

## Central corneal thickness: Correlation with intraocular pressure and disease severity in primary open angle glaucoma

Bindu S<sup>1,\*</sup>, Jyothi P.T<sup>2</sup>, Aswathy.P<sup>3</sup>

<sup>1</sup>Associate Professor, <sup>2</sup>Professor, <sup>3</sup>Sr.Resident, Dept. of Ophthalmology, Govt. Medical College, Kozhikode

**\*Corresponding Author:**

Email: binsuseela@yahoo.co.in

### Abstract

**Aim:** To evaluate the relation between central corneal thickness (CCT), intraocular pressure (IOP) and vertical cup-disc ratio in Primary open angle glaucoma (POAG) compared to normal and to find out correlation between Central corneal thickness and disease severity in POAG.

**Materials and Methods:** Cross sectional study. Hundred patients on treatment for POAG and hundred age matched subjects were studied. Central corneal thickness was measured using ultrasound pachymeter. Intraocular pressure was measured by applanation tonometry. Statistical analysis was done using SPSS version 18.

**Results:** The mean CCT in glaucoma patients was 528.03±33.37 μm in right eye and 529.69±34.14 μm in the left eye. The mean value obtained for the control group was 541.46±31.20 μm in right eye and 541.25±30.32 in left eye. There was no statistical significance in mean CCT values in males and females. CCT was found to decrease with age in both groups. In glaucoma patients there was a positive correlation of CCT with IOP, and a negative correlation with vertical cup-disc ratio (VCDR). Patients with severe glaucoma had thinner cornea.

**Conclusion:** The average CCT obtained for normal as well as glaucoma patients in our study was lower than the suggested value of 555 μm as a risk factor for development of glaucoma by Ocular hypertension study group. Patients with severe glaucoma had thinner cornea. Hence our population maybe at a greater risk of developing glaucoma. In patients with POAG, CCT helps to identify patients with thinner cornea who may be at a higher risk of progression, and require more aggressive control.

**Keywords:** Central corneal thickness, Intraocular pressure, POAG- disease severity.

### Introduction

Central corneal thickness is considered to be an independent risk factor for the development of glaucoma. Elevated IOP is the only modifiable risk factor. The other ocular risk factors are myopia, disc hemorrhage, increased vertical cup-disc ratio and asymmetric cupping. Various studies have shown that significant variation in central corneal thickness (CCT) occur in the normal population. Corneal thickness can vary with ethnicity age gender, refractive status, hormonal status and medications. According to the Ocular Hypertension study<sup>(1)</sup> in addition to the confounding effect of IOP measurement by Goldman applanation tonometry (GAT), lower central corneal thickness predicts the development of primary open angle glaucoma.

**Study design:** Descriptive cross sectional comparative study

### Materials and Methods

100 patients under treatment for Primary open angle glaucoma and 100 age matched controls were taken up for the study.

Patients with other conditions affecting the corneal thickness (spherical equivalent more than 5 diopters or 3 or more diopters of astigmatism, opacities in the cornea and history of any previous ocular surgery), subjects with visual field defects due to causes other than

glaucoma and patients with media opacities excluded from the study. Institutional ethics committee approval was obtained.

Informed consent was taken from all the subjects. All subjects underwent ophthalmologic examination including visual acuity, intra ocular pressure measurement by Goldman applanation tonometry, and slit lamp examination including gonioscopy and biomicroscopy with +90D lens. Field charting was done by Humphreys Field Analyzer (Zeiss SR 720 8371) and retinal nerve fiber layer thickness was measured by Optical coherence tomography (Spectral OCT SLO-OPKO/OTI Instrumentation SN 1461). Pachymetry was performed using ultrasonic pachymeter, PACSCAN 300p model of SONOMED Inc. Topical anesthetic was applied in the eye and patient was seated. Probe was placed over the central part of cornea after asking the patient to look straight ahead. 5 readings were taken in each eye and the mean was chosen as the representative value in that eye.

Severity of glaucoma was assessed based on vertical CD ratio, visual field changes and retinal nerve fiber layer analysis and grouped into mild, moderate and severe disease based on American Academy of Ophthalmology guidelines.<sup>(2)</sup>

Statistical analysis was performed using SPSS Version 18. Chi square test was done to test variance. One way Anova and test was done to compare means.

## Observation & Results

**Table 1: Demographic profile of POAG patients and Control**

	POAG N=100	Control N=100
Mean Age	58.41±9.59yrs	57.42±9.38 yrs
Males	44 (47.3%)	49 (52.3%)
Females	56 (52.7%)	51 (47.7%)

**Table 2: Distribution of cases based on Mean CCT**

	N=	Mean ±SD CCT µm RE	Mean±SD CCT µm LE	CCT ≤ 555µm or N=		CCT >555µm N=	
				RE	LE	RE	LE
POAG	100	528.03±33.37	529.69±34.14	79	79	21	21
Control	100	541.46±31.20	541.25±30.32	70	66	30	34
P value				0.144	0.04*		

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.

**Table 3. Central corneal thickness in different age groups in POAG and Normal**

Category	Age group	No.	Mean CCT ±SD Right eye	Mean CCT±SD Left eye
POAG	35-45	10	516.70±35.88	522±39.72
	46-55	28	541.11±29.98	543.5±31.87
	56-65	33	520.24±32.83	519.39±29.7
	66-75	25	533.28±31.79	536.40±34.05
	76-85	4	496.25±30.67	495.25±28.50
P value			*0.019	0.009*
Control	35-45	13	553±32.20	549.54±32.64
	46-55	32	549.25±31.06	547.34±29.89
	56-65	33	535.85±27.41	537.39±28.65
	66-75	20	534.30±33.77	535.45±31.82
	76-85	2	506±5.65	511.50±2.12
P value			0.072	0.245

There was a reduction of CCT with advancing age in both groups but was significant only in glaucoma patients, as shown in the table.

**Table 4: Distribution of CCT based on gender**

POAG	N=	Mean CCT RE±SD	Mean CCT LE±SD
Male	44	524.91±35.77	527.59±34.56
Female	56	530.48±31.46	531.34±34.03
P value		0.410	0.588
Control			
Male	49	542.51±28.14	541.78±27.04
Female	51	540.45±34.13	540.45±33.43
P value		0.743	0.866

CCT values were slightly higher in female glaucoma patients even though not statistically significant.

**Table 5. Comparison of IOP, VCDR, CCT in POAG & Normal**

	POAG	Control	P value
IOP	17.22±5.03	13.96±2.48	* 0.000
RE	18.82±4.95	13.66±2.59	*0.000
LE			
VCDR	0.663±0.198	0.322±0.90	*0.000
RELE	0.683±0.15	0.318±0.09	*0.000
CCT	528.03±33.37	541.46±31.20	*0.004
RE	529.69±34.14	541.25±30.32	*0.012
LE			

Mean IOP in POAG group was higher than normal even though they were on treatment. Vertical CD ratio was higher as expected in POAG.

POAG group had thinner CCT than Normal. All these differences were statistically significant.

**Table 6: Correlation between IOP, VCDR & CCT in POAG**

	Mean/ SD	correlation	P value
IOP BE	18.12±5.44	0.179	*0.011
CCT BE	528.86±33.68		
VCDR	0.673±0.173	-0.165	*0.019
BE			

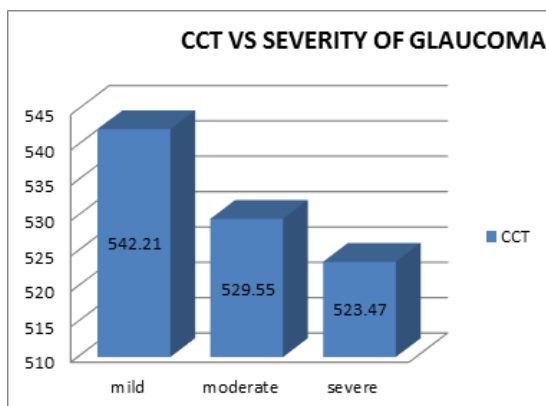
IOP had positive correlation with CCT and was statistically significant.

Vertical cup-disc ratio had a negative correlation with CCT and had statistical significance.

**Table 7: Severity of glaucoma Vs CCT**

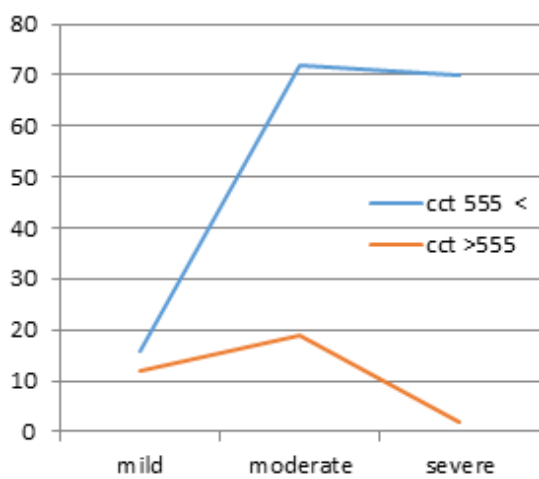
Severity of glaucoma	Right eye				Left eye			
	Total No.	≤555 μm	>555 μm	Mean CCT	Total No.	≤555 μm	>555 μm	Mean CCT
Mild	16	10	6	534.25±32.98	12	6	6	552.83±40.73
Moderate	42	34	8	528.88±30.97	49	38	11	530.12±31.68
Severe	42	35	7	524.81±36.13	39	35	4	522.03±32.57
P value	*0.02			0.619	*0.009			*0.022

Majority of glaucoma patients in this study had moderate and severe glaucoma (p value <0.05 in both eyes) Patients with severe glaucoma had thinner cornea, but was statistically significant only in the left eye.



**Fig. 1: Chart showing thinner CCT in patients with advanced glaucoma**

CCT values are lower in patients with severe glaucoma.



**Fig. 2: Distribution of cases in different stages of glaucoma in both eyes**

## Discussion

Mean age of patients with POAG was 58.41±9.59yrs. with a range of 38-80yrs. and in the control group it was 57.42±9.38yrs (range- 41-77yrs). Out of the 200 subjects studied, there were 93 males and 107 females. In the POAG group there were 44 males and 56 females. In the control group, there were 49 males and 51 females. The mean age and gender distribution in both groups were comparable.(Table 1) The mean CCT

in glaucoma patients was 528.03±33.37μm in right eye and 529.69±34.14μm in the left eye. The mean value obtained for the control group was 541.46±31.20μm in right eye and 541.25±30.32 in left eye. A meta-analysis of corneal thickness done by Chua et al<sup>(3)</sup> had found that the mean central corneal thickness in normal population range between 535-545μm and reported a mean CCT of 540 μm among Indians. This is similar to our results in the control group. In the study by Maya et al,<sup>(4)</sup> the CCT of normal controls was 536 μm. Another study done in rural central India found a mean central corneal thickness of 514 μm,<sup>(5)</sup> both of which were thinner when compared to our values. The difference may be attributed to the wide variation in CCT that can occur even within races in addition to the inter-racial differences. Meideros et al<sup>(6)</sup> suggested that thin cornea was a significant predictor for the development of visual field loss in patients with pre perimetric glaucoma. In our study, in patients with glaucoma, the mean CCT in both eyes were thinner than the control group, but was statistically significant only in the left eye (P value 0.04) as shown in Table 2. This is in accordance with the study by Jorge Fernandez-Bahamonde et al<sup>(7)</sup> where a statistical association was found between thinner cornea and POAG. Natarajan et al<sup>(8)</sup> and Kitsos et al<sup>(9)</sup> found no difference in CCT between POAG and normal.

Gelaw et al<sup>(10)</sup> reported a statistically significant decline in CCT as age advances. Studies by Day et al<sup>(11)</sup> and Wang et al<sup>(12)</sup> were in accordance with the statistical association of CCT with age. In our study, when different age groups were considered, there was a reduction in CCT values as age advances in normal as well as in patients with POAG, but it was statistically significant only in glaucoma (P value 0.019 RE and 0.009 in LE) as shown in Table 3. This finding was similar to that by Brandt et al.<sup>(13)</sup> CCT was found to be lower in Blacks, Hispanics and Mangolians as compared to whites.<sup>(12,14-17)</sup> Heritability of central corneal thickness has also been suggested.<sup>(18)</sup>

On comparing the right eye CCT (528.03±33.37μm) with the left eye CCT (529.69±34.14 μm) we did not get any statistically significant difference. Females with POAG had a slightly higher CCT values than males, even though not statistically significant (Table 4). This may be due to the effect of estrogens which can increase

the CCT.<sup>(19)</sup> But Vijaya et al<sup>(20)</sup> found that females had a thinner cornea.

Comparison of central corneal thickness, intraocular pressure and vertical cup-disc ratio between normal and glaucomatous patients, showed a statistically significant difference between the two groups p value 0.000 in both eyes for IOP and Vertical CDR and for CCT 0.004 RE and 0.012 LE (Table 5). However Day et al<sup>(21)</sup> found that there was no difference in CCT values in POAG patients and normal unlike our study. In the Barbados eye study, there was a positive correlation between CCT and intraocular pressure only in white participants but black and mixed population had a thinner cornea and higher IOP.<sup>(22)</sup> However there was a positive correlation of IOP with CCT in POAG patients in our study as seen in studies by Vijaya et al and Day et al.<sup>(20,21)</sup> Review of literature reveals that the relationship between CCT and IOP is not linear. There is no standard nomogram that has been validated for correcting applanation IOP measurements for CCT. Ehlers et al<sup>(23)</sup> found that GAT accurately reflected true IOP when CCT value was 520µm and deviation from this value produced a change in IOP of 7mmHg per 100µm. Doughty and Zaman<sup>(24)</sup> calculated a correction of 2.5mm of Hg for each 50µm. Kim et al<sup>(25)</sup> was of the view that a thinner cornea was associated with visual field progression in glaucomatous eyes. Congdon et al<sup>(26)</sup> suggest that IOP is more affected by corneal hystereis than CCT, a lower hysteresis being associated with visual field progression.

In our study, when glaucoma patients were considered, there was a significant correlation between CCT and IOP (p value 0.011) as well as CCT and vertical CD ratio (p value 0.019) (Table 6). This was seen in a similar study by Kniestedt.<sup>(27)</sup> VCDR had a negative correlation with CCT which means that an increased CD ratio is associated with a thinner cornea. This finding is similar to that in other studies.<sup>(27-30)</sup> Ntim-Amponsah et al<sup>(31)</sup> found no correlation bet CCT and CD ratio. Pakaravan et al<sup>(32)</sup> 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.

Correlation of severity of glaucoma with CCT (Table 7) showed that patients with thinner cornea had more severe disease in either eye and this was statistically significant (p value 0.02 in RE and 0.009 in LE). This was in accordance other studies.<sup>(32,34)</sup> This is relevant as IOP recording by applanation in these patients may be underestimated and may give a false sense of control of glaucoma.

Studies like Ocular hypertension study,<sup>(1)</sup> European Glaucoma Prevention Study<sup>(35)</sup> recognized CCT as a strong predictor of development and progression of POAG, with people having CCT 555µm or less having three fold risk. Majority of patients in both groups in our study had CCT values less than 555 that is 149 out of 200

eyes in the RE and 145 out of 200 eyes in the left eye. The average CCT in our study was 541µm in normal and still lower in glaucoma patients.

The thinner CCT in both the study groups warrant a population based study for early detection of glaucoma. Even though glaucoma patients were on treatment and IOP was under control in majority, there was a positive correlation with CCT.

### Limitation

Anti-glaucoma medication may have an effect on central corneal thickness measurement.<sup>(36,38)</sup>

### Conclusion

The mean central corneal thickness in patients with and without glaucoma in this study was less than the value predicted (555 microns) as a risk factor for glaucoma by Ocular Hypertension Study Group. This would mean that our population is at a greater risk of developing glaucoma, and established cases may need to maintain IOP at a lower range. People above 40years should undergo screening for glaucoma with emphasis on central corneal thickness measurement in addition to IOP, as a thinner cornea may underestimate the IOP by applanation and glaucoma may be missed. CCT measurement should be included in the treatment protocol as well as follow up of glaucoma patients with thinner cornea as thickness may decrease with age as well as due to the effect of anti-glaucoma medications. This gives a false low IOP measurement in these patients.

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