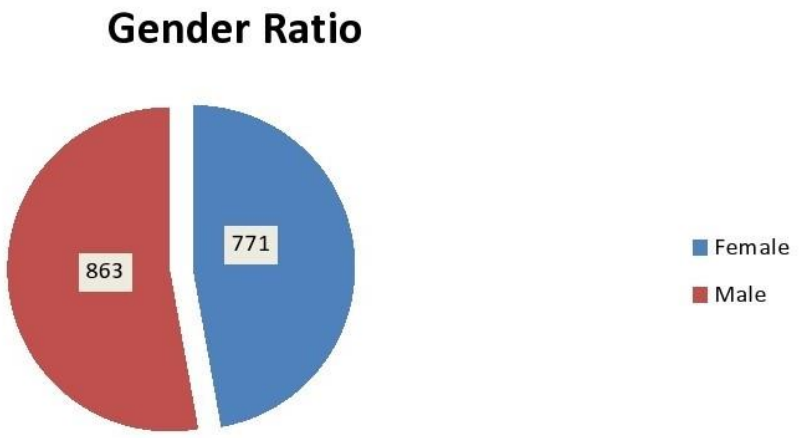

Figure 1: Male and Female Ratio

II. Average CCT of Male and Female Population:

Males in our study had higher CCT (528) than the Female (521) as shown in Table 1.

Gender	Average CCT (µm)
Male	528
Female	521

Table 1: Average CCT of Male and Female

III. Distribution CCT across population:

The mean CCT of the entire patient was 525.2766 µm, with a standard deviation of 38.99679 (Figure 2). The p- value of the data was 0.00871 using one sample Kolmogorov-Smirnov test and 0.000131 using Shapiro-Wilk normality test. The p-value shows that the above data are significant.

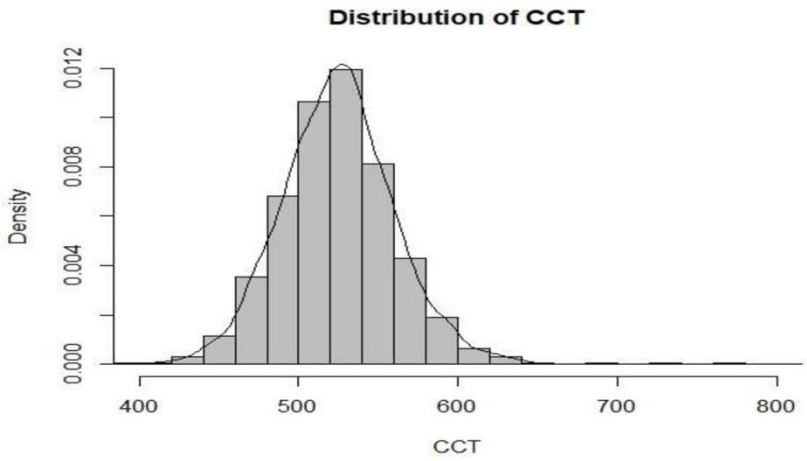

Figure 2: Distribution of CCT across population

IV. Mean CCT of patient having systemic diseases.

Table 2 shows the distribution of mean CCT of all the systemic diseases that were collected. The asthma patient had the highest mean CCT i.e. 536 µm, while the patients with arthritis had the lowest CCT i.e. 511 µm. For every 1 µm change in the average CCT of both eyes it is seen there is a mathematical change of 0.025 values in average IOP. The calculation was done through multiple variants' regression calculations. The p-value of the above data also shows <0.001, which is very much significant.

Systemic Diseases	Mean CCT (µm)
HTN	531
DM	530
Thyroid	521
CAD	523
Asthma	536
Arthritis	511

Table 2: Average CCT of patient having Systemic diseases

V. Average IOP of Systemic diseases.

HTN, CAD, and asthma show a mean IOP of 14 mm Hg, while DM, thyroid and arthritis showed a mean IOP of 15 mm Hg as seen in table 3.

Systemic Disease	Average IOP (mm of Hg)
HTN	14
DM	15
Thyroid	15
CAD	14
Asthma	14
Arthritis	15

Table 3: Average IOP of Systemic diseases

VI. Distribution of Systemic Diseases:

Table 4 shows the distribution of all the systemic diseases that were collected from the patient's records after proper examination. Out of 1635 data, 325 patients were found to have hypertension (HTN), which was the highest, while 20 patients had arthritis, which was the lowest.

Systemic Diseases	Total no. of patient
HTN	325
DM	285
Thyroid	100
CAD	52
Arthritis	20
Asthma	23

Table 4: Distribution of Systemic Diseases

VII. Mean CCT across different age group.

The highest mean CCT was seen in the age group of 31 to 40, while the lowest mean CCT in the 21-30 age groups is seen in figure 3.

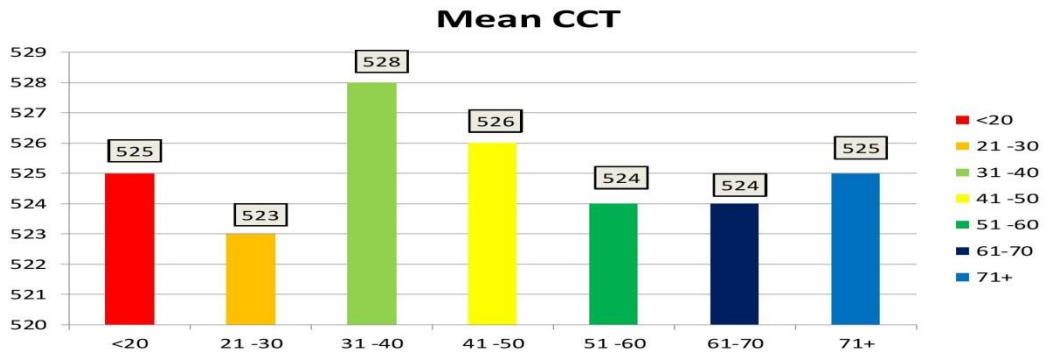

Figure 3: Mean CCT of different age group

The age group of the whole data was distributed into six groups (21-30, 31 - 40, 41-50, 51-60, 61-70, and 71+) and the relationship between the IOP and CCT was compared with the data of the age group of 20 years and below. It is seen that for every 1 µm change in the CCT, there is a mathematical 0.478 value change in the IOP of age group 21 -30, 0.860 in the age group 31-40, 0.859 in the age group of 41 -50, 0.986 in the age group 51-60, 0.663 in the age group 61-70 and 0.260 in the 71+ age group. The p-value of the 21-30 age group was 0.13832, the 31-40 age groups was 0.00992, the 41-50 age group was 0.00792, the 51-60 was 0.00207, the 61-70 age group was 0.04265 and for the 71+ age group was 0.48271. The 31-40, 41-50, and 51- 60 age groups showed high significance, while 61-70 also showed significance, but was less when compared to the other groups. However, there was no statistical significance in the 21-30 and 71+ groups.

VIII. Distribution of CCT without Systemic Diseases.

Out of 1635 data, 1061 patients were found who did not have any systematic illness (Figure 4). The mean deviation was 523.8083, with a standard deviation of 38.43323. The p-value was 0.000 using both the Kolmogorov-Smirnov test and the Shapiro-Wilk normality test.

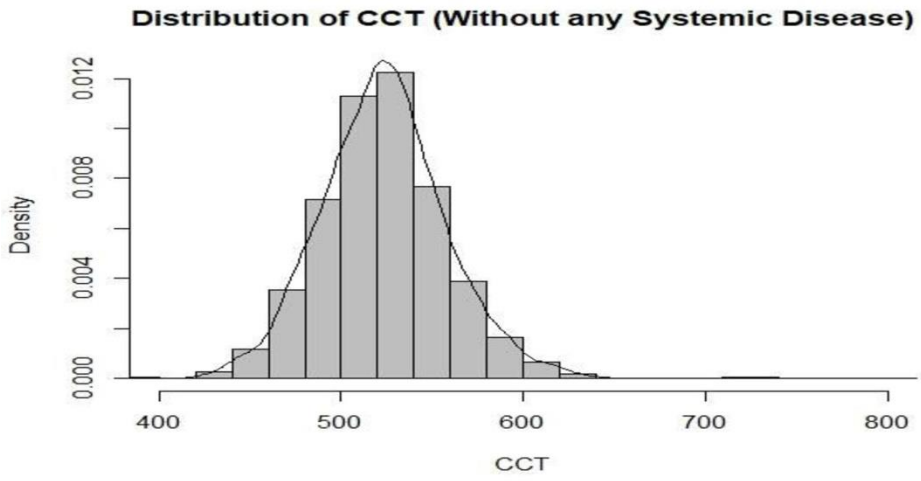

Figure 4: Distribution of CCT without any systemic diseases

IX. Effect of IOP with Systemic Disease.

The effect of IOP and its relationship with systemic disease on CCT was calculated. The data were calculated by comparing with the average IOP and the CCT of patients without any systemic diseases, which was taken as the baseline. For every 1 µm change in the CCT, there is a mathematical change of -0.224 value in the IOP for CAD patients, +0.392 for DM, -0.070 for HTN, +0.685 for arthritis, -0.152 for asthma and +0.345 for thyroid.
The p-value of each systemic disease in the patients with CAD was 0.5934, for DM was 0.04964, for HTN was 0.71727, for arthritis was 0.28019, for asthma was 0.79691, and for the thyroid was 0.23971. In this data, the p- value of DM is highly significant, while the p-value of other systemic diseases does not show any significance with our data.

X. Effect of IOP with Age.

In our study we found that the IOP increases with age; however, after the age of 60 years, it again declines. The 31-40 (p-value=0.00992), 41-50 (p-value=0.00797), and 51-60 (p-value=0.00207) age groups showed high significance, while the 61-70 (p-value=0.04265) age group also showed significance but less compared to the other groups. However, there was no statistical significance in the 21-30 (p-value=0.13832) and 71+ (p-value=0.48271) age groups.

All the above data suggest that the mean distribution of the CCT in north- Indian population is 525.2766 µm. The CCT and IOP are interrelated as the CCT increases; the IOP also increases upon some units. There was no statistically significant showing an increase in IOP with any systemic diseases apart from DM, which was highly significant (p-value=0.0496).
However, the whole modality did not show any significance as the p-value was 0.1114, which is less. The p-value was calculated using the multiple R- squared formula.

4. DISCUSSION:

In this study, we found that the mean central corneal thickness in the North Indian population was 525.2766 µm (figure 3) with a standard deviation of 38.99679, which is statistically significant with a p-value 0.00871. In the South-Indian population, the mean CCT is 511.4± 33.5 µm [7], while in the Central Indian population, the mean CCT is 514±33 µm [8]. The mean CCT is 552.3 ± 33.4 µm in the Chinese, 540.9 ± 33.6 µm in the Malays, and 540.4±33.6 µm in the Indian population was seen in another study [9]. Therefore, we can say that the North Indian population has a slightly higher mean CCT than the South and Central Indian populations.

The mean CCT without any systemic disease was found to be 523.8083 µm (figure 7), with a standard deviation of 38.43323 (p=0.000). There were no significant changes in the mean CCT of patients with systemic diseases and the overall mean CCT of the population.

The CCT and IOP are directly proportional to each other. In this study, we found that as the CCT increases, the IOP also increases. For every 1 µm increase in the CCT, there is 0.025 unit of increase in IOP also (p= <0.001) and it co-relates with another study also, where for every 10 µm change in the CCT, there is a 0.28 increase in the IOP in Goldmann applanation tonometry [10].

It has been seen that gender also plays a role in the CCT distribution, as shown in Figure 1. The males had thicker corneas compared to females by an estimation of 0.407 (p=0.0429), which shows a significant relationship. In this study, we found that the mean CCT of the males was 528 µm, while in the females it was 521 µm (table 1). In other studies, it was also found that the males had thicker corneas compared to the females, which correlates with our studies[11, 12]. The tendency for the females to have steeper corneas may be linked to the fact that the females have shorter axial length than the males [8].

In this study, we distributed age in seven groups, as shown in Fig 6. We found a significant relationship between CCT and age. We found that the 31-40 years of age group had the highest mean CCT (528 µm), while the 21-30 years of age group had the lowest mean CCT (523 µm).

However, according to another study, it is elaborated that a 10-year increase in age would lead to approximately a 7.0 µm decrease in the CCT [13]. This contradicts our data, where we found that there was an increase in the mean CCT from 21 to 40 years of age, followed by a decrease in the CCT from 41 to 70 years of and then again increased in the 70+ age group. This contradiction in our study may be due to the effect of systemic diseases on the CCT and also due to the change in the body mass index of patients, which was not taken into consideration[6].

We found a constant increase in IOP in the age group between 20 to 60 years of age, but there was a sudden drop in IOP after 60 years of age. This may be because keratocytes are the major cellular components of the corneal stroma [14]. The density of keratocytes decreases with age, so the collagen fibers are broken down. These changes are the most likely reasons for the observed reduction in CCT with age [15]. The relationship between each age group and the CCT and its changes in IOP were calculated. As the age increases, the IOP also increases by some units when compared with < 20 years of age. The 31-40, 41-50, and 51-60 age groups showed high significance, while the 61-70 age group also showed significance but less compared to the other groups. However, there was no statistical significance in the 21-30 and 71+ age groups. Therefore, as the age increases from the fifth to sixth decades, the IOP slightly decreases, which co-relates with previous studies [16].

There was a significant relationship between DM, CCT and IOP. It was seen in patients with DM, for every 1 µm increase in the CCT, there was a change in the IOP by 0.392 (p= 0.04964), which showed a significant relationship. Therefore, we can say that diabetes is associated with CCT and IOP [17]. This co-relates with other studies, which also suggests that DM patients have a thicker CCT and higher IOP [18], [19].

In this study, we did not find any significant relationship between HTN, CAD, arthritis and asthma with the CCT and IOP. Alls hypertensive patients were taking drugs to maintain the blood flow, which caused thinner venous pressure, and this might be one of the reasons for getting IOP in the normal range in hypertensive patients [19]. However, other studies have shown a significant relationship between HTN, CCT and IOP. In other studies, it has been seen that hypertensive patients have a thicker cornea as compared to patients not having hypertension [20].

Although most of our data's are co-related with all the other previous studies done, however according to statistical analysis done by the multiple R- squared, the p-value of the whole modality is less i.e. 0.1114.

5. LIMITATION:

The body mass index (BMI) of the patient was not included in the study. Any change in body obesity leads to structural changes in the body, including the eye, which also leads to changes in the CCT [6].

The systolic and diastolic pressures of the patients were not included, which may also show significant changes in CCT and IOP [20].

6. CONCLUSION:

The mean CCT of the North Indian population is 525.2766 µm The CCT of the North Indian population is more than that CCT of the South-Indian and Central Indian populations. Males have a thicker CCT than females. CCT and IOP have a direct relationship with each other. An increase in the CCT also leads to an increase in IOP. Females were seen to have higher IOP than males, with a change in CCT. Systemic diseases and age also effects CCT and IOP.

7. ACKNWOLEDGEMENT:

We would like to thank Mr. Atanu Majumder for doing the statistical analysis of our study.

8. Ethical Consent:

Before collecting data from the patients, a proper consent were taken from the patient about their data being used for the research paper and none of their name or personal information will be revealed during the research period

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Figure and Table Caption:

Figure 1 Male and Female Ratio.

Figure 2 Distribution CCT across population.

Figure 3 Mean CCT across different age group.

Figure 4 Distribution of CCT without Systemic Diseases.

Table 1 Average CCT of Male and Female Population**.**

Table 2 Average CCT of patient having systemic diseases.

Table 3 Average IOP of Systemic diseases.

Table 4 Distributions of Systemic Diseases.