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Original Research Article

A comparative study on the central corneal thickness (CCT) readings and intraocular pressure (IOP) changes in primary open angle glaucoma patients and age matched general population

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Abstract: To compare the central corneal thickness (CCT) and intraocular pressure (IOP) changes in primary open angle glaucoma (POAG) patients and age matched general population. 100 normal (n=200) & 70 POAG (n=92) patients between 35-80yrs recruited. CCT was measured by ultrasonic pachymetry & IOP by Goldmann Applanation Tonometry. The statistical analysis was linear regression analysis of IOP on CCT done to compare means between groups. In results the Mean values are: Normal population-CCT=490±46µm, IOP=13±5mmHg. POAG-CCT=512±43.6 µm, IOP=21±5mmHg. No specific association of CCT & IOP with age & sex found.No such association found in POAG. In conclusion No significant difference in the CCT between normal population and the POAG patients found.
Keywords: Central corneal thickness, intraocular pressure, primary open angle glaucoma.

INTRODUCTION

The measurement of the central corneal thickness is an important factor in the evaluation and management of glaucoma suspects and glaucoma patients and the measurement of the intraocular pressure by Goldmann applanation tonometry, which is the gold standard, is affected by central corneal thickness.

The purpose of this study is to measure:

1. Central corneal thickness in primary open angle glaucoma patients and age matched general population
2. Intraocular pressure in primary open angle glaucoma patients and age matched general population
3. If corneal thickness plays a clinically significant role in classifying patients as having normal intraocular pressure or glaucoma.

MATERIAL AND METHODS

1. **DURATION:** A period of 1 year (one) from 1st June 2012 to 31rst May 2013.

2. **NUMBER OF CASES:** The present study includes 200 eyes of 100 normal patients and 92 eyes of 70 primary open angle glaucoma patients.

3. **STUDY POPULATION:**
   a. Primary open angle glaucoma patients (both male and female) attending OPD or admitted in the indoor ward
   b. Age matched general population (both male and female) in OPD or indoor ward

SELECTION OF CASES:

The patients were selected and informed consent was obtained. The study was approved by the local ethics committee.

STUDY DESIGN: Masked cross sectional study

INCLUSION CRITERIA:

1. POAG was defined as an IOP of 22mmHg or higher in the presence of a typical glaucomatous disc and visual field changes and an open angle on gonioscopy. Established cases of POAG with antiglaucoma medicines were included.
2. Normal eyes were defined as those with no corneal /ocular surface disorder and no evidence of glaucomatous disease, optic nerve head shows no signs of glaucoma, no visual field defects and no IOP above 21mmHg.

EXCLUSION CRITERIA:

1. Ocular disease other than POAG.
2. Myopia or hypermetropia of more than three diopters (D).
3. Astigmatism of more than one D.
4. Patients wearing contact lenses.
5. Who had undergone any ocular surgery.
6. Corneal disease or clinical corneal changes.
7. Dilated pupils at the time of examination.

METHODS OF CLINICAL ASSESSMENT OF THE PATIENTS:

1. **HISTORY**
2. **EXAMINATION:** General , systemic and ocular examination

OCULAR EXAMINATION:

- External ocular examination in diffuse light, best corrected visual acquity, slit lamp biomicroscopy, direct and indirect ophthalmoscopy, and 90D lens examination, lacrimal syringing, indirect gonioscopy and visual field testing were done.
- The central corneal thickness (CCT) was measured in all subjects using an ultrasonic pachymeter.
- Measurements of IOP were made using Goldmann applanation tonometer mounted on a slit lamp.

CENTRAL CORNEAL THICKNESS MEASUREMENT:

INSTRUMENT:

Pacscan 300AP (Sonomed digital biometric ruler, A-Scan and Pachymeter)

PATIENT PREPARATION:

- A drop of topical anesthetic 4% xylocaine is applied to the eye that is to be measured.
- The patient is either seated or is in a supine position. Following entry of user and patient information, corneal thickness measurements may be obtained.

PROCEDURE OF TAKING THE MEASUREMENTS –

Here in our study we have used the multiple readings single point mode and 5 readings are taken.

TONOMETRY:

PRINCIPLE:

In our study we have used the Goldmann Applanation Tonometer which is considered as the "Gold Standard" method for the measurement of intraocular pressure.

APPLANATION TONOMETRY: GOLDMANN

INSTRUMENT:

1. Applanation Tonometer (Haag-Streit International, Bern, Switzerland)
2. Slit Lamp (Model 900, Haag-Streit International, Bern, Switzerland)

PRINCIPLE:

The principle that it follows is the **"IMBERT-FICK LAW"** which states that:

Pressure within a sphere (P) is roughly equal to the external force (f) needed to flatten a portion of the sphere divided by the area (A) of the sphere which is flattened

$$P = f / A$$

TECHNIQUE OF USE:

PROCEDURE:

The procedure was explained to the patient. The patient was seated comfortably. A drop of 4% xylocaine was instilled in both the eyes. Moistened 2% sodium fluorescein strips were used to instill a small amount of flourescein in inferior cul-de-sac. The biprism head was sterilized with alcohol swab & waited for 2 mins. The angle between the illumination and the microscope was set at approximately 60 degrees and the cobalt filter was used with the slit being open maximally whereby the instrument was set at its brightest illumination.

Now, the slit lamp was moved forward and the measuring prism brought in contact in the center of the cornea in the pupillary area when the limbus shines with a bluish light.

Only after the contact, the microscope was used and the applanation viewed through the biprism. The steady pulsation of the two fluorescein semicircles was noted. The pressure on the eyes was then increased until the inner borders of the fluorescein rings just touch each other at the midpoint. The IOP was measured directly from the scale reading, multiplied by ten. In this way three readings were taken in each eye starting from the right eye and the mean was recorded. The Goldmann's tonometer was calibrated once a month.

STATISTICS:

METHODS ADOPTED FOR CALCULATING DIFFERENT VALUES:

a. Range
b. Mean
c. Standard deviation
d. Test of significance: Analysis of variance was applied.
e. Linear regression analysis

RESULTS AND OBSERVATIONS

The aims and the objectives of the study were prefixed. Studies carried out in different categories were as follows:

Table 1: Various data in population included in the study

DATA	NORMAL POPULATION	PRIMARY OPEN ANGLE GLAUCOMA
NO. OF PATIENTS	100	70
NO. OF PATIENTS	100	70
NO. OF EYES	200	92
AGE GROUP	35-75	35-80
MALE	66 (66%)	45(64%)
FEMALE	34(34%)	25(36%)

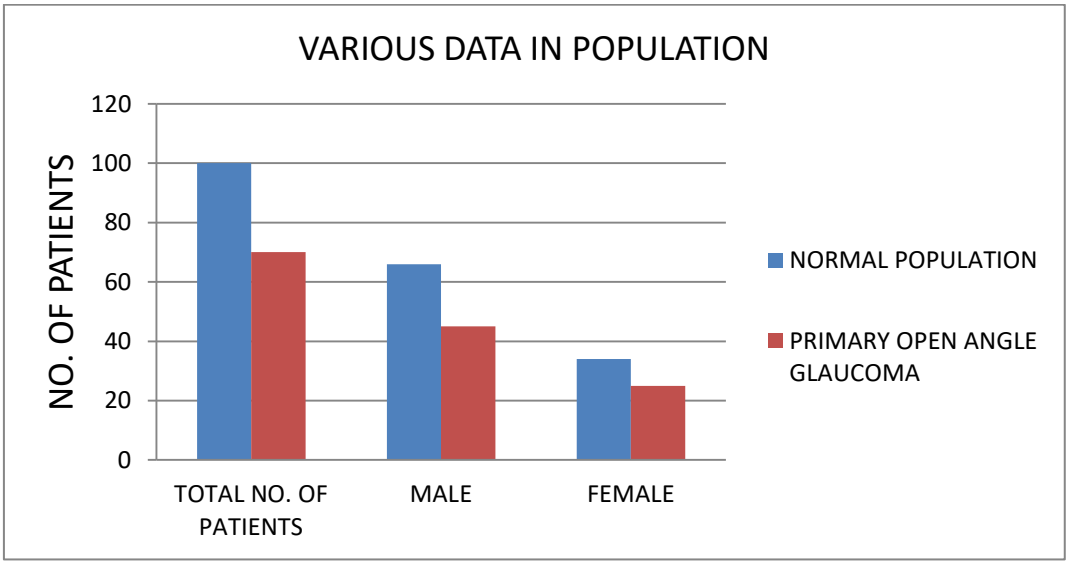

Fig 1: Various data in population included in our present study

AGE SPECIFIC CCT DISTRIBUTION IN NORMAL POPULATION:

The age of the normal population included ranged from 35-75 years. The maximum number of patients was in the 35-45 years of range. Total number of normal population was 100.

Table 2: Age specific mean central corneal thickness Mean ± SD

AGE(yrs)	RANGE(µm)	MEAN±SD
35-45	460-532(58)	496±36
46-55	462-532(25)	497±35
56-65	444-536(13)	490±46
66-75	464-530(4)	497±33

Values in parenthesis are the number of subjects

No specific association of CCT with age was found

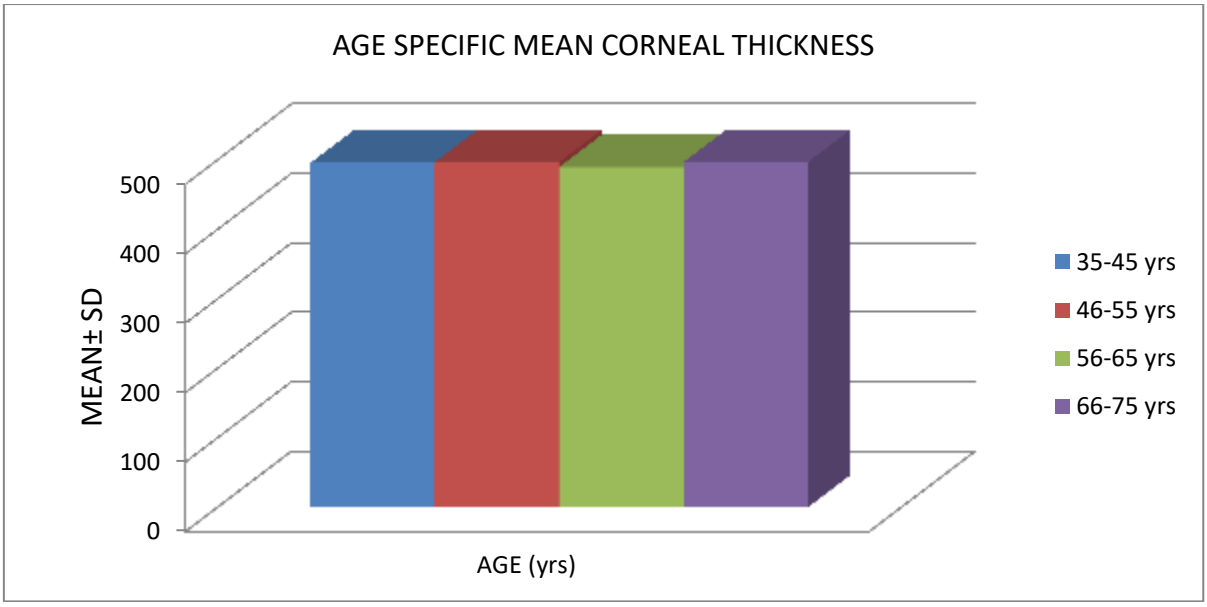

Fig 2: Age specific mean corneal thickness

SEX SPECIFIC CENTRAL CORNEAL THICKNESS IN NORMAL POPULATION:

Amongst 100 patients studied, 66 were male and 34 were female. Maximum number of both male and female patients was in the age group of 35-45 years.

Table3: Sex specific mean central corneal thickness Mean ± SD

AGE (yrs)	MALE RANGE (µm)	FEMALE RANGE (µm)	MALE MEAN± SD	FEMALE MEAN± SD
35-45	460-532 (40)	478-532 (18)	496± 36	505±27
46-55	462-532 (16)	472-532 (9)	497±35	502±30
56-65	444-536 (9)	462-524 (4)	490±46	493±31
66-75	490-494 (1)	464-530 (3)	492±2	497±33

Values in parenthesis are the number of subjects

No specific association of CCT with sex was found

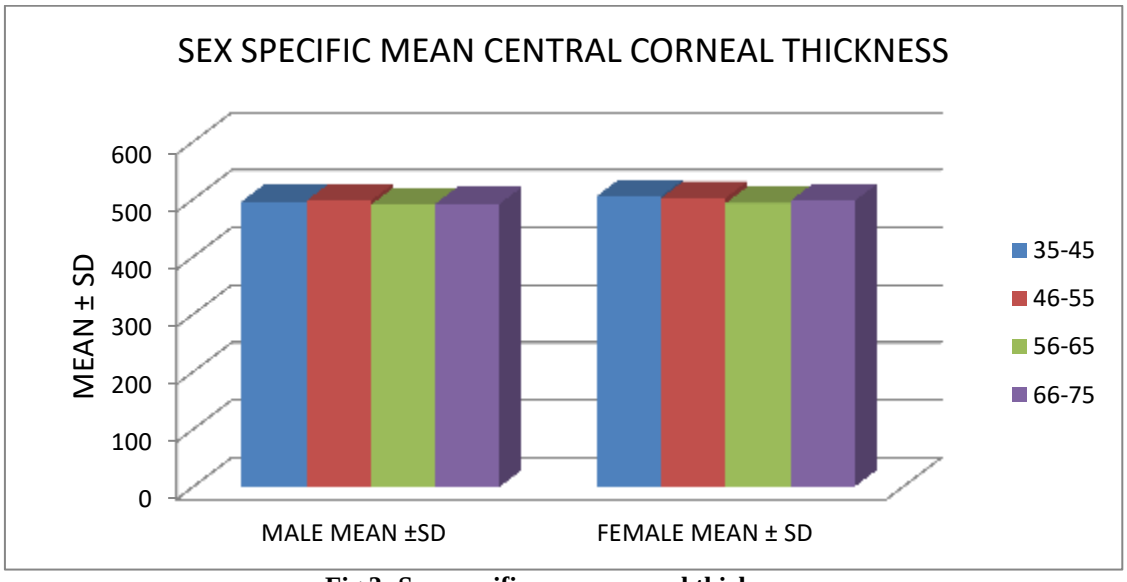

Fig 3: Sex specific mean corneal thickness

AGE SPECIFIC INTRAOCULAR PRESSURE DISTRIBUTION IN NORMAL POPULATION:

The age group and the number of normal patients were same as for CCT distribution i.e. age ranged from 35-75 years and 100 normal patients included.

Table 4: Age specific mean intraocular pressure Mean ± SD

AGE(yrs)	RANGE(mmHg)	MEAN±SD
35-45	9-18 (58)	13.5±4.5
46-55	9-17 (25)	13±4
56-65	8-16 (13)	12±4
66-75	13-15 (4)	14±1

Values in parenthesis are the number of subjects

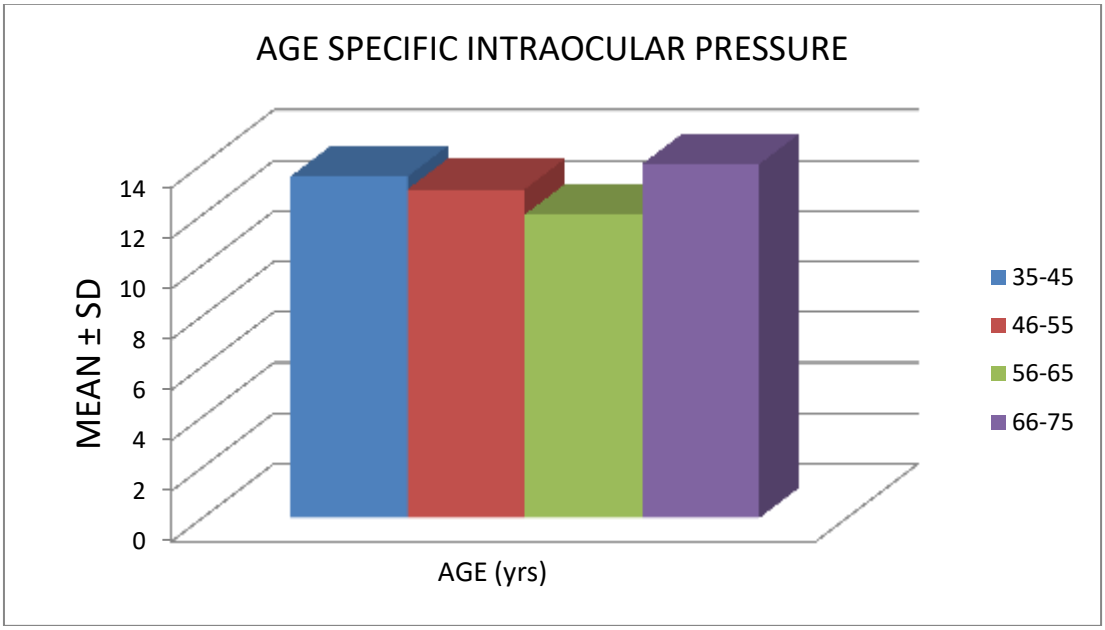

Fig 4: Age specific mean intraocular pressure

SEX SPECIFIC INTRAOCULAR PRESSURE DISTRIBUTION IN NORMAL POPULATION:

The age group and the number of normal patients are same as in Table 3.

Table 5: Sex specific mean intraocular pressure Mean ± Standard deviation

AGE (yrs)	MALE RANGE (µm)	FEMALE RANGE (µm)	MALE MEAN± SD	FEMALE MEAN± SD
35-45	9-17 (40)	10-18(18)	13±4	14±4
46-55	9-17 (16)	13-17 (9)	13±4	15±2
56-65	8-16 (9)	9-13 (4)	12±4	11±2
66-75	14 (1)	13-15(3)	14±0	14±1

Values in parenthesis are the number of subjects

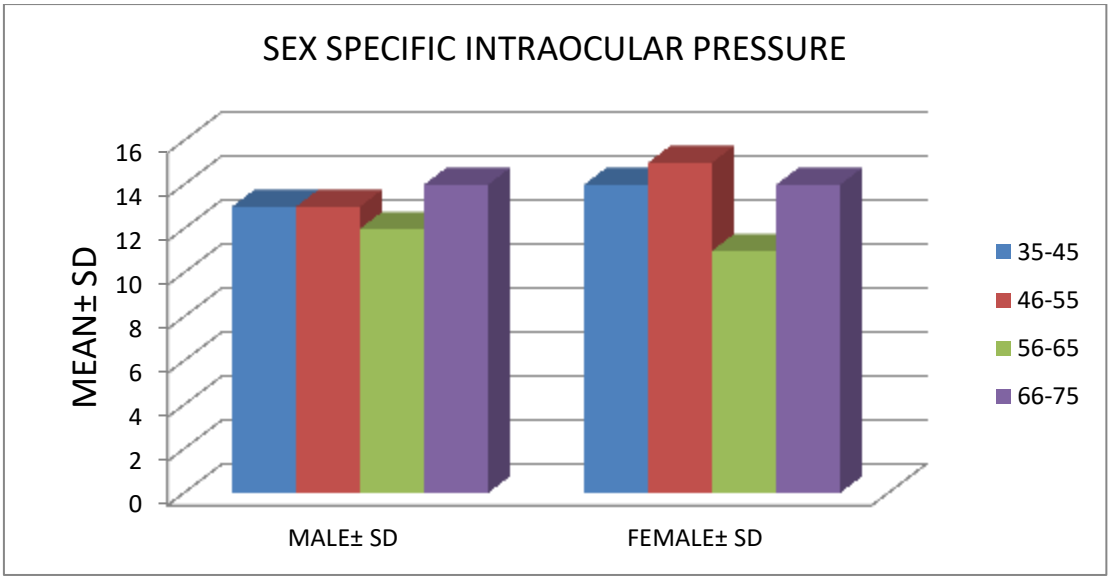

Fig 5: Sex specific mean intraocular pressure

CCT DISTRIBUTION BETWEEN RIGHT AND LEFT EYES IN NORMAL POPULATION: (AGE AND SEX SPECIFIC)

Mean CCT of the right eyes was found to be 488µm and mean CCT for the left eyes was found to be 491µm. For male, mean CCT was 490µm and for females, mean CCT was 497µm. The difference in CCT measurements between right and left eyes was not significant in both genders.

Table 5: Sex specific mean central corneal thickness between right and left eyes in males

AGE (yrs)	RIGHT EYE (µm)	LEFT EYE (µm)	RIGHT EYE (MEAN± SD) µm	LEFT EYE (MEAN± SD) µm
35-45	460-530	464-532	495±35	498±34
46-55	462-532	468-532	497±35	500±32
56-65	444-523	446-536	483.5±39.5	491±45
66-75	490	494	490±0	494±0

Table 6: Sex specific mean central corneal thickness between right and left eyes in females

AGE (yrs)	RIGHT EYE (µm)	LEFT EYE (µm)	RIGHT EYE (MEAN± SD) µm	LEFT EYE (MEAN± SD) µm
35-45	478-532	478-532	505±27	505±27
46-55	472-532	476-526	502±30	501±25
56-65	462-518	466-524	490±28	495±29
66-75	464-521	464-530	492.5±28.5	497±33

Table 7: Age and sex specific mean central corneal thickness between right and left eyes: Mean ± SD

AGE (yrs)	MALE (MEAN± SD) µm		FEMALE (MEAN± SD) µm	
	RIGHT EYE	LEFT EYE	RIGHT EYE	LEFT EYE
35-45	495±35	498±34	505±27	505±27
46-55	497±35	500±32	502±30	501±25
56-65	483.5±39.5	491±45	490±28	495±29
66-75	490±0	494±0	492.5±28.5	497±33

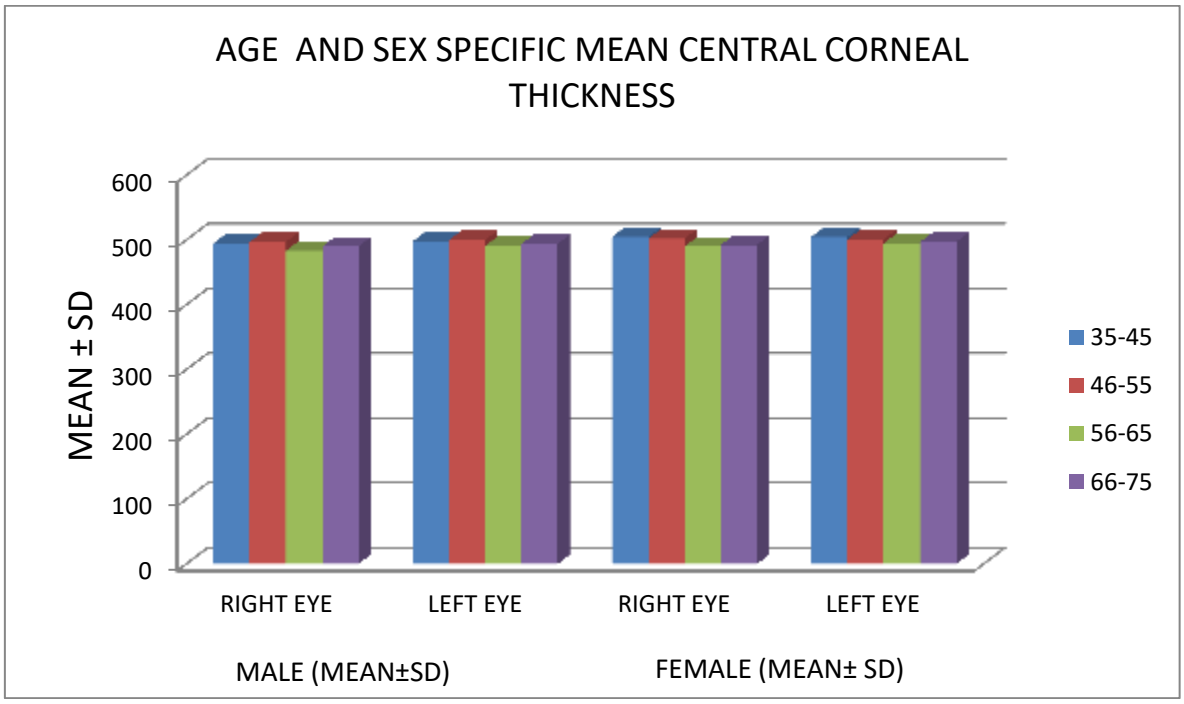

Fig 5: Age and sex specific mean central corneal thickness between right and left eyes

Va. CENTRAL CORNEAL THICKNESS: Both eyes (MEAN±SD)

Table 7a: Central corneal thickness: Both eyes (MEAN±SD)

AGE GROUP (yrs)	RIGHT EYE (µm)	LEFT EYE (µm)
35-75	488±44 (444-532)	491±45 (446-536)

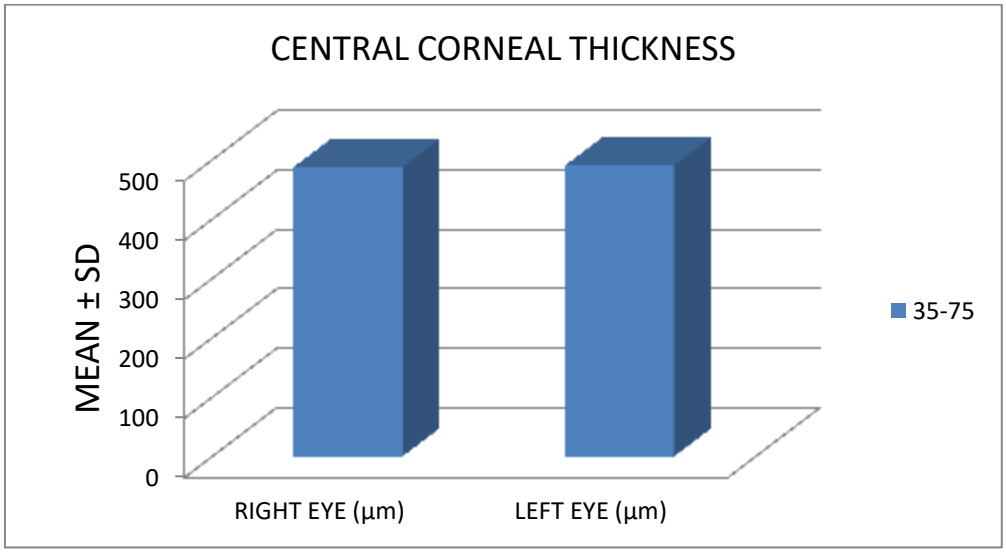

Fig-5a: Central corneal thickness in right and left eyes

Vb. CENTRAL CORNEAL THICKNESS: Sex specific (MEAN±SD)

Table 7b: Central corneal thickness: Sex specific (MEAN±SD)

AGE GROUP (yrs)	MALE (µm)	FEMALE (µm)
35-75	490±46 (444-536)	497±35 (462-532)

Values in parenthesis are the number of subjects

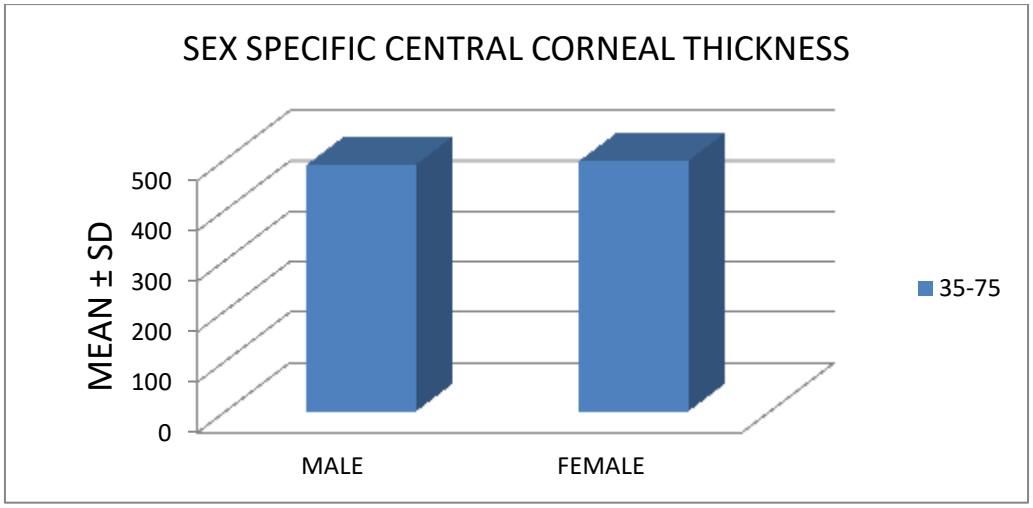

Fig-5b: Central corneal thickness: Sex specific

IOP DISTRIBUTION BETWEEN RIGHT AND LEFT EYES IN NORMAL POPULATION: (AGE AND SEX SPECIFIC)

Mean CCT of the right eyes was found to be 12±4 mmHg and mean CCT for the left eyes was found to be 13 ±5mmHg.For male, mean CCT was 12.5± 4.5 mmHg and for females, mean CCT was 13.5±4.5mmHg.

Table 8: Sex specific mean intraocular pressure between right and left eyes in males

AGE (yrs)	RIGHT EYE (mmHg)	LEFT EYE (mmHg)	RIGHT EYE (MEAN± SD) mmHg	LEFT EYE (MEAN± SD) mmHg
35-45	9-16	10-17	12.5±3.5	13.5±3.5
46-55	9-16	10-17	12.5±3.5	13.5±3.5
56-65	8-16	8-15	12±4	11.5±3.5
66-75	14	14	14±0	14±0

Table 9: Sex specific mean intraocular pressure between right and left eyes in females

AGE (yrs)	RIGHT EYE (mmHg)	LEFT EYE (mmHg)	RIGHT EYE (MEAN± SD) mmHg	LEFT EYE (MEAN± SD) mmHg
35-45	10-16	10-18	13±3	14±4
46-55	13-16	13-17	14.5±1.5	15±2
56-65	9-12	10-13	10.5±1.5	11.5±1.5
66-75	13-15	13-15	14±1	14±1

Table 10: Age and sex specific mean intraocular pressure between right and left eyes: Mean ± SD

AGE (yrs)	MALE (MEAN± SD) mmHg		FEMALE (MEAN± SD)mmHg	
AGE (yrs)	MALE (MEAN± SD) mmHg		FEMALE (MEAN± SD) mmHg	
	RIGHT EYE	LEFT EYE	RIGHT EYE	LEFT EYE
35-45	12.5±3.5	13.5±3.5	13±3	14±4
46-55	12.5±3.5	13.5±3.5	14.5±1.5	15±2
56-65	12±4	11.5±3.5	10.5±1.5	11.5±1.5
66-75	14±0	14±0	14±1	14±1

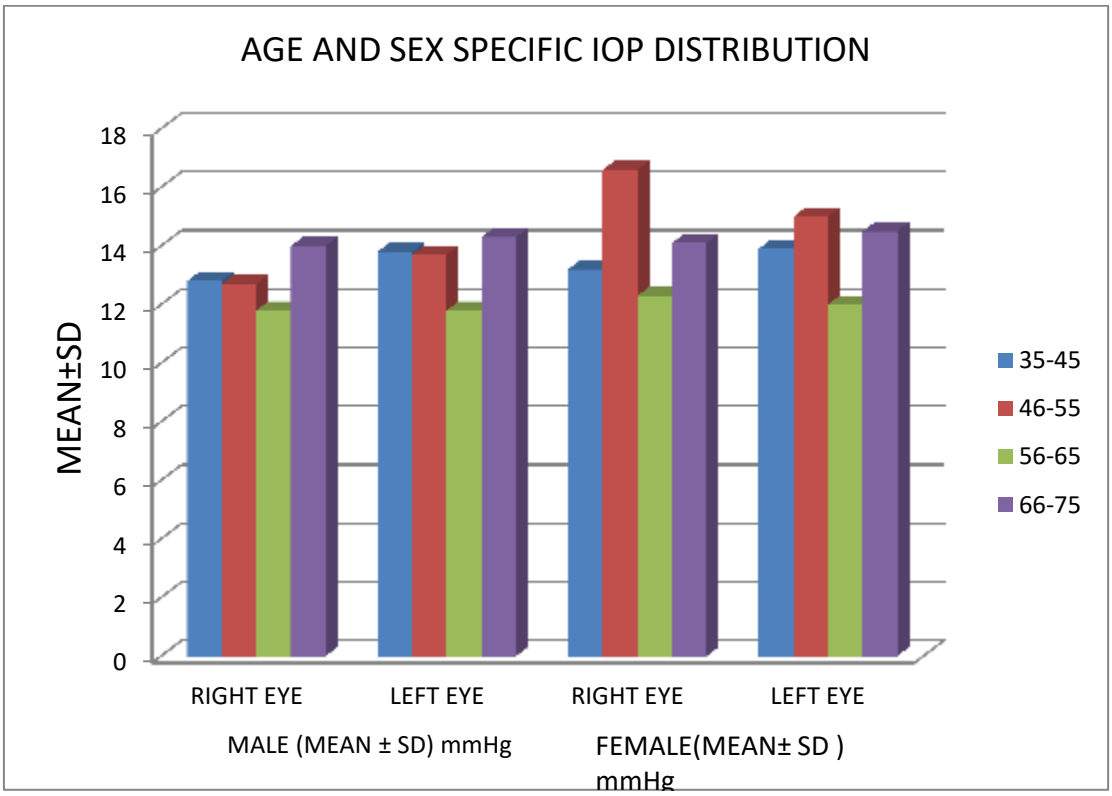

Fig 6: Age and sex specific IOP distribution between right and left eyes

VIa. **INTRAOCULARPRESSURE DISTRIBUTION:** Both eyes (Mean ± SD)

Table 10a: IOP distribution in right and left eyes: (Mean ± SD)

AGE GROUP (yrs)	RIGHT EYE (mmHg)	LEFT EYE (mmHg)
35-75	12±4 (8-16)	13±5 (8-18)

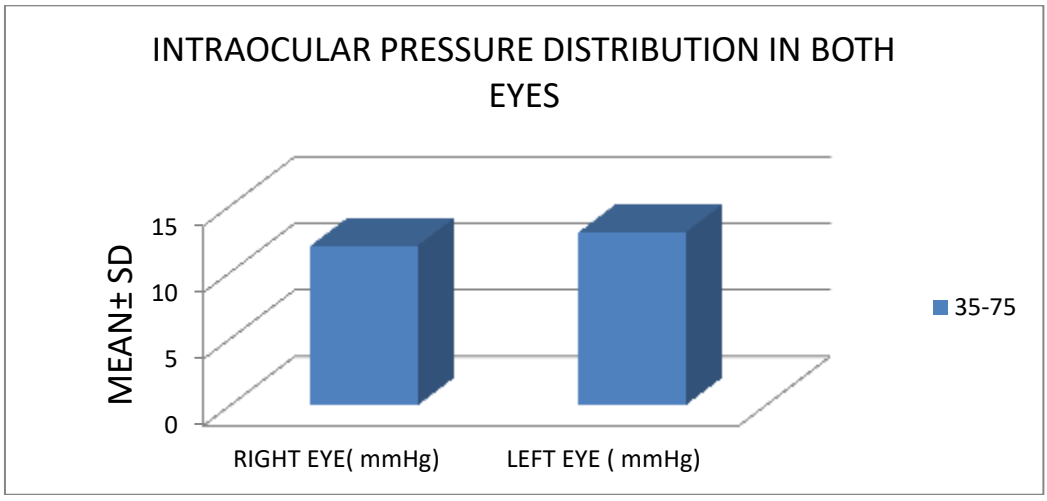

Fig- 6a: Intraocular pressure distribution in right and left eyes

VIb. INTRAOCULARPRESSURE DISTRIBUTION: Sex specific (Mean ± SD)

Table 10b: Sex specific IOP distribution: (Mean ± SD)

AGE GROUP (yrs)	MALE (mmHg)	FEMALE (mmHg)
35-75	12.5±4.5 (8-17)	13.5±4.5 (9-18)

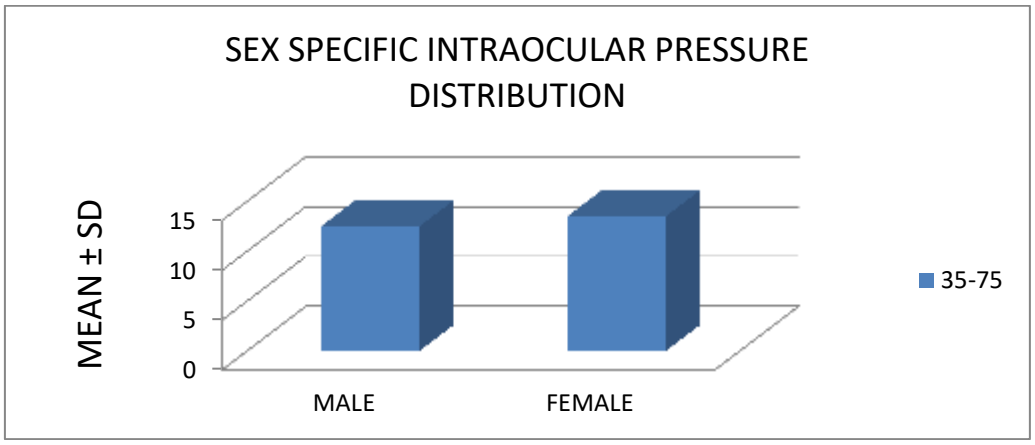

Fig-6b: Sex specific intraocular pressure distribution

RESULT IN NORMAL POPULATION:

Central corneal thickness in our study showed no significant change with age. There was also no significant difference between the right and the left eyes or between men and women.

CCT VARIATION IN NORMAL AND PRIMARY OPEN ANGLE GLAUCOMA PATIENTS:

92 eyes of 70 primary open angle glaucoma patients and 200 eyes of 100 normal subjects were included in the study. CCT in the primary open angle glaucoma eyes ranged from 447-555.6 µm, with the mean CCT being 501.3µm. CCT in the normal population ranged from 444-536 µm with the mean CCT being 490µm

Table 11: CCT variation in normal and primary open angle glaucoma patients

AGE (yrs)	NORMAL POPULATION (µm)		PRIMARY OPEN ANGLE GLAUCOMA PATIENTS (µm)	
	MEAN	RANGE	MEAN	RANGE
35-80	490±46	444-536 (200)	501.3±54.3	447-555.6 (92)

Values in parenthesis are the number of subjects

There was no significant difference in the mean CCT between normal population and the primary open angle glaucoma patients. (by unpaired t-test, p=0.668 which is not significant, t=1.840)

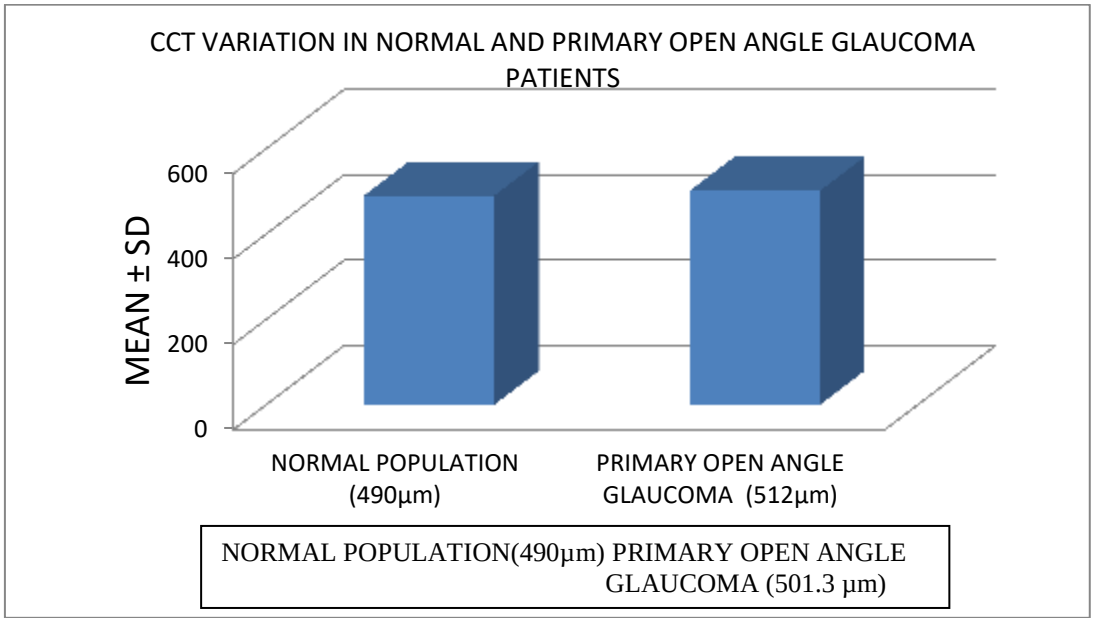

Figure: CCT variation in normal and primary open angle glaucoma patients

DISCUSSION

This present study was conducted over a period of one year.

AGE SPECIFIC CCT DISTRIBUTION IN NORMAL POPULATION

In this study, the age of the normal subjects included ranged from 35- 75 years and the maximum number of patients was in the 35 – 45 years group.

The mean CCT was found to be the highest in two groups: (497±35µm) in the 46-55 years age group and (497±33 µm) in the 66-75 years of age group and there was no age related decrease of corneal thickness.

So our study was in accordance with the studies of Roger CW Wolfs [1], Hansen FK [2], Korey M and Siu A [3] ,Velten IM *et al.;* [4] and Herndon *et al.;* [5].

It may be noted ultrasonic pachymetry is performed along the visual axis of the cornea. Because the visual axis is not the thinnest portion of the cornea in many patients, over estimations of the corneal thickness may occur. This disparity between the visual axis and the thinnest portion of the cornea may explain why several patients in our study with normal or slightly thickened corneas had underestimations of their intraocular pressure by Applanation Tonometry. Additionally, the variability in the location of the corneal apex in relation in relation to the visual axis may also obscure a relationship between corneal thickness and resistance to indentation [13].

SEX SPECIFIC CCT DATA IN NORMAL POPULATION

Of the 100 patients in normal population group, 66 were male and 34 were female. Male patients showed a mean CCT of 490±46 µm, whereas females had a slightly higher CCT i.e. 497±35 µm.

Our study was not similar with the study "Central corneal thickness in adult South Indians: the Chennai Glaucoma Study [14]. The mean CCT for the population was 511.4+/-33.5 micron, and CCT in males 9515.6+/-33.8 micron) was significantly ($p<0.0001$) greater than females (508.0+/-32.8 micron).

No significant difference in CCT between the genders was detected in our study. Thus our study correlates with studies of the Mongolian population [6], Caucasian population, the Rotterdam study [1] and the study by Eghosasere Iyamu & Ebi Osuobeni [7].

AGE SPECIFIC IOP VARIATION IN NORMAL POPULATION

In the category of age specific IOP variation, 100 normal subjects were included, with their age ranging from 35 - 75 years. Subjects in the 66-75 years age group recorded highest intraocular pressure 14±1mm of Hg in comparison to the others, with the mean CCT being 497±33 µm in this group. There was not much difference in the IOP in other age groups and it was statistically insignificant. Therefore our study results match the results of Herndon *et al.;* [5] and Foster *et al.;* [6].

SEX SPECIFIC IOP VARIATION IN NORMAL POPULATION

Amongst the 100 normal subjects, 66 were male and 34 were female. Both the genders in our study showed similar IOP, with the male group showing 12.5±4.5 mmHg and females' 13.5± 4.5 mmHg. The results of the studies in the Mongolian population [6] and by H. Hashimi *et al.;* [8] match our results.

CCT AND IOP DISTRIBUTION BETWEEN RIGHT AND LEFT EYES

- Our study included both the eyes of the normal subjects i.e. 200 eyes of 100 normal subjects.
- It was found that the mean CCT for the right eye was 488±44 µm and for the left eye was 491± 45 µm and the mean IOP for the right eye was 12±4 mmHg and for the left eye was 13±5 mmHg

- Thus our study results were similar to the studies of Goldmann & Schimdt [9], Wilensky JT & Grieser DK, and the study in Mongolian population [6], Suzuki *et al.;* [10], study by Kruse Hansen & Ehlers [2], and Herndon *et al.;* [5].

CCT VARIATION IN NORMAL AND POAG PATIENTS:

Our study included 70 POAG patients with 92 diseased eyes and 200 eyes of 100 normal subjects.

In the POAG eyes, mean CCT was found to be 501.3±54.3, which was almost similar to the mean CCT in the normal population i.e. 490±46. This difference was not statistically significant.

Therefore, our study is consistent with the studies of Rene-Pierre *et al.;* [11], Shah *et al.;* [12] and Herndon *et al.;* [5].

CONCLUSION

From this study, we have found that the measurement of intraocular pressure by Goldmann applanation tonometer is not affected significantly by changes in the central corneal thickness (measured by ultrasonic pachymetery) in Primary open angle glaucoma patients.

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