*Original Article*

# Central corneal thickness and intraocular pressure in patients of primary open angle glaucoma and normal population in Nepalese population: A hospital based study

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## Abstract

**Introduction:** Central corneal thickness (CCT) is a powerful predictor of primary open angle glaucoma. Individualized risk assessment is critical for early diagnosis and management of glaucoma.

**Objectives:** To compare CCT and intraocular pressure in patients of primary open angle glaucoma (POAG) with those of normal population.

**Materials and methods:** A Comparative Cross-Sectional Study was performed in Ophthalmology department of B. P. Koirala Institute of Health Sciences, Nepal. Newly diagnosed cases of primary glaucoma (open angle, normal tension) of 18 years and above, without known systemic diseases were included.

**Results:** Out of a total of 291 subjects (582 eyes), 105 subjects (210 eyes) were with primary glaucoma and 186 (382 eyes) were normal subjects. There was no significant difference in CCT between glaucomatous (533.57 μm) and normal (530.06 μm) eyes (p=0.1). Cornea was thinner (518.±18.03 μm) in eyes with severe glaucomatous damage (cup:disc ratio > 0.8) than in moderate glaucomatous damage (cup:disc ratio=0.5-0.8) (p=0.003). There was a statistically significant difference of 22.05 μm in CCT between POAG and NTG (p<0.001). A positive correlation was found between IOP & CCT in both cases and control group (p=0.000; r = 0.355, 0.254; $r^2$ =0.126, 0.064 respectively).

**Conclusion:** Majority of studied Nepalese population have CCT less than 550 μm, thus increasing the risk of POAG. CCT decreases with age, and females with glaucoma have significantly thicker cornea than men. There is a significant positive correlation between CCT and IOP, and IOP will have to be adjusted for CCT for proper diagnosis and monitoring of glaucomatous damage in Nepalese population too.

**Key words:** Central Corneal Thickness, Glaucoma, Intraocular Pressure, Nepal

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**Conflict of Interest:** Nil

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## Introduction

Glaucoma refers to all forms of the disease which have in common a potentially progressive and characteristic optic neuropathy which is associated with visual field loss as damage progresses, and in which intraocular pressure is usually a key modifying factor (Kanski and Bowling, 2011). It accounts for leading cause of permanent blindness worldwide.

Tham et al projected that the individuals (aged 40–80 years) with glaucoma globally was 64.3 million in 2014, increasing to 111.8 million by 2040. In 2004, Aghaian et al stated that the normal (mean ± standard deviation) intraocular pressure (IOP) value is 16±3 mmHg (range- 10 to 22 mmHg). Goldman applanation tonometer is the standard method of IOP measurement. It is most accurate with a central corneal thickness (CCT) of 520 µm; however, studies have revealed a wide range of normal CCT ranging from 537 to 554 µm (American academy of Ophthalmology, 2011-2012). The Ocular Hypertension Treatment Study (OHTS), 2002 emphasized role of CCT as a powerful predictor of primary open angle glaucoma (POAG).

Eyes having CCT of 555 µm are at three times higher risk of developing glaucoma than eyes having CCT of 588 µm (OHTS, 2002). Taken together, high IOP and thin cornea are important inter-related predictors for developing glaucoma. It is crucial to understand the effect of CCT on IOP to catch hold of undiagnosed cases of glaucoma.

This study was undertaken to relate CCT and IOP in patients of POAG and those of normal population to assess individualized risk for evidence-based decision making in early diagnosis and management of glaucoma in Nepalese population.

Materials and methods: A Comparative Cross-Sectional Study was carried out at B. P. Koirala Institute of Health Sciences, Dharan, Nepal, in the Department of Ophthalmology, for 1 year.

A sample size of minimum 100 cases of primary open angle glaucoma (POAG) was decided based on the records of newly diagnosed cases of POAG per year from the annual report of the institute 2008. Quota sampling method was used to include cases attending the glaucoma clinic of Ophthalmology department. Age and gender matched control were taken from general outpatient department. The study was conducted in accordance with declaration of tenets of Helsinki.

Informed consent was taken from each and every study participants. Newly diagnosed cases of primary glaucoma (open angle, normal tension) of 18 years and above, without known systemic diseases affecting corneal thickness and IOP were included.

Participants with prior history of diabetes, leprosy, hypertension, pregnancy, incisional ophthalmic surgery, corneal infection and scarring, inflammatory connective tissue disease, secondary or angle closure glaucoma were excluded.

All the included subjects underwent a detailed history taking followed by examination by two fixed Ophthalmologists. Examination included recording uncorrected and best spectacle corrected Snellen's visual acuity, slit lamp examination, gonioscopy (Goldman one mirror, using Shaffer classification), intraocular pressure (Goldman applanation tonometry) and Humphrey's automated visual field. Anterior chamber depth (ACD) and axial length (AL) were measured with ultrasound A-Scan (PacScan-300A, 300P, 300AP; Sonomed, Inc).

CCT was measured in both eyes by ultrasound pachymetry (PacScan-300A, 300P, 300AP; Sonomed, Inc) after application of topical xylocaine drop. Severity of glaucoma was graded based on Cup:Disc (C:D) ratio as grade I = <0.5, grade II = 0.5 to 0.8, grade III = > 0.8.

**Statistical analysis**

The data was evaluated using SPSS version 11.5 to find out the mean, frequencies, risk ratios and to conduct the correlation test.

**Results**

Five hundered and eighty two (582) eyes of 291 consecutive subjects satisfied the eligibility criteria and were included in the study. Of this, 105 patients (210 eyes) were case of primary glaucoma and 186 (382 eyes) were normal

subjects. 50.5% (147) were men and 49.5% (144) were female. Mean age (±standard deviation) of total study population was 50.44 ±13.94 years (Range=23 to 76 years). 99% of them belonged to Hill Janajati ethnic group (Magar, Tamang, Newar, Rai, Gurung and Limbu).

Various demographic and biometric parameters were compared among the two groups (Table 1). Majority of cases and controls had Snellem's visual acuity of 6/6 (Table 1, Figure 1). Majority of study cases and controls had a CCT in between 500 to 549 µm (Table 1, Figure 2).

The 2 groups did not show significant difference in CCT (p=0.1). CCT and age showed a negative correlation (normal eyes, p=0.005, r= -0.145, r2= 0.021; and glaucomatous eyes, p=0.000, r= -0.504, r2= 0.254). Females with glaucoma had significantly thicker cornea (539.28±27.36) than men (528.38±24.77) with a difference of 10.9 µm (p =0.003). However, no such gender disparity was seen in CCT of normal subjects.

In the glaucoma group, 75.7% had IOP in the range of 22-33 mm Hg (Figure 3). There was a significant difference of 7.88 mm Hg in IOP between case and control group (p<0.001). IOP and age was found to be negatively correlated (p=0.000, r=-0.295, r2=8.7%). A positive correlation was found between CCT and IOP in case and control group (p=0.000, r=0.355, r2=12.6% and p=0.000, r = 0.254, r2 = 6.45% respectively).

**Table 1: Comparing various parameters amongst cases and control group.**

| Characteristics | | Case (n=105) | Control (n=186) | p value |
|---|---|---|---|---|
| Age: Mean ± SD (years) | | 50.74±1.01 | 50.27±0.70 | |
| Gender | M:F | 50 :55 | 97:89 | |
| | % Male | 47.6 | 52.2 | |
| Visual acuity 6/6 (%) | | 62.9 | 80.6 | |
| Clear lens (%) | | 62.9 | 81.2 | |
| CCT | Mean ± SD (µm) | 533.57±26.54 | 530.06±23.52 | 0.1 |
| | 500-549µm | 61.4% | 58.9% | |
| Axial length: | Mean±SD (mm) | 23.25±0.71 | 23.19±0.68 | 0.301 |
| | 23-24mm | 47.1% | 50.3% | |
| Anterior chamber depth: Mean±SD (mm) | | 3.25±0.27 | 3.59±0.25 | <0.001 |
| IOP: Mean ±SD (mmHg) | | 25.12±5.27 | 17.24±2.57 | <0.001 |
| SD- standard deviation, CCT- central corneal thickness, IOP- intraocular pressure | | | | |

**Table 2: Comparison of various parameters among Primary Open Angle Glaucoma (POAG) and Normal Tension Glaucoma (NTG)**

| Characters | Group | Mean | Standard deviation | p value |
|---|---|---|---|---|
| Cup:Disc ratio | NTG | 0.664 | 0.151 | 0.851 |
| | POAG | 0.659 | 0.168 | |
| Central corneal thickness (µm) | NTG | 515.93 | 30.38 | <0.001 |
| | POAG | 537.98 | 23.60 | |
| Axial length (mm) | NTG | 23.12 | 0.823 | 0.178 |
| | POAG | 23.29 | 0.688 | |
| Anterior chamber depth (mm) | NTG | 3.33 | 0.333 | 0.049 |
| | POAG | 3.24 | 0.258 | |
| Intraocular pressure (mmHg) | NTG | 17.93 | 1.930 | <0.001 |
| | POAG | 26.93 | 4.199 | |

**Table 3: Central Corneal Thickness (CCT) in relation to severity of Cup: Disc ratio in glaucoma group**

| C:D ratio | N of eyes (%) | Mean CCT (µm) | Standard deviation |
|---|---|---|---|
| <0.5 | 18 (8.6) | 529.17 | 25.278 |
| 0.5-0.8 | 171 (81.4) | 535.95 | 26.950 |
| >0.8 | 21 (10.0) | 518.00 | 18.033 |
| **Total** | **210** | **533.57** | **26.543** |

Out of 210 glaucomatous eyes, 42 (20%) had NTG and 168 (80%) had POAG. There was a significant difference in CCT, ACD and IOP in between the two subgroups (Table 2). In NTG eyes, a strong positive correlation was found between CCT & IOP (p=0.000, r=0.669, r2 =0.461). In POAG eyes, CCT & IOP did not show any correlation.

Eyes with severe glaucomatous damage (cup:disc ratio > 0.8) had thinner cornea (518.±18.03 µm) than those with moderate glaucomatous damage (cup:disc ratio=0.5-0.8) with a difference of 17.95µm (p=0.003) (Table 3). Majority of subjects (47.1% of cases and 50.3% of controls) had an axial length between 23 to 24 mm. There was no major difference in axial length between the two groups (p=0.301). There was a weak positive correlation between AL and IOP (p=0.000, r=0.25, r2 =6.25%) among glaucomatous eyes. AL and CCT did not show any correlation (p=0.691, r=0.028) in glaucomatous eyes. However a weak positive correlation between AL and CCT (p<0.001, r=0.441, r2=19.44%) has been found in normal eyes.

Majority (54.8%) of normal eyes had ACD in the range of 3.5 to 3.99 mm whereas in the glaucoma group majority (68.6%) had it in the range of 3 to 3.49 mm (Figure 4). There was a significant difference of 0.34 mm in between the two groups (p<0.001).

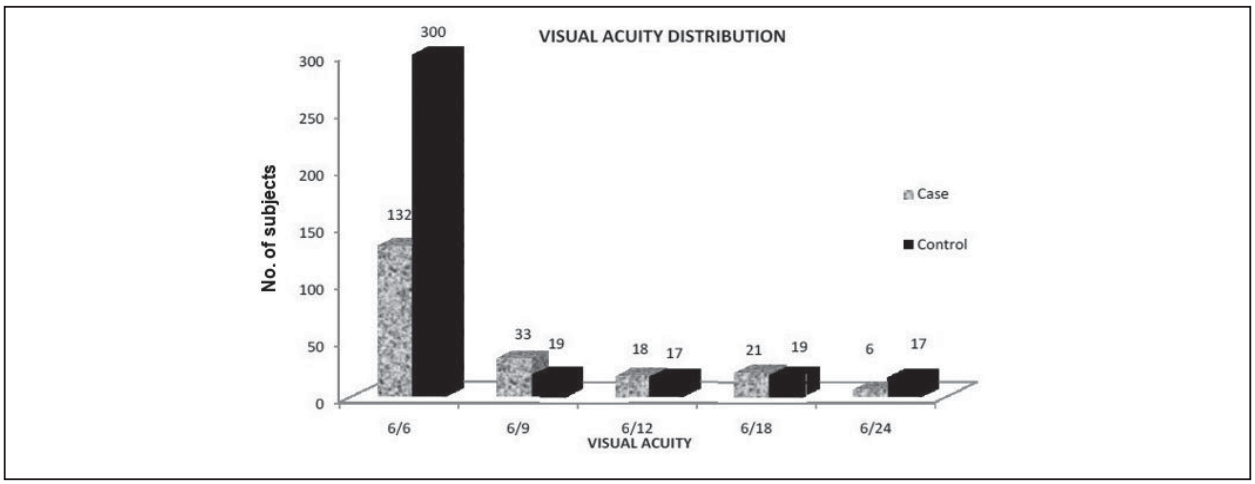


**Figure 1:** Visual acuity distribution of both cases and controls.

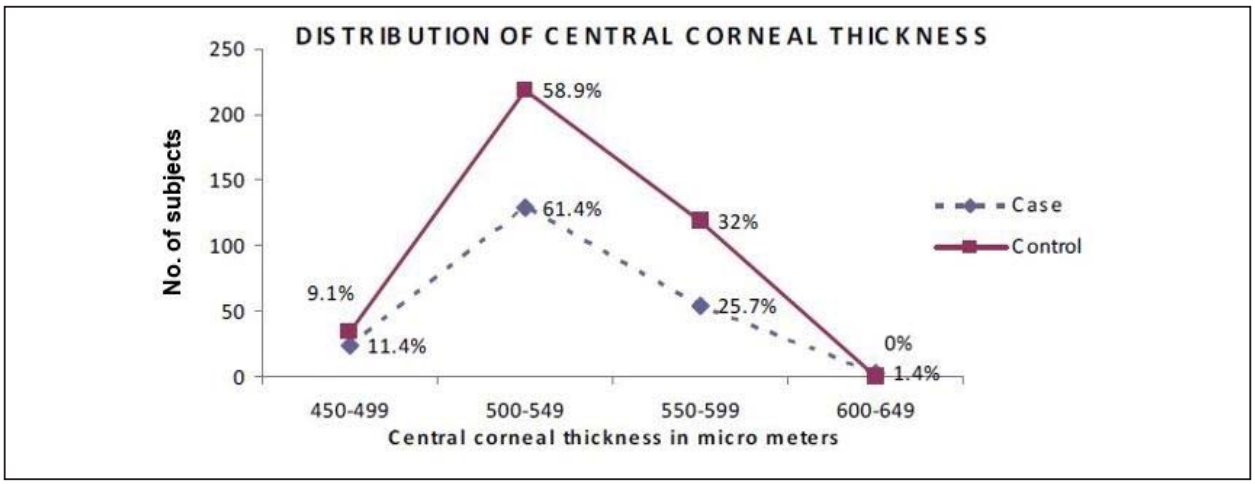


**Figure 2:** Distribution of Central Corneal Thickness in both the study groups.

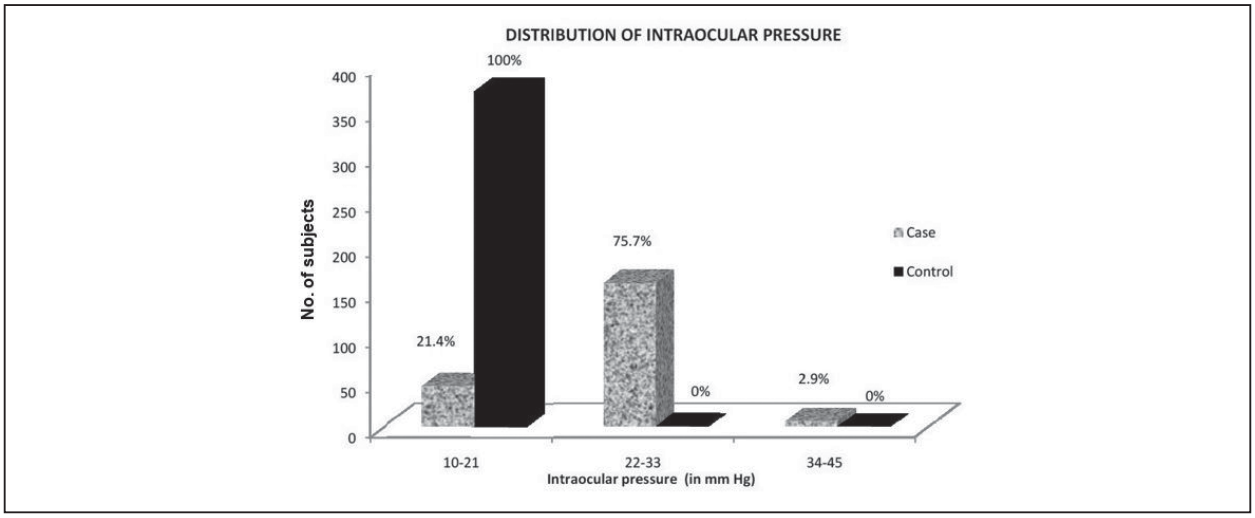


**Figure 3:** Distribution of Intraocular pressure in both cases and controls.

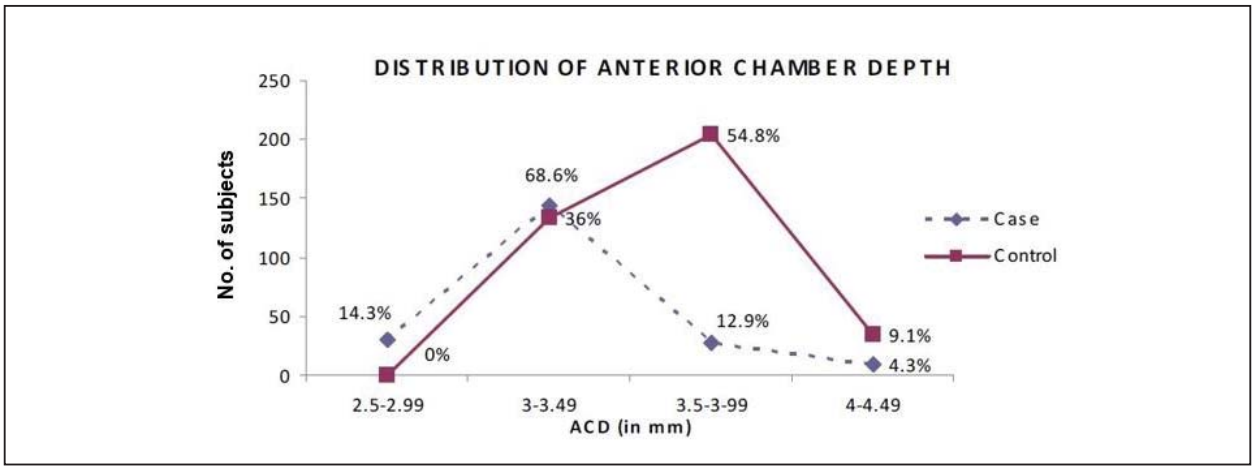


**Figure 4:** Distribution on Anterior Chamber Depth (ACD) in both the study groups.

## Discussion

There are normal anatomical variations in IOP and CCT among various subjects. It is crucial to identify the effect of CCT on IOP for proper diagnosis of glaucoma patients.

### CCT

Majority of cases (61.4%) and controls (58.9%) in our study had CCT in the range 500-549µm. There was no significant difference in CCT between glaucomatous and normal subjects (p=0.1). However, there was a significant difference of 22.05µm between POAG and NTG (p<0.001). Mello et al (2009) found a mean of 520.6µm central corneal thickness in POAG group and 519.2µm in normal eyes (p=0.18), which was lower than that in our study. In a meta-analysis (Doughty and Zaman, 2000), the average normal CCT was found to be 544µm, which was higher than that obtained in our study. There was a significant positive correlation between CCT and IOP in both cases as well as control group in the present study. In Pakistani population, the mean CCT measurement was 531µm by Channa et al (2009) which is comparable to our study results. But in contrast to our finding, they didn't find any significant correlation between CCT and IOP (r = 0.158, p = 0.12).

### CCT and age

In the present study, both normal as well as glaucomatous eyes showed a negative correlation between CCT and age. Daughty and Zaman (2000) suggested that for the majority of individuals there is no substantial change in CCT beyond the infancy except for some ethnic groups in which a significant age dependent decrease in CCT occurs in later life. Foster et al (1998) reported 0.005mm/decade decrease of CCT in Mongolian individuals. Similarly, 0.004 mm/decade decrease in Japanese ($p < 0.01$), white Danish and Scandinavian individuals ($r = -0.230$; $p > 0.05$) (Olsen and Ehler, 1984; Doughty and Zaman, 2000). Substantial age-dependent decrease in CCT has also been reported by Li et al (1994) for young Chinese myopes. On the contrary, various literature reports an increase in CCT ranging from 2-4% after the age of 60 year (Schultz et al, 1984; Yee et al, 1985; Polse et al, 1989; Larsson, 1996).

### CCT and gender

In this study, females with glaucoma had thicker cornea than men (p = 0.003). No such difference was seen in normal eyes. Also, the overall literature shows higher CCT values for women (554 µm) than overall average CCT of 535 µm (Leach et al, 1971; Millodot, 1977; Feldman et al, 1978; Kiely et al, 1983; Cho and Lam, 1999; Oku et al, 2009.

### CCT and C:D ratio:

Eyes with severe glaucomatous damage had thinner cornea than those with moderate damage in our study (difference of 17.95µm,p=0.003). Similarly, in a study by Jiménez-Rodríguez and colleagues (2009), subgroup with advanced visual field damage had thinner cornea than in moderate damage group (p< 0.01).

### Axial length

There was no significant difference in mean axial length between normal and glaucomatous eyes (p=0.301) as well as NTG eyes and POAG eyes (p=0.178). Axial length in normal Taiwanese Chinese adults (23.25±1.1 mm) was comparable to our results (Chen et al,2009). Similarly, in a study by Mello et al (2009), there was no significant difference (p=0.13) in axial length between POAG (22.68 mm) and normal eyes (22.64 mm).

### Axial length (AL) and IOP

There was a positive correlation between AL and IOP among glaucomatous eyes in our study. Oku and colleagues (2009) reported long axial length (=25 mm) as risk factor (OR-2.29) for NTG and POAG. However, in contrary, Kohlhaas et al (2006) found no significant

association between IOP and axial length (p=0.31).

**Axial length and CCT:**

AL and CCT were not correlated in eyes with glaucoma in this study. However a positive correlation was found in normal eyes. Shimmyo and Orloff (2005) reported that CCT and AL are two free factors, and thin cornea may not be associated with long eyes.

**Anterior chamber depth**

Anterior chamber of glaucomatous eyes was significantly shallower in comparison to normal eyes ($p<0.001$) in our study. Similar finding has been reported in Korea where Kim et al (2008) found that there is a significant difference in ACD between POAG and non-glaucomatous subjects (2.945±0.402 and 2.584±0.602 respectively). However, there was no significant difference (p=0.049) in ACD between NTG (3.33 mm) and POAG (3.23 mm) in our study.

Similarly, Caprioli et al (1986) also found no significant differences in ACD between groups of patients with primary open angle glaucoma, low tension glaucoma or glaucoma suspects.

**IOP**

In our study, there was an obvious difference of 7.88mmHg in IOP between glaucomatous and normal subjects ($p<0.001$) and of 9mmHg in between POAG and NTG ($p<0.001$). A negative correlation was found between IOP and age in glaucoma group. A positive correlation was found between IOP & CCT in both cases and control group. As per a meta-analysis by Doughty and Zaman (2000), linear regression model predicted 1.1 ± 0.6 mmHg difference in IOP measures by applanation tonometry for every 10% difference in CCT ($p< 0.05$).

For the sets of data on eyes designated as having a chronic disease (POAG, OHT, NTG, diabetes and lens exfoliation syndrome), the group averaged CCT was 0.545 mm, which was higher than our study value. The linear regression model predicted 2.5 ± 1.1-mmHg differences in IOP measures by applanation tonometry for every 10% difference in CCT ($p< 0.05$).

Using these studies, many investigators have used a conversion table for IOP based on CCT, considering 545µm as the normal cutoff point (Doughty and Zaman, 2000). For every 50 µm reduction in CCT, IOP was increased by 2.5-3.5 mm Hg. Researchers have reported that the risk of developing POAG was three times higher among participants whose corneas were =555 µm than in those with CCT =588 µm (OHTS, 2002).

As the CCT of normal population was 530µm in our study and 539 µm in Bhaktapur Glaucoma Study (Thapa et al 2002), the Nepalese population may be at a higher risk of developing POAG. Limitations of this study is its small sample size and limits in representation of entire Nepalese population. However a sample size of 186 would be representative of population of Sunsari district.

**Conclusion**

Majority of studied Nepalese population have CCT less than 550 µm thus increasing the risk of POAG. Eyes with POAG have thicker cornea than NTG eyes. CCT decreases with age and females with glaucoma have a significantly thicker cornea than men. There is a significant positive correlation between CCT and IOP, and IOP will have to be adjusted for CCT for proper diagnosis and monitoring of glaucomatous damage in Nepalese population too.

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