

Original research article**A clinical study on central corneal thickness in normal tension glaucoma, primary open angle glaucoma and ocular hypertension****¹Neelapareddy Likhitha Reddy, ²Dr. D Udaya Kumar, ³Dr. Dasari Swetha**^{1,3}Post Graduate 3rd Year, Department of Ophthalmology, Narayana Medical College and Hospital, Chinthareddypalem Nellore, Andhra Pradesh, India.²Professor & HOD, Department of Ophthalmology, Narayana Medical College and Hospital, Chinthareddypalem Nellore, Andhra Pradesh, India**Corresponding Author:**

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Abstract

Aim and Objective: The study's goal is to assess central corneal thickness in individuals with normal-tension glaucoma, primary open-angle glaucoma, and ocular hypertension. The current study aims to calculate the CCT in individuals with normal-tension glaucoma, primary open angle glaucoma, ocular hypertension, and healthy individuals. to research how glaucoma patients' central corneal thickness affects their diagnosis and care.

Materials And Methods:

This prospective observational study was collected from patients of normal tension Glaucoma, primary open-angle glaucoma, & ocular hypertension presenting to the Ophthalmology Department, Narayana Medical College and Hospital, Nellore from December 2021 to December 2022. This study was carried out after approval from the institute's ethical committee and taking written consent from the patients. All the samples were collected and values documented. The sample size of the present study was 100 patients.

Results: Patients with glaucoma were categorized using the corrected IOP for CCT. NTG patients were reclassified as POAG patients in 22.7% of cases, and OHT patients were reclassified as Normal in 25% of cases. According to this study, we concluded that OHT patients have significantly higher CCT than controls & POAG patients, while normal-tension glaucoma patients have significantly lower CCT than controls & POAG patients.

Conclusion: This randomized comparative study led us to the conclusion that, while OHT patients' CCT was significantly higher than that of controls and POAG patients', normal-tension glaucoma patients' CCT was significantly lower. There is no statistically significant difference between patients with primary open angles and controls.

Keywords: Ophthalmology, glaucoma, ocular hypertension, corneal thickness

Introduction

Glaucoma is a large group of disorders with progressive optic neuropathy. It results in characteristic morphological changes in optic disc leading to a specific pattern of irreversible visual field defects with or without rise in IOP. Raised IOP, heredity, nearsightedness, & race are all risk factors for glaucoma. IOP is the main factor that we can address now. Cartwright & Anderson found that in patients with Normal-Tension Glaucoma (NTG) & unbalanced IOP, with a greater IOP, glaucomatous changes were more visible in the eye ^[1]. When a patient's IOP is decreased in any way, VF loss is often halted ^[2].

Most of glaucoma patients seem to have unusual IOP responsiveness, which might be counterbalanced assuming IOP is decreased to some extent & maybe 90% or more might profit from adequately low IOP. Exact IOP estimation is basic for glaucoma grouping as well as for treatment. As a result, we need to ensure that IOP values are obtained using a highly exact method. Goldmann's. Applanation is generally viewed as the "gold standard" for ascertaining IOP. Research has shown that CCT influences applanation tonometry precision ^[3].

When the actual IOP is 20mmHg, a reduced CCT of 0.45mm can result in lower estimation of up to 4.7mmHg, but raised CCT 0.59 mm can result in the overestimation IOP 5.2 mmHg ^[4] Accordingly, GAT-based IOP estimation might deliver erroneously high readings in persons with higher CCT values & low readings in individuals with lower CCT values. When deciding management of glaucoma patients denovo and during follow up central corneal thickness would be a significant component to consider. Shih *et al.*, ^[5] found that CCT significantly affects the glaucoma management. The current study is a clinical trial to compare the CCT in NTG by POAG, OHT & to investigate the result on the medical

management of glaucoma.

Aims & objectives

Materials and methods

Methodology

This prospective observational study was collected from patients of normal tension Glaucoma, primary open-angle glaucoma, & ocular hypertension presenting to the Ophthalmology Department, Narayana Medical College Hospital, Nellore from December 2021 to December 2022. This study was carried out after approval from the institute’s ethical committee and taking written consent from the patients. All the samples were collected and values documented. The sample size of the present study was 100 patients.

Inclusion & exclusion criteria

Inclusion criteria

- Normal-Tension Glaucoma – NTG Patients having an IOP < 21mmHg at the 1st visit, an open-angle as seen on gonioscopy, glaucomatous disc changes, visual fields- glaucomatous defects.
- POAG – POAG Patients have an unmanaged IOP > 21mmHg, an open-angle on gonioscopy, optometric disc shows glaucomatous changes, & visual field defects with glaucomatous changes.
- Ocular Hypertension Glaucoma – OHT Patients with unmanaged IOP>21mmHg, open angles on gonioscopy, normal OD, normal VF and without glaucoma history.
- Controls - Controls had IOPs of < 21mmHg, have open-angle when seen on gonioscopy, had a normal optic disc, & visual fields are within normal.

Exclusion criteria

- Corneal pathology
- H/o intra-ocular surgery
- Secondary Glaucomas.

Results

A hospital-based study is to be conducted on 100 patients attending the Ophthalmology department, Narayana medical college, and hospital, Nellore over a period from December 2021 to December 2022.

Table 1: Age distribution

| Age Group | Number | Percentage (%) |
|-------------|--------|----------------|
| 40-49 Years | 19 | 19.00% |
| 50-59 Years | 48 | 48.00% |
| 60-69 Years | 20 | 20.00% |
| >= 70 Years | 13 | 13.00% |
| Total | 100 | 100.00% |

In a total of 100 patients, the range of age was 42 years to 78 years and the overall mean ± SD age (years) was 57.12 ± 9.17 years. According to age group, 19 (19.0%) patients had an age between 40-49 years, 48 (48.0%) patients had an age between 50-59 years, 20 (20.0%) patients had an age between 60-69 years, 13 (13.0%) patients had aged more than 70 years.

Table 2: Sex distribution

| Age Group | Number | Percentage (%) |
|-----------|--------|----------------|
| Males | 63 | 63.00% |
| Females | 37 | 37.00% |
| Total | 100 | 100.0% |

In a total of 100 patients, 63 (63.0%) patients were males, and 37 (37.0%) patients were females.

Table 3: Association between age and sex distribution

| | | Sex | | Total | |
|-----------|-------------|--------------------|--------|-------|--------|
| | | Male | Female | | |
| Age Group | 40-49 Years | Count | 13 | 6 | 19 |
| | | % within Age Group | 68.4% | 31.6% | 100.0% |
| | | % within Sex | 20.6% | 16.2% | 19.0% |
| | 50-59 Years | Count | 30 | 18 | 48 |
| | | % within Age Group | 62.5% | 37.5% | 100.0% |
| | | % within Sex | 47.6% | 48.6% | 48.0% |
| | 60-69 Years | Count | 16 | 4 | 20 |
| | | % within Age Group | 80.0% | 20.0% | 100.0% |

| | | | | | |
|-------|-------------|--------------------|--------|--------|--------|
| | >= 70 Years | % within Sex | 25.4% | 10.8% | 20.0% |
| | | Count | 4 | 9 | 13 |
| | | % within Age Group | 30.8% | 69.2% | 100.0% |
| Total | | % within Sex | 6.3% | 24.3% | 13.0% |
| | | Count | 63 | 37 | 100 |
| | | % within Age Group | 63.0% | 37.0% | 100.0% |
| | | % within Sex | 100.0% | 100.0% | 100.0% |

Chi-square value = 8.518, P-value = 0.036 (Sig.)

From Table-3, it was inferred that, in males, the maximum number of patients fell in the age group of 50-59 years (47.6%) whereas, in females, the maximum number of patients fell in the age group of 50-59 years (48.6%). The association between age and sex group was shown statistically significant (P = 0.036).

Table 4: Distribution of study groups

| Groups | Number | Percentage (%) |
|--------|--------|----------------|
| Normal | 36 | 36.00% |
| NTG | 20 | 20.00% |
| POAG | 29 | 29.00% |
| OHT | 15 | 15.00% |
| Total | 100 | 100.00% |

In this study, 36% of cases had Normal, 20% of cases had NTG, 29% of cases had POAG, and 15% of cases had OHT.

Table 5: Association between sex and study groups

| | | | Group | | | | Total |
|-------|----------------|----------------|--------|--------|--------|--------|--------|
| | | | Normal | NTG | POAG | OHT | |
| Sex | Male | Count | 25 | 15 | 15 | 8 | 63 |
| | | % within Sex | 39.7% | 23.8% | 23.8% | 12.7% | 100.0% |
| | | % within Group | 69.4% | 75.0% | 51.7% | 53.3% | 63.0% |
| | Female | Count | 11 | 5 | 14 | 7 | 37 |
| | | % within Sex | 29.7% | 13.5% | 37.8% | 18.9% | 100.0% |
| | | % within Group | 30.6% | 25.0% | 48.3% | 46.7% | 37.0% |
| Total | Count | 36 | 20 | 29 | 15 | 100 | |
| | % within Sex | 36.0% | 20.0% | 29.0% | 15.0% | 100.0% | |
| | % within Group | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | |

Chi-square value = 4.06, P-value = 0.255 (Not Sig.)

From Table-5, we inferred that the association between gender and study group was shown statistically not significant (P = 0.255).

Table 6: Comparison of the mean difference between sex groups for age

| | Sex | N | Mean | Std. Deviation | t-value | p-value |
|-------------|--------|-----|-------|----------------|---------|---------|
| Age (Years) | Male | 63 | 56.92 | 8.770 | -0.282 | 0.778 |
| | Female | 37 | 57.46 | 9.938 | | |
| | Total | 100 | 57.12 | 9.17 | | |

From table-6, the mean±SD age for males was 56.92±8.77 years and for females was 57.46±9.94 years. It was inferred that the mean difference between males and females was shown statistically not significant (P = 0.778).

Table 7: Comparison of the mean difference between study groups for age

| Age | N | Mean | Std. Deviation | F-value | P-value |
|--------|-----|-------|----------------|---------|---------------------|
| Normal | 36 | 56.31 | 9.001 | 0.322 | 0.810 (Not Sig). |
| NTG | 20 | 57.90 | 9.330 | | |
| POAG | 29 | 56.72 | 9.227 | | |
| OHT | 15 | 58.80 | 9.908 | | |
| Total | 100 | 57.12 | 9.173 | | |

Table-7 showed that the mean difference among the study groups for the age. The mean± SD age was slightly greater in the OHT group (58.80±9.91 years) followed by NTG (57.90±9.33 years), POAG (56.72±9.23 years), and normal group (56.31±9.00 years). However, the mean difference between the groups was shown statistically not significant (P = 0.810).

Table 8: Comparison Mean IOP for right & left eye with sex group

| Sex | IOP – Right Eye | | IOP - Left Eye | | |
|--------|-----------------|----------------------|----------------|----------------------|--|
| | Mean | SD | Mean | SD | |
| Male | 21.54 | 5.29 | 19.57 | 4.85 | |
| Female | 21.14 | 5.48 | 20.68 | 4.04 | |
| Total | 21.39 | 5.34 | 19.98 | 4.58 | |
| | | P = 0.717 (Not Sig.) | | P = 0.246 (Not Sig.) | |

In the table-8 showed that comparison of the mean IOP right & left eye with sex group. For IOP-Right eye, the mean IOP for males was 21.54 ± 5.29 and, the mean IOP for females was 21.14±5.48. The difference observed in mean IOP values between males & females for right eye was not statistically significant (P=0.717). For IOP-Left eye, the mean IOP for males was 19.57± 4.85 and the mean IOP for females was 20.68±4.04. There was no statistically significant difference in mean IOP levels between males and females (P=0.246).

Table 9: Mean IOP for right & left eye values with the study group

| | | N | Mean | Std. Deviation | F-value | P-value |
|--------|--------|-----|-------|----------------|---------|---------------------|
| IOP_RE | Normal | 36 | 22.50 | 4.849 | 1.493 | 0.221 (Not sig.) |
| | NTG | 20 | 21.35 | 5.761 | | |
| | POAG | 29 | 21.24 | 5.767 | | |
| | OHT | 15 | 19.07 | 4.743 | | |
| | Total | 100 | 21.39 | 5.343 | | |
| IOP_LE | Normal | 36 | 19.61 | 4.668 | 0.727 | 0.538 (Not sig.) |
| | NTG | 20 | 20.35 | 4.945 | | |
| | POAG | 29 | 19.45 | 3.888 | | |
| | OHT | 15 | 21.40 | 5.193 | | |
| | Total | 100 | 19.98 | 4.577 | | |

From Table-9, it was shown that the mean of IOP values for right & left eyes among the study groups. The mean ±SD IOP for the right eye and left eye was 21.39 ±5.34, and 19.98 ±4.58.

The mean± SD IOP for the right eye, for the normal group, was 22.50±4.85, NTG was 21.35±5.76, POAG was 21.24±5.77, & for OHT 19.07±4.74 respectively. However, the mean difference between the groups for the right eye was shown statistically not significant (P=0.221).

The mean±SD IOP for the left eye, for the normal group, was 19.61±4.67, NTG was 20.35±4.95, POAG was 19.45±3.89, and for OHT 21.40±5.19 respectively. However, the mean difference between the groups for the left eye was shown statistically not significant (P=0.538). Moreover, the post-tests were also shown statistically not significant (p>0.05).

Post Hoc Tests

| Multiple Comparisons | | | | | | | |
|----------------------|-----------|-----------|----------------------|------------|---------|-------------------------|-------------|
| Tukey HSD | | | | | | | |
| Dependent Variable | (I) Group | (J) Group | Mean Difference(I-J) | Std. Error | P value | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| IOP_RE | Normal | NTG | 1.150 | 1.479 | .864 | -2.72 | 5.02 |
| | | POAG | 1.259 | 1.323 | .777 | -2.20 | 4.72 |
| | | OHT | 3.433 | 1.630 | .158 | -.83 | 7.69 |
| | NTG | Normal | -1.150 | 1.479 | .864 | -5.02 | 2.72 |
| | | POAG | .109 | 1.541 | 1.000 | -3.92 | 4.14 |
| | | OHT | 2.283 | 1.811 | .590 | -2.45 | 7.02 |
| | POAG | Normal | -1.259 | 1.323 | .777 | -4.72 | 2.20 |
| | | NTG | -.109 | 1.541 | 1.000 | -4.14 | 3.92 |
| | | OHT | 2.175 | 1.687 | .572 | -2.24 | 6.58 |
| | OHT | Normal | -3.433 | 1.630 | .158 | -7.69 | .83 |
| | | NTG | -2.283 | 1.811 | .590 | -7.02 | 2.45 |
| | | POAG | -2.175 | 1.687 | .572 | -6.58 | 2.24 |
| | Normal | NTG | -.739 | 1.282 | .939 | -4.09 | 2.61 |
| | | POAG | .163 | 1.147 | .999 | -2.84 | 3.16 |
| | | OHT | -1.789 | 1.412 | .586 | -5.48 | 1.90 |
| | NTG | Normal | .739 | 1.282 | .939 | -2.61 | 4.09 |
| | | POAG | .902 | 1.336 | .906 | -2.59 | 4.39 |
| | | OHT | -1.050 | 1.570 | .909 | -5.15 | 3.05 |

| | | | | | | | |
|--------|------|--------|--------|-------|------|-------|------|
| IOP_LE | POAG | Normal | -1.63 | 1.147 | .999 | -3.16 | 2.84 |
| | | NTG | -.902 | 1.336 | .906 | -4.39 | 2.59 |
| | | OHT | -1.952 | 1.462 | .543 | -5.77 | 1.87 |
| | OHT | Normal | 1.789 | 1.412 | .586 | -1.90 | 5.48 |
| | | NTG | 1.050 | 1.570 | .909 | -3.05 | 5.15 |
| | | POAG | 1.952 | 1.462 | .543 | -1.87 | 5.77 |

Table 10: Mean IOP value for right eye & left eye between the age groups

| Age group | | N | Mean | Std. Deviation | F-value | P-value |
|-----------|-------------|-----|-------|----------------|---------|---------------------|
| IOP_RE | 40-49 Years | 19 | 21.26 | 3.856 | 0.561 | 0.642 (Not sig.) |
| | 50-59 Years | 48 | 21.54 | 6.428 | | |
| | 60-69 Years | 20 | 22.20 | 4.467 | | |
| | >= 70 Years | 13 | 19.77 | 3.961 | | |
| | Total | 100 | 21.39 | 5.343 | | |
| IOP_LE | 40-49 Years | 19 | 18.00 | 3.232 | 1.557 | 0.205 (Not sig.) |
| | 50-59 Years | 48 | 20.56 | 4.920 | | |
| | 60-69 Years | 20 | 20.50 | 5.021 | | |
| | >= 70 Years | 13 | 19.92 | 3.796 | | |
| | Total | 100 | 19.98 | 4.577 | | |

Table-10 showed the comparison of mean differences between the age groups for IOP right eye and IOP left eye.

The mean± SD of IOP for the right eye, the higher mean was in the age group of 60- 69 years was 22.20±4.47, followed by the age group of 50-59 years was 21.54±6.43, age group of 40-49 years was 21.26±3.86, and the age group more than 70 years was 19.77±3.96.

The mean± SD of IOP for the left eye, the higher mean was in the age group of 50-59 years was 20.56±4.92, followed by the age group of 60-69 years was 20.50±5.02, age group of more than 70 years was 19.92±3.79, and the age group of 40-49 years was 18.00±3.23.

From this we inferred that the mean difference between the age groups for both right eye (P=0.642) and left eye (P=0.205) was statistically not significant. Moreover, the post hoc test was also shown statistically not significant (p>0.05).

| Multiple Comparisons | | | | | | | |
|----------------------|---------------|---------------|-----------------------|------------|---------|-------------------------|-------------|
| Tukey HSD | | | | | | | |
| Dependent Variable | (I) Age Group | (J) Age Group | Mean Difference (I-J) | Std. Error | P value | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| IOP_RE | 40-49 Years | 50-59 Years | -.279 | 1.458 | .998 | -4.09 | 3.53 |
| | | 60-69 Years | -.937 | 1.723 | .948 | -5.44 | 3.57 |
| | | >= 70 Years | 1.494 | 1.936 | .867 | -3.57 | 6.56 |
| | 50-59 Years | 40-49 Years | .279 | 1.458 | .998 | -3.53 | 4.09 |
| | | 60-69 Years | -.658 | 1.431 | .968 | -4.40 | 3.08 |
| | | >= 70 Years | 1.772 | 1.682 | .718 | -2.62 | 6.17 |
| | 60-69 Years | 40-49 Years | .937 | 1.723 | .948 | -3.57 | 5.44 |
| | | 50-59 Years | .658 | 1.431 | .968 | -3.08 | 4.40 |
| | | >= 70 Years | 2.431 | 1.916 | .585 | -2.58 | 7.44 |
| | >= 70 Years | 40-49 Years | -1.494 | 1.936 | .867 | -6.56 | 3.57 |
| | | 50-59 Years | -1.772 | 1.682 | .718 | -6.17 | 2.62 |
| | IOP_LE | 40-49 Years | 50-59 Years | -2.563 | 1.230 | .166 | -5.78 |
| 60-69 Years | | | -2.500 | 1.454 | .319 | -6.30 | 1.30 |
| >= 70 Years | | | -1.923 | 1.634 | .643 | -6.19 | 2.35 |
| 50-59 Years | | 40-49 Years | 2.563 | 1.230 | .166 | -.65 | 5.78 |
| | | 60-69 Years | .063 | 1.208 | 1.000 | -3.10 | 3.22 |
| | | >= 70 Years | .639 | 1.419 | .969 | -3.07 | 4.35 |
| 60-69 Years | | 40-49 Years | 2.500 | 1.454 | .319 | -1.30 | 6.30 |
| | | 50-59 Years | -.063 | 1.208 | 1.000 | -3.22 | 3.10 |
| | | >= 70 Years | .577 | 1.617 | .984 | -3.65 | 4.80 |
| >= 70 Years | | 40-49 Years | 1.923 | 1.634 | .643 | -2.35 | 6.19 |
| | | 50-59 Years | -.639 | 1.419 | .969 | -4.35 | 3.07 |
| | | 60-69 Years | -.577 | 1.617 | .984 | -4.80 | 3.65 |

Table 11: Mean CCT values for right & left eyes

| Study group | | N | Mean | Std. Deviation | F-value | P-value |
|-------------|--------|-----|--------|----------------|---------|---------------------|
| CCT_RE | Normal | 36 | 531.83 | 31.235 | 1.581 | 0.199 (Not Sig.) |
| | NTG | 20 | 527.25 | 29.476 | | |
| | POAG | 29 | 528.79 | 24.384 | | |
| | OHT | 15 | 513.53 | 21.550 | | |
| | Total | 100 | 527.29 | 27.971 | | |
| CCT_LE | Normal | 35 | 533.29 | 30.137 | 1.853 | 0.143 (Not Sig.) |
| | NTG | 20 | 528.10 | 30.063 | | |
| | POAG | 29 | 530.07 | 24.071 | | |
| | OHT | 15 | 513.73 | 21.648 | | |
| | Total | 99 | 528.33 | 27.660 | | |

| Multiple Comparisons | | | | | | | |
|----------------------|-----------|-----------|-----------------------|------------|---------|-------------------------|-------------|
| Tukey HSD | | | | | | | |
| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | P-value | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| CCT_RE | Normal | NTG | 4.583 | 7.733 | .934 | -15.63 | 24.80 |
| | | POAG | 3.040 | 6.919 | .971 | -15.05 | 21.13 |
| | | OHT | 18.300 | 8.521 | .146 | -3.98 | 40.58 |
| | NTG | Normal | -4.583 | 7.733 | .934 | -24.80 | 15.63 |
| | | POAG | -1.543 | 8.059 | .997 | -22.61 | 19.53 |
| | | OHT | 13.717 | 9.471 | .473 | -11.05 | 38.48 |
| | POAG | Normal | -3.040 | 6.919 | .971 | -21.13 | 15.05 |
| | | NTG | 1.543 | 8.059 | .997 | -19.53 | 22.61 |
| | | OHT | 15.260 | 8.818 | .314 | -7.80 | 38.32 |
| | OHT | Normal | -18.300 | 8.521 | .146 | -40.58 | 3.98 |
| | | NTG | -13.717 | 9.471 | .473 | -38.48 | 11.05 |
| | | POAG | -15.260 | 8.818 | .314 | -38.32 | 7.80 |
| CCT_LE | Normal | NTG | 5.186 | 7.654 | .905 | -14.83 | 25.20 |
| | | POAG | 3.217 | 6.857 | .966 | -14.71 | 21.15 |
| | | OHT | 19.552 | 8.427 | .101 | -2.48 | 41.59 |
| | NTG | Normal | -5.186 | 7.654 | .905 | -25.20 | 14.83 |
| | | POAG | -1.969 | 7.937 | .995 | -22.72 | 18.79 |
| | | OHT | 14.367 | 9.327 | .418 | -10.02 | 38.76 |
| | POAG | Normal | -3.217 | 6.857 | .966 | -21.15 | 14.71 |
| | | NTG | 1.969 | 7.937 | .995 | -18.79 | 22.72 |
| | | OHT | 16.336 | 8.685 | .243 | -6.38 | 39.05 |
| | OHT | Normal | -19.552 | 8.427 | .101 | -41.59 | 2.48 |
| | | NTG | -14.367 | 9.327 | .418 | -38.76 | 10.02 |
| | | | POAG | -16.336 | 8.685 | .243 | -39.05 |

The mean ±SD CCT for the right eye and left eye was 527.29 ±27.97, and 528.33 ±27.66 respectively. The mean± SD CCT for the right eye, for the normal group was 531.83±31.23, NTG was 27.25±29.48, POAG was 528.79±24.38, and for OHT 513.53±21.55 respectively. However, the mean difference between the groups for the right eye was shown statistically not significant (P=0.199). The mean± SD CCT for the left eye, for the normal group, was 533.29±30.14, NTG was 8.10±30.06, POAG was 530.07±24.07, and for OHT 513.73±21.65 respectively. However, the mean difference of CCT between the groups for the left eye was shown statistically not significant (P=0.143). Moreover, the post hoc test was also shown statistically not significant (p>0.05).

Table 12: Mean CCT value for right eye & left eye between the age groups

| | | N | Mean | Std. Deviation | F-value | p-value |
|--------|-------------|-----|--------|----------------|---------|---------------------|
| CCT_RE | 40-49 Years | 19 | 532.53 | 26.761 | 0.646 | 0.588 (Not Sig.) |
| | 50-59 Years | 48 | 524.44 | 26.416 | | |
| | 60-69 Years | 20 | 525.05 | 30.258 | | |
| | >= 70 Years | 13 | 533.62 | 32.707 | | |
| | Total | 100 | 527.29 | 27.971 | | |
| CCT_LE | 40-49 Years | 18 | 535.33 | 26.117 | 0.738 | 0.532 (Not Sig.) |
| | 50-59 Years | 48 | 525.58 | 26.302 | | |
| | 60-69 Years | 20 | 525.50 | 29.523 | | |
| | >= 70 Years | 13 | 533.15 | 32.406 | | |
| | Total | 99 | 528.33 | 27.660 | | |

| Multiple Comparisons | | | | | | | |
|----------------------|---------------|---------------|-----------------------|------------|---------|-------------------------|-------------|
| Tukey HSD | | | | | | | |
| Dependent Variable | (I) Age Group | (J) Age Group | Mean Difference (I-J) | Std. Error | P-value | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| CCT_RE | 40-49 Years | 50-59 Years | 8.089 | 7.622 | .714 | -11.84 | 28.02 |
| | | 60-69 Years | 7.476 | 9.009 | .840 | -16.08 | 31.03 |
| | | >= 70 Years | -1.089 | 10.122 | 1.000 | -27.55 | 25.38 |
| | 50-59 Years | 40-49 Years | -8.089 | 7.622 | .714 | -28.02 | 11.84 |
| | | 60-69 Years | -.612 | 7.485 | 1.000 | -20.18 | 18.96 |
| | | >= 70 Years | -9.178 | 8.793 | .724 | -32.17 | 13.81 |
| | 60-69 Years | 40-49 Years | -7.476 | 9.009 | .840 | -31.03 | 16.08 |
| | | 50-59 Years | .612 | 7.485 | 1.000 | -18.96 | 20.18 |
| | | >= 70 Years | -8.565 | 10.019 | .828 | -34.76 | 17.63 |
| | >= 70 Years | 40-49 Years | 1.089 | 10.122 | 1.000 | -25.38 | 27.55 |
| | | 50-59 Years | 9.178 | 8.793 | .724 | -13.81 | 32.17 |
| | | 60-69 Years | 8.565 | 10.019 | .828 | -17.63 | 34.76 |
| CCT_LE | 40-49 Years | 50-59 Years | 9.750 | 7.676 | .584 | -10.32 | 29.82 |
| | | 60-69 Years | 9.833 | 9.023 | .697 | -13.76 | 33.43 |
| | | >= 70 Years | 2.179 | 10.108 | .996 | -24.25 | 28.61 |
| | 50-59 Years | 40-49 Years | -9.750 | 7.676 | .584 | -29.82 | 10.32 |
| | | 60-69 Years | .083 | 7.391 | 1.000 | -19.25 | 19.41 |
| | | >= 70 Years | -7.571 | 8.683 | .819 | -30.28 | 15.14 |
| | 60-69 Years | 40-49 Years | -9.833 | 9.023 | .697 | -33.43 | 13.76 |
| | | 50-59 Years | -.083 | 7.391 | 1.000 | -19.41 | 19.25 |
| | | >= 70 Years | -7.654 | 9.894 | .866 | -33.53 | 18.22 |
| | >= 70 Years | 40-49 Years | -2.179 | 10.108 | .996 | -28.61 | 24.25 |
| | | 50-59 Years | 7.571 | 8.683 | .819 | -15.14 | 30.28 |
| | | 60-69 Years | 7.654 | 9.894 | .866 | -18.22 | 33.53 |

Table-12 showed the comparison of mean differences between the age groups for IOP right eye and IOP left eye.

The mean±SD of IOP for the right eye, the higher mean was in the age group of more than 70 years was 533.62±32.71, followed by the age group of 40-49 years was 532.53±26.76, age group of 60-69 years was 525.05±30.26, and the age group 50-59 years was 524.44±26.41.

The mean±SD of IOP for the left eye, the higher mean was in the age group of 40-49 years was 535.33±26.12, followed by the age group of more than 70 years was 533.15±32.41, age group of 50-59 years was 525.58±26.30, and the age group of 60-69 years was 525.50±29.52.

From this, we inferred that the mean difference between the age groups for the right eye (P=0.588) and left eye (P=0.532) was statistically not significant. Moreover, the post hoc test was also shown statistically not significant (P>0.05).

Table 13: Significant of management changes (>=1.5) after modifying IOP for CCT in the glaucoma patients

| | Significant of changes (>=1.5) | | TOTAL |
|-------|--------------------------------|-------------|-------------|
| | NO | YES | |
| NTG | 14 (70.0%) | 6 (30.0%) | 20 (31.25%) |
| POAG | 22 (75.86%) | 7 (24.14%) | 29 (45.31%) |
| OHT | 5 (33.33%) | 10 (66.67%) | 15 (23.44%) |
| Total | 43 (67.19%) | 21 (32.81%) | 64 (100.0%) |

Chi-square value = 8.212, P-value = 0.016 (Sig.)

Table-13 showed that the Significant changes (>=1.5) were observed for glaucoma patients after IOP was corrected for CCT. From this, 21 (32.81%) cases had significant of measurement changes (> = 1.5), among them, 66.67% of cases had the highest significant of measurement changes (>=1.5) in the group of OHT. Moreover, there was a statistical significant between the study group & significant of measurement changes (>=1.5). [P=0.016].

Table 14: Significant of outcome changes (>=3.0) after modifying IOP for CCT in the glaucoma patients

| | Significant of outcome changes (>= 3.0) | | Total |
|-------|---|------------|-------------|
| | NO | YES | |
| NTG | 20 (100.0%) | 0 (0.0%) | 20 (31.25%) |
| POAG | 28 (96.55%) | 1 (3.45%) | 29 (45.31%) |
| OHT | 11 (73.33%) | 4 (26.67%) | 15 (23.44%) |
| TOTAL | 59 (92.19%) | 5 (7.81%) | 64 (100.0%) |

Chi-square value = 9.865, P-value = 0.007 (Sig.)

Table-14 showed that the significant of outcome changes (≥ 3.0) after modifying IOP for CCT in the glaucoma patients. From this, 5 (7.81%) cases had outcome significant changes (≥ 3.0), among them, 26.67% of cases had the highest measurement significant changes (≥ 3.0) in the group of OHT. Moreover, there was a statistical significance between the study group and significant of the outcome changes (≥ 3.0). [P=0.007].

Table 15: Reclassification of following IOP correction for CCT

| | | Count | Recls RE | | | | Total |
|-------|-------------------|-------------------|----------|--------|--------|--------|--------|
| | | | N | NTG | OHT | POAG | |
| Group | Normal | 2 | 6 | 5 | 23 | 36 | |
| | | % within Group | 5.6% | 16.7% | 13.9% | 63.9% | 100.0% |
| | | % within Recls_RE | 5.1% | 35.3% | 55.6% | 65.7% | 36.0% |
| | NTG | 14 | 1 | 1 | 4 | 20 | |
| | | % within Group | 70.0% | 5.0% | 5.0% | 20.0% | 100.0% |
| | | % within Recls_RE | 35.9% | 5.9% | 11.1% | 11.4% | 20.0% |
| | POAG | 23 | 2 | 1 | 3 | 29 | |
| | | % within Group | 79.3% | 6.9% | 3.4% | 10.3% | 100.0% |
| | | % within Recls_RE | 59.0% | 11.8% | 11.1% | 8.6% | 29.0% |
| | OHT | 0 | 8 | 2 | 5 | 15 | |
| | | % within Group | 0.0% | 53.3% | 13.3% | 33.3% | 100.0% |
| | | % within Recls_RE | 0.0% | 47.1% | 22.2% | 14.3% | 15.0% |
| Total | 39 | 17 | 9 | 35 | 100 | | |
| | % within Group | 39.0% | 17.0% | 9.0% | 35.0% | 100.0% | |
| | % within Recls_RE | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | |

From the table-15, we inferred that the association between groups and reclassification of groups for following IOP modifying for CCT was shown statistically not significant (P<0.0001).

Discussion

According to recent research, NTG patients have a lesser CCT than normal, with OHT have a thicker CCT than controls. As a result, in this study, we correlate CCT with NTG controls this study to compare the central corneal thickness of NTG with that of controls, POAG, & OHT to investigate the differences in this population, as well as to evaluate the impact of CCT on glaucoma diagnosis (result reclassification) & management for its outcome on IOP measures.

Comparison of present study results with other studies age group

In this study, a total of 100 patients, the range of age was 42 years to 78 years and the overall mean \pm SD age (years) was 57.12 ± 9.17 years. According to age group, 19 (19.0%) patients had an age between 40-49 years, 48 (48.0%) patients had an age between 50-59 years, 20 (20.0%) patients had an age between 60-69 years, 13 (13.0%) patients had aged more than 70 years.

Sex

In this study, a total of 100 patients, 63 (63.0%) patients were males, & 37 (37.0%) patients were females.

Association between age & sex

In this study, an association between the age and sex group, in males, the maximum number of patients fell in the age group of 50-59 years (47.6%) whereas, in females, the maximum number of patients fell in the age group of 50-59 years (48.6%). The association between age & sex group was shown statistically significant (P = 0.036).

In the study of Wolf's *et al.* (1997), there were no differences between sexes & no significant association with age [6].

Study group

In this study, 36% of cases had Normal, 20% of cases had NTG, 29% of cases had POAG, and 15% of cases had OHT.

In the study of Wolf *et al.* (1997), 352 were controls, 13 patients were OHT, & 30 patients were POAG [6].

Association between sex & study groups

In this study, the association between gender & study group was shown statistically not significant (P = 0.255).

Mean difference between sex group for age

In this study, the mean±SD age for males was 56.92±8.77 years, and for females was 57.46±9.94 years. It was inferred that the mean difference between males & females was shown statistically not significant (P=0.778).

Comparison of the mean difference between study groups for age

In this present study, the mean±SD age was slightly higher in OHT group (58.80±9.91 years) followed by NTG (57.90±9.33 years), POAG (56.72±9.23 years), & normal group (56.31±9.00 years). However, the mean difference between the groups was shown statistically not significant (P = 0.810) it was like to that found in the Morad *et al.* (1998) study^[7]. OHT patients were significantly younger than POAG, NTG similar to that found in the Copt RP group. No significant difference in NTG, POAG, and Controls was found in the present study.

Comparison Mean IOP for right & left eye with sex group

For IOP-Right eye, the mean IOP for males was 21.54 ± 5.29 and, the mean IOP for females was 21.14±5.48. The difference in mean IOP between males & females for right eye was statistically insignificant (P=0.717). For IOP-Left eye, the difference observed between the mean IOP for males (19.57± 4.85) & females (20.68±4.04). was not statistically significant (P=0.246).

Mean IOP for right & left eye values with the study group

In this study, the mean ±SD IOP for the right eye was 21.39 ±5.34, & for the left eye was 19.98 ±4.58. The mean±SD IOP for the right eye, for the normal group, was 22.50±4.85, NTG was 21.35±5.76, POAG was 21.24±5.77, and for OHT 19.07±4.74 respectively. However, the mean difference between the groups for the right eye was shown statistically not significant (P=0.221). The mean±SD IOP for the left eye, for the normal group, was 19.61±4.67, NTG was 20.35±4.95, POAG was 19.45±3.89, and for OHT 21.40±5.19 respectively. However, the mean difference between the groups for the left eye was shown statistically not significant (P=0.538).

In a study of Iwase (2004) [8], the average IOP for eyes with POAG was 15.4±2.8 in the right eye (n = 115) & 15.2±2.8 mmHg in the left eye (n = 115), was significantly higher than nonglaucoma subjects. The POAG mean CCT with IOP levels of 21 mmHg or less was 518±29 (n = 109) in the right eye & 519±29 μm (n = 110) in the left eye, levels that were not significantly different from that of nonglaucoma eyes (520±32 μm; & 522±32 μm, P>0.05).

Mulugeta (2018) [9] the mean CCT for the group with OHT, POAG, Pseudoexfoliative glaucoma, NTG, & non-glaucoma was 562.5±24.5μm, 517.5±27.5μm, 512.5±32.1μm, 488.0±32.4 μm, & 516.2±23.4μm respectively. Ocular hypertension patients had significantly thicker central corneas on average than those with primary open-angle glaucoma, pseudoexfoliative glaucoma, normal tension glaucoma subtypes, and non-glaucoma patients (P 0.001). Patients with normal-tension glaucoma had significantly lower mean CCTs than those with POAG, pseudoexfoliative glaucoma, subtypes, ocular hypertension, and those without glaucoma (P 0.001).

Mean IOP value for the right eye & left eye between the age groups

In this study, the mean±SD of IOP for the right eye, the higher mean was in the age group of 60-69 years was 22.20±4.47, followed by the age group of 50-59 years was 21.54±6.43, age group of 40-49 years was 21.26±3.86, & the age group more than 70 years was 19.77±3.96. The mean±SD of IOP for the left eye, the higher mean was in the age group of 50-59 years was 20.56±4.92, followed by the age group of 60-69 years was 20.50±5.02, age group of more than 70 years was 19.92±3.79, & the age group of 40-49 years was 18.00±3.23. From this, we inferred that the mean difference between the age groups for both the right eye (P=0.642) & left eye (P=0.205) was statistically not significant. Moreover, the post hoc test was also shown statistically not significant (P>0.05).

Mean CCT values for right & left eyes by study group

In this study, the mean±SD CCT for the right eye, for the normal group was 531.83±31.23, NTG was 527.25±29.48, POAG was 528.79±24.38, & for OHT 513.53±21.55 respectively. However, the mean difference between the groups for right eye was shown statistically not significant (P=0.199). The mean±SD CCT for the left eye, for the normal group, was 533.29±30.14, NTG was 528.10±30.06, POAG was 530.07±24.07, & for OHT was 513.73±21.65 respectively. However, the mean difference of CCT between groups for the left eye was shown statistically not significant (P=0.143).

Wolf *et al.* (1997)^[6] stated that the mean CCT was slightly higher in OHT patients, & significantly lower in POAG patients.

A study by Bechmann *et al.* (2000)^[10], the mean of CCT was significantly higher in ocular hypertensive subjects than in the controls, whereas patients with LTG, PEX, & POAG showed significantly lower readings.

Vilchez-Riestra (2002)^[11], CCT was significantly higher in patients with OHT compared to healthy patients.

A retrospective study of Doyle, A (2005) [12], the mean CCT (549 ± 34 mm) in POAG patients & the NTG patients (528 ± 31 mm) ($p = 0.001$). Mean CCT (512 ± 31 mm) in group A ($n = 13$) & 533 ± 31 mm in group B ($n = 41$) was shown significant ($P = 0.034$).

In a study by Yagci *et al.* (2005) [13], CCT values in the OHT group shown significantly more than CCT values of POAG, followed by the PXG group, & the normal group.

Lee *et al.* (2007) [14], Mean CCT was significantly highest in eyes with OHT ($582.1 \mu\text{m}$), significantly lowest in NTG ($537.5 \mu\text{m}$), and intermediate & similar in eyes with POAG and healthy eyes (550.7 & $553.6 \mu\text{m}$; $P = 0.289$). CCT was inversely correlated with age ($r = -0.12$; $P < 0.0001$). There was no significant changes in mean CCT between eyes of different gender or presence of diabetes and hypertension. Mean CCT in normal & OHT eyes were weakly correlated with refractive error ($P < 0.05$).

Mean CCT value for the right eye and left eye between the age groups

In this study, the mean \pm SD of IOP for the right eye, the higher mean was in the age group of more than 70 years was 533.62 ± 32.71 , followed by the age group of 40-49 years was 532.53 ± 26.76 , age group of 60-69 years was 525.05 ± 30.26 , and the age group 50-59 years was 524.44 ± 26.41 . The mean \pm SD of IOP for the left eye, the higher mean was in the age group of 40-49 years was 535.33 ± 26.12 , followed by the age group of more than 70 years was 533.15 ± 32.41 , age group of 50-59 years was 525.58 ± 26.30 , & the age group of 60-69 years was 525.50 ± 29.52 . From this, we inferred that the mean difference between the age groups for both right eye ($P = 0.588$) & left eye ($P = 0.532$) was statistically not significant. Moreover, the post hoc test was also shown statistically not significant ($P > 0.05$).

Significant changes of Measurement (≥ 1.5) after modifying IOP for CCT in glaucoma patients: -

In this study, 21 (32.81%) cases had measurement significant changes (≥ 1.5), among them, 66.67% of cases had the highest measurement significant changes (≥ 1.5) in the group of OHT. Moreover, there was a statistical association between study group & measurement significant changes (≥ 1.5). [$P = 0.016$].

Significant changes of Outcome (≥ 3.0) after modifying IOP for CCT in glaucoma patients

In this study, 5 (7.81%) cases had significant changes of outcome (≥ 3.0), among them, 26.67% of cases had the highest measurement significant changes (≥ 3.0) in the group of OHT. Moreover, there was a statistical association between the study group and outcome significant changes (≥ 3.0). [$P = 0.007$] [15].

Reclassification of groups after correcting IOP for CCT

In this study, the association between the study groups and reclassification of study groups was shown statistically not significant ($P < 0.0001$).

The observed difference was statistically significant ($p 0.05$). None of the patients in the NTG group demonstrated significant changes in outcome, whereas 3.57% of patients in the POAG group and 25% of patients (3 out of 12) in the OHT group did. The significant change of outcome (≥ 3.0) was observed in 6.45% of all glaucoma patients. A statistically significant difference was demonstrated ($p 0.05$) [16, 17].

The relationship between central corneal thickness (CCT) and Goldmann applanation tonometry has been the subject of numerous studies, and it has been established that CCT affects applanation tonometry accuracy. Other formulas have been developed since then to correct the IOP for CCT.

According to the results of the Early Manifest Glaucoma Trial, a 10% (increased or decreased) change in progression is correlated with every 1mmHg change in IOP on follow-up. 8.5% of study participants changed their medication, 2.1% deferred or added laser therapy, and 3.2% changed their minds about having glaucoma surgery. Lack of a long-term follow-up to support the clinical conclusions about these variations' management using CCT corrected IOP was one of the study's limitations [18, 19].

Glaucoma patients were classed after corrected IOP for CCT. In 22.7 percent of cases, NTG patients reclassified as POAG patients, & in 25% of cases, OHT patients reclassified as Normal. In research by Copt RP *et al.* (1999) [3], about one fourth of NTG and OHT misdiagnosed, whereas 31 percent of NTG reclassified as POAG and 56 percent of OHT was classed as normal.

Conclusion

From this perspective, randomized comparative study, we concluded that normal-tension glaucoma patients have significantly lower CCT than controls & POAG patients, while OHT patients have significantly higher CCT than controls & POAG patients, according to this study. Between primary open-angle patients and controls, there is no statistically significant difference.

Due to the IOP effect of CCT measurement and an applanation tonometer, the main limitation in the diagnosis and follow-up of glaucoma patients, many POAG patients are misdiagnosed as NTG patients, and normals are misdiagnosed as OHT patients and improperly managed. When a patient's corneal thickness deviates significantly from normal, as it often does, the measurement of CCT helps the Ophthalmologist make an accurate diagnosis and manage glaucoma and glaucoma suspects.

Funding Source: None

Conflict of Interest: None**References**

1. Cartwright MJ, Anderson DR. Correlation of asymmetric damage with asymmetric intraocular pressure in normal-tension glaucoma (low-tension glaucoma). *Archives of Ophthalmology*. 1988 Jul 1;106(7):898-900.
2. Jay JL, Murdoch JR. The rate of visual field loss in untreated primary open angle glaucoma. *British journal of ophthalmology*. 1993 Mar 1;77(3):176-8.
3. Copt RP, Thomas R, Mermoud A. Corneal thickness in ocular hypertension, primary open-angle glaucoma, and normal tension glaucoma. *Archives of ophthalmology*. 1999 Jan 1;117(1):14-6.
4. Ehlers N, Bramsen T, Sperling S. Applanation tonometry and central corneal thickness. *Acta ophthalmologica*. 1975 Mar;53(1):34-43.
5. Shih CY, Zivin JS, Trokel SL, Tsai JC. Clinical significance of central corneal thickness in the management of glaucoma. *Archives of ophthalmology*. 2004 Sep 1;122(9):1270-5.
6. Wolfs RC, Klaver CC, Vingerling JR, Grobbee DE, Hofman A. Distribution of central corneal thickness and its association with intraocular pressure: The Rotterdam Study. *American journal of ophthalmology*. 1997 Jun 1;123(6):767-72.
7. Herndon LW, Choudhri SA, Cox T, Damji KF, Shields MB, Allingham RR. Central corneal thickness in normal, glaucomatous, and ocular hypertensive eyes. *Archives of Ophthalmology*. 1997 Sep 1;115(9):1137-41.
8. Dave H, Kutschan A, Pauer A, Wiegand W. Hornhautdickenmessung bei glaukmapatienten. *Der Ophthalmologe*. 2004 Sep;101(9):919-24.
9. Thornton SP, Gardner SK, Waring GO. Surgical instruments used in refractive keratotomy. In: *Refractive keratotomy for myopia and astigmatism 1992* (pp. 407- 431). Mosby Year Book, St. Louis, St. Louis.
10. D M, EH T, NH A. *Ophthalmic Instrumentation*. In: Yanoff M DJ, editor. St. Louis: Mosby; 2004.
11. Vilchez-Riestra SE, Ascanio-Gutiérrez MA, Palacios-Machuca GA, Niño-Pecina A, Garza-León MA, Gil-Carrasco F. Measurement of the central corneal thickness in patients with ocular hypertension, normal tension glaucoma and primary open-angle glaucoma. *Revista Mexicana de Oftalmología*. 2002 Sep 1;76(5):167-70.
12. Iwase A, Suzuki Y, Araie M, Yamamoto T, Abe H, Shirato S, Kuwayama Y, Mishima HK, Shimizu H, Tomita G, Inoue Y. The prevalence of primary open- angle glaucoma in Japanese: the Tajimi Study. *Ophthalmology*. 2004 Sep 1;111(9):1641-8.
13. Doyle A, Bensaid A, Lachkar Y. Central corneal thickness and vascular risk factors in normal tension glaucoma. *Acta Ophthalmologica Scandinavica*. 2005 Apr;83(2):191-5.
14. Lee ES, Kim CY, Ha SJ, Seong GJ, Hong YJ. Central corneal thickness of Korean patients with glaucoma. *Ophthalmology*. 2007 May 1;114(5):927-30.
15. Shetgar AC, Mulimani MB. The central corneal thickness in normal tension glaucoma, primary open angle glaucoma and ocular hypertension. *Journal of clinical and diagnostic research: JCDR*. 2013 Jun;7(6):1063.
16. Yagci R, Eksioğlu U, Midillioglu I, Yalvac I, Altıparmak E, Duman S. Central corneal thickness in primary open angle glaucoma, pseudoexfoliative glaucoma, ocular hypertension, and normal population. *European journal of ophthalmology*. 2005 May;15(3):324-8.
17. Moghimi S, Torabi H, Hashemian H, Amini H, Lin S. Central corneal thickness in primary angle closure and open angle glaucoma. *Journal of ophthalmic & vision research*. 2014 Oct;9(4):439.
18. Ntim-Amponsah CT, Seidu AY, Essuman VA, Fordjour G, Tagoe NN, Coker A, Adam-Zakariah LI. A study of central corneal thickness in glaucoma and nonglaucoma patients in a West African population. *Cornea*. 2012 Oct 1;31(10):1093-6.
19. Belovay GW, Goldberg I. The thick and thin of the central corneal thickness in glaucoma. *Eye*. 2018 May;32(5):915-23.