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# Clinical Comparison of Topcon CT-80 Non-contact Tonometer with Goldmann Applanation Tonometer in Nepalese Population

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## ABSTRACT

**Introduction:** Goldmann applanation tonometer (GAT) is the gold standard method of measuring the intraocular pressure (IOP) but, it is subjected to intra and inter-reading variability, risk of cross-infection, and possible damage to the cornea. A non-contact tonometer (NCT) reduces the risk of cross-infection, is not operator dependent, and can be used in post-refractive surgery patients. Therefore, the study aims to correlate the IOP readings obtained by non-contact tonometer and GAT.

**Methods:** A hospital-based, prospective, cross-sectional descriptive study was carried out in the Department of Ophthalmology, Manipal Teaching Hospital, Pokhara. One hundred and twenty cases were recruited in the study from June 2019 to May 2020. The IOP was taken from NCT followed by GAT.

**Results:** Mean IOP was 17.03±5.14 mmHg for GAT and 16.49 mmHg±5.35 mmHg for NCT and this difference was statistically insignificant ($p=0.2$). The difference in the mean value increased with higher intraocular pressure which was statistically significant ($p<0.05$). The NCT underestimated the IOP in lower intraocular pressures whereas it overestimated the IOP in higher intraocular pressures which were statistically significant ($p<0.00$). The overall mean ± SD difference between GAT and NCT measured IOPs was 0.53±2.07 mmHg. Bland-Altman analysis revealed that 95% limits of agreement (LoA) ranged from -3.53 to 4.60 mmHg. Correlation analysis showed a high correlation between NCT and GAT ($r=0.92$).

**Conclusion:** NCT compared favorably with GAT but it tends to yield lower IOP readings within the normal range and higher IOP readings at a higher range. NCT can be used as a fair tool for screening purposes.

***Keywords***: *GAT; Intraocular Pressure; Tonometry, Ocular*

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## INTRODUCTION

Glaucoma affects more than 60 million people worldwide and is the second leading cause of blindness.[1] The overall prevalence of glaucoma is 1.9% in Nepal.[2] Accurate measurement of intraocular pressure (IOP) has a very important role in the diagnosis and management of glaucoma.[3]

Although the Goldmann applanation tonometer (GAT) is the gold standard, it is subjected to intra and inter-reading variability.[4] There is a risk of cross-infection and possible damage to the corneal epithelium. It requires anesthesia which slightly decreases the IOP. A non-contact tonometer (NCT) has certain advantages as it reduces the risk of cross-infection, is not operator dependent, and can be used in post-refractive surgery patients. Hence, a comparative study of IOP obtained by NCT and GAT was undertaken which has not been reported earlier in Nepalese eyes.

Therefore, the study aims to correlate the IOP readings obtained by non-contact tonometer and GAT.

## METHODS

A hospital-based, prospective, cross-sectional descriptive study was conducted in the Department of Ophthalmology, Manipal Teaching Hospital, Phulbari, Pokhara, Nepal. One hundred and twenty cases were recruited in the study from June 2019 to May 2020. The sample size was calculated using the formula:

$$n = 2\sigma^2 (Z_{\alpha/2} + Z_{\beta})^2 / (\mu_1 - \mu_2)^2$$

Where,

Confidence interval=95%,

$Z_{\alpha/2}$=1.96,

$Z_{\beta}$=0.84,

$\sigma$ =3.62mmHg,

Mean 1($\mu_1$)=16.5 mmHg, and Mean 2 ($\mu_2$)=15 mmHg from the study by Kim et al.[5]

$$n = \frac{2x(3.62)^2 (1.96+0.84)^2}{(16.5-15)^2} = 92$$

Preceding the study, ethical approval from the institutional research committee was obtained with ID no. MEMG/IRC/232/GA. All the subjects were explained about the procedure in detail and verbal informed consent was taken. They underwent comprehensive eye examination consisting of subjective and objective refraction, anterior and posterior segment eye examination.

All IOP readings were taken in a sitting position. Based on the Imbert-Fick principle, the GAT assesses the IOP by measuring the force necessary to applanate a fixed area of the cornea. [6] Air-puff tonometry is based on the principle of applanation, the central part of the cornea is flattened by a jet of air to measure the time or force of the air puff to create a standard amount of corneal deformation. The non-contact air-puff tonometry (Topcon CT-80, Topcon Medical Systems, Paramus, New Jersey, USA) was performed before the slit lamp mounted Goldmann applanation tonometry (OP-1H, Optilasa S.L, Spain) to avoid the known mild reduction of IOP by anterior chamber compression by GAT. An average of three readings were recorded as NCT records 1st high reading followed by lower consecutive readings. After 15 minutes, topical Xylocaine was instilled and GAT was performed using a properly calibrated Topcon slit lamp. Inclusion criteria included BCVA of 6/6, refractive error within ±2 D spherical and within 2 D of astigmatism, and age >16 years. Patients with the scarred or hazy cornea, history of previous corneal surgery, contact lens wear, refractive error > ±2 D, any active disease - uveitis, infection, discharge, nystagmus, and age <16 years were excluded from the study.

A provisional diagnosis was made depending on the data available at the initial visit. Ocular hypertension (OHT) was defined by an IOP > 21 mmHg, an open angle, and an absence of optic disc or visual field changes. A diagnosis of glaucoma was made if any evidence of characteristic glaucomatous optic disc and/ or visual field damage, irrespective of IOP.

Patients with suspicious optic disc or visual field changes were classified as glaucoma suspects. Patients without any signs of OHT or glaucoma was classified as normal. Statistical analysis was performed by using statistical software SPSS Version 21. Data were expressed as the mean ± standard deviation (SD). Paired t-test was used to compare the IOP readings between the two tonometry methods. The inter-device agreement was assessed by Bland-Altman analysis. In the Bland-Altman analysis, the distribution of measurements was expressed as the mean difference between the two devices with standard deviation and in terms of the 95% limits of agreement (LoA), which were defined as the mean±1.96 SD. The correlation between the IOP measured by GAT and NCT was tested by Pearson correlation. A value of $p<0.05$ was considered to be statistically significant.

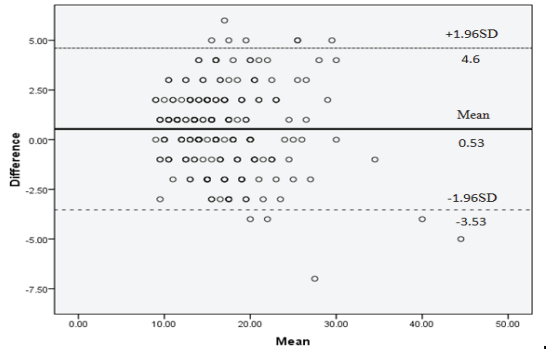


***Figure 1: Bland-Altman plots of the agreement between NCT and GAT measured IOPs***

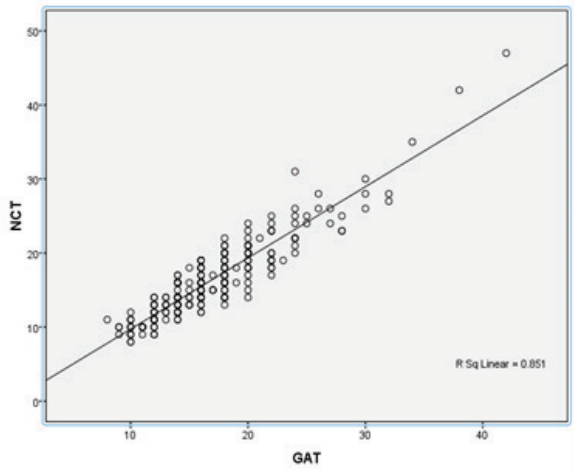


***Figure 2: Scatter plot shows the correlation between IOP measurements obtained by GAT and NCT***

## RESULTS

The mean age of the patients enrolled in the study was 48.97±17.44 years. Out of the total of 120 subjects, 65 (54.17%) were males and 55 (45.83%) were females. The patients were classified as the following: normal 23.3%, OHT 2.5%, glaucoma suspect 28.3%, and glaucoma 45.8%.

***Table 1: Patient distribution***

| Diagnosis | Frequency (n) | Percentage (%) |
|---|---|---|
| Normal | 28 | 23.33 |
| POAG | 55 | 45.84 |
| Glaucoma Suspect | 34 | 28.33 |
| OHT | 3 | 2.50 |

POAG: Primary open angle glaucoma; OHT :Ocular hypertension

All the patients with open-angle glaucoma were on topical anti-glaucoma treatment. The Goldmann applanation tonometer on both eyes of 120 subjects recorded a mean of 17.03±5.14 mmHg. Similarly, the mean of non-contact tonometer readings was 16.49 mmHg±5.35 mmHg.

Table 2 summarizes the demographic data of the study participants.

Although NCT tended to measure the IOP slightly lower than those obtained by GAT, there was no statistically significant difference in IOP measurement among both the tonometers (p=0.2).

For further analysis of IOP measurements made by GAT and NCT, two groups were considered in different IOP ranges: Group 1 (IOP <21 mmHg), Group II (IOP≥21 mmHg). There was no difference in age between the two groups (p=0.49). The difference in the mean value increased with higher intraocular pressure which was statistically significant ($p<0.05$) as seen in table 3. The non-contact tonometer underestimated the IOP in lower intraocular pressures whereas it overestimated the IOP in higher intraocular pressures which were statistically significant ($p<0.001$).

The overall mean±SD difference between GAT and NCT measured IOPs was 0.53±2.07 mmHg (95% limits of agreement: -3.53 to 4.60 mmHg). There was a close level of agreement between the IOPs taken by GAT and NCT. There was no evidence of proportional bias, as shown by the lack of correlation between the difference and the mean of the measurements (p=0.10). Figure 1 shows Bland-Altman plots of the agreement between IOP measured by GAT and NCT. Two hundred and thirteen eyes out of two hundred and forty (88.75%) had IOP difference within ±3 mmHg. In addition, correlation analysis showed a high correlation between NCT and GAT (r=0.92).

## DISCUSSION

Intraocular pressure (IOP) is the most important and only modifiable risk factor. Ocular hypertension is associated with an increased risk of developing glaucoma and reducing IOP has been shown to lessen the progressive loss of the visual field.[7] Studies have shown that for every 1mmHg reduction in IOP, visual field damage can be reduced by 10%.[8]

Goldmann applanation tonometer and Non-Contact Air Puff tonometer are commonly used in clinical practice. This study noted that the non-contact tonometer gave slightly lower readings as compared to the Goldmann applanation tonometer although statistically insignificant. The same results were seen in other studies.[3,7,9-12] Some studies, in contrast to the above-mentioned studies, detected the NCT to read higher than GAT.[6,13-16,18] However, there was no significant difference between the IOP measured by NCT and GAT. [5,13-18] It has been seen that if the readings of NCT are taken after GAT, then it may display lower IOP readings because applanation produces a slight decrease in IOP.[19] So, in this study, NCT was done before GAT to avoid this error of measurement.

Our study suggested that there were 88.75% of eyes had IOP variations within ±3 mmHg. Salim et al. reported that 92.8% had IOP variation within ± 3mmHg.[20] Similarly, Shalini et al.[3] and Moseley et al.[21] demonstrated that 86.4% and 71% of the patients had IOP variation within ±3 mmHg. The overall mean difference in IOP between GAT and NCT readings was 0.53±2.07 mmHg. Other studies reported a mean difference of 0.9±3.1 mmHg, 0.39±1.7 mmHg, and 0.37±2.17 mmHg between GAT and NCT readings.[7,11,12] The mean difference in IOP in the present study was 0.42±1.84 mmHg for IOP within the normal range, whereas it was 1.09±2.93

***Table 2: Demographic data of study participants***

| Variables | Mean | Standard Deviation (SD) | Minimum | Maximum |
|---|---|---|---|---|
| Age (years) | 48.97 | 17.44 | 15 | 81 |
| Gender | 64/55 | | | |
| IOP with GAT (mm of Hg) | 17.03 | 5.14 | 8 | 42 |
| IOP with NCT (mm of Hg) | 16.49 | 5.35 | 8 | 47 |

NCT: Non-contact tonometer; GAT: Goldmann applanation tonometer; SD: Standard deviation

***Table 3: Mean IOP difference between NCT and GAT in different ranges of IOP***

| IOP range | Frequency (n) | IOP NCT (Mean ±SD) | IOP GAT (Mean ±SD) | Mean Difference |
|---|---|---|---|---|
| < 21 mmHg | 42 | 14.75 ± 3.04 | 15.36 ± 3.19 | 0.42 ± 1.84 |
| ≥ 21 mmHg | 198 | 25.19 ± 5.36 | 24.08 ± 5.36 | 1.09 ± 2.93 |

NCT: Non-contact tonometer; GAT: Goldmann applanation tonometer; SD: Standard deviation

mmHg in the higher ranges. Other studies revealed a mean difference of 0.99±1.66 mmHg if IOP<18 mmHg and 1.71±1.88 mmHg if IOP>18 mmHg.[3] The difference in the mean value increased with higher intraocular pressure which was statistically significant in this study. Other studies also revealed that the accuracy decreases as the IOP increases.[6, 20, 22]

The non-contact tonometer underestimated the IOP in lower intraocular pressures whereas it overestimated the IOP in higher intraocular pressures which were statistically significant ($p<0.001$). A similar finding was seen in the study conducted by Tonnu et al.[7] whereas other studies with the NCT showed that it overestimated at low pressures and underestimated at high pressures when the IOP readings are compared with GAT.[11,21]

There was a significant positive correlation between IOP measured by GAT and NCT ($r=0.922$) as seen in most of the other studies where r=0.909,0.938,0.0.871,0.982 respectively.[3,12,14,23]

The level of agreement between IOP measured by GAT and NCT as seen by Bland-Altman plots showed that 95% LoA ranged from -3.53 to +4.60 mmHg. Similarly, 95% LoA ranged from -3.50 to +4.90 mmHg, -3.88 to +4.63 mmHg and -4.78 to +4.00 mmHg in various studies.[11,17,24]

The relatively small sample size of the present study made it difficult to carry out further analyses with sufficient statistical power. Further, the study is limited by the lack of patients with higher IOP as the NCT has been seen to be less accurate with increased IOP. Other factors that may influence the IOP readings such as the corneal biomechanical properties like the central corneal thickness and corneal curvature were not taken into account.

## CONCLUSION

The results of this study concluded that non-contact tonometer compared favorably with GAT. However, our data suggest that the NCT may tend to yield lower IOP readings within the normal range and higher IOP readings at a higher range. NCT can be used as a fair tool for screening purposes as it can be used easily by health personnel.

## CONFLICT OF INTEREST

None

## SOURCES OF FUNDING

None

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