

Comparative study of Intra-ocular pressure measurement with GAT(Goldman Applanation Tonometer) and NCT(Non-Contact Tonometer) with respect to Central Corneal Thickness(CCT)

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Abstract

Background: GAT is gold standard technique but it is invasive and time consuming procedure. NCT is non-invasive, OPD and non-contact procedure with no risk of abrasions or cross-infections. Measurements of IOP by GAT and NCT, both influenced by central corneal thickness (CCT). **Aim:** To compare the values of IOP measured by GAT and NCT with special emphasis on CCT. **Material and Methods:** Hospital based cross-sectional study was conducted on 200 cases (400 eyes) attending ophthalmology OPD for 4 months. **Results:** Most of cases were of age between 36 to 45 years with average age of 54.69 years and male to female ratio was 0.87:1. Mean levels of IOP measured with NCT (22.42mmHg) was higher than that of GAT (19.18mmHg). Difference between IOP levels measured by GAT and NCT was statistically significant for IOP more than 12 mmHg. The Pearson correlation coefficient(r) between the GAT and NCT was 0.90 (very strong positive correlation). Correlation was statistically significant ($p < 0.001$). Linear regression analysis equation was $[GAT = 5.8 + (0.597 * NCT)]$ to predict IOP. **Conclusion:** Strong positive correlation found between NCT and GAT. NCT being a non-invasive and non-contact technique, can be used routinely as a screening procedure for IOP measurements in OPD and mass screening camps. However, adjustment of IOP readings measured with NCT according to CCT should be done to avoid underestimation or overestimation.

Keywords: Glaucoma, CCT, Tonometry, GAT, NCT.

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INTRODUCTION

Measurement Intra-ocular pressure (IOP) is a crucial part of comprehensive and routine eye care especially in management of glaucoma as it only modifiable risk factor for glaucoma.^{1,2} In India, Goldmann applanation tonometry (GAT) and Non-contact tonometry (NCT) are

still commonly used for measuring IOP. GAT is gold standard technique for IOP measurements since 1954. It is invasive and time consuming procedure.³ Grolman introduced NCT in 1972, is a non-invasive, non-contact procedure which measures the duration or force of air-puff required to create a standard amount of corneal deformation.^{3,4} Measurements of IOP by GAT and NCT, both influenced by central corneal thickness (CCT). Measurements of IOP by GAT is based on CCT presumption of 520 μ m. As NCT measurements based on larger surface of cornea and corneal deformation by air-puff, it is more affected by CCT.^{3,5} Small variation in CCT due to inter-individual variations affect IOP measurement but they are clinically insignificant. But that is not a case in larger variations in CCT where it may result in misdiagnosis due to false estimation of the IOP.^{6,7,8} Therefore, knowledge about the quantitative effect of CCT on different IOP measuring techniques is very essential to

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attain higher accuracy. The techniques used for IOP measurement should be safe, accurate, time saving and should cause least inconvenience to the patient. Considering this, study was undertaken to compare the values of IOP measured by GAT and NCT with special emphasis on CCT.

MATERIAL AND METHODS

An observational analytical cross-sectional hospital based study was conducted at Ophthalmology out-patient department (OPD) of tertiary care hospital from September 2019 to December 2019. Institution Ethics Committee (IEC) permission was taken for study. Cases attending Ophthalmology OPD of any gender, more than 18 years of age and willing to give consent for participation in study were enrolled. Patients with ocular injuries, corneal and ocular surface diseases were excluded. Total 200 cases (400 eyes) were enrolled for study. Standard operating protocols and definitions were formulated before commencement of study and followed till end. Written informed consent was taken from each study participant after giving detailed information about study and procedure. Information about socio-demographic profile, symptoms and past history of lasses/contact lenses, surgery, any illness and ophthalmic disease was collected through interview. Vitals were recorded. Through ophthalmic examination was done including anterior segment examination by slit-lamp, unaided visual acuity and best corrected visual acuity with refraction and fundus examination done by direct and indirect ophthalmoscope Intra-ocular pressure (IOP) was recorded by both, NCT (Perkins) and GAT. All measurements of IOP by both methods were performed during fixed time (OPD timing i.e. 0900 to 1500) to avoid day time fluctuations. Eye was anaesthetized using Paracaine 0.5% eye drops for GAT and CCT measurements. IOP measurement by NCT (Perkins) was done first followed by GAT to prevent bias due to a reduction of measured IOP caused by applanation. Participants were asked to relax and to fix the gaze on an object behind the examiner without blinking with both eyes open. Three readings of NCT was taken with a gap of 30 seconds and final intraocular pressure reading for each eye was calculated by taking mean. After a break of 30 seconds, GAT was performed for 3 times for each eye and average of 3 was taken as a final reading. Periodical calibration of all instruments were done. Measurements of GAT, NCT and CCT were taken by 3 different experienced Ophthalmologists who were masked to others readings to avoid bias. Data was entered in Microsoft Excel 2010 and analysed with SPSS v16. Frequency, proportions, mean and standard deviation were used for descriptive statistics. Pearson correlation coefficient, Student 't' test and linear regression model were used as inferential statistics

($p < 0.05$). Data was summarized through tables and graph at appropriate places.

RESULTS

Study conducted on 200 cases (400 eyes). Sociodemographic profile details are shown in table no.1. Mean age was 54.69 ± 14.86 years ranging from 18 years to 78 years of age. Percentage of cases belong to 18 to 25, 26 to 35, 36 to 45, 46 to 55 and more than 55 were 7%, 20%, 39%, 16% and 18% respectively. Highest cases were reported from 36 to 45 years of age. Female to male ratio was 0.87:1 as proportion of female and male were 46.5% and 53.5%. Mean values of intra-ocular pressure (IOP) measured by Goldmann Applanation Tonometer (GAT) and Non-contact Tonometer (NCT) and Central Corneal Thickness (CCT) are shown in table no. 2. Mean IOP measured by GAT was 19.18 ± 6.89 mmHg ranging between 09 to 43 mmHg. Mean IOP measured by NCT was 22.42 ± 9.17 mmHg ranging between 09 to 46 mmHg. Average CCT measured was 547.36 ± 53.26 microm. ranging between 495 to 559 microm. The difference between the mean value of IOP measured by GAT and NCT was statistically significant ($p < 0.0001$). Among different age groups, this difference was statistically significant in 26 to 35 years, and 46 to 55 years of age. In both, males as well as females, difference between IOP by two tonometers was not statistically significant (table no.1). As shown in table no.3, IOP readings taken by GAT was divided into 3 groups viz. G1 (< 12 mmHg), G2 (12 to 21 mmHg) and G3 (> 21 mmHg) to check difference in IOP measurements by two tonometers at different levels of IOP. Number of cases in group 1, 2 and 3 were 47, 210 and 143 respectively. Difference in IOP levels of group 1,2 and 3 were 1.44, 2.44 and 5.85 mmHG, respectively. Difference between IOP levels measured by GAT and NCT was statistically significant for IOP more than 12 mmHg i.e. group 2 and 3. Table no.4 depicts, IOP readings taken by GAT and NCT at different levels of CCT measured by Pachymeter (divided into 4 groups) to check difference in IOP measurements by two tonometers at different levels of CCT. Mean IOP by GAT and NCT at CCT ($\leq 518 \mu\text{m}$) were 17.57 and 20.9 mmHg, respectively. Mean IOP by GAT and NCT at CCT (519-551 μm) were 18.96 and 22 mmHg which increased to 20.13 and 23.51 mmHg at CCT (552-569 μm). The difference between mean levels of IOP measured by GAT and NCT at different levels of CCT were statistically significant ($p < 0.0001$). Figure no.1 depicts the correlation between IOP measurements by GAT and NCT. The Pearson correlation coefficient (r) between the GAT and NCT was 0.90 (very strong positive correlation). Correlation was statistically significant ($p < 0.001$). Linear regression analysis equation was $[GAT = 5.8 + (0.597 * NCT)]$ to predict IOP.

Table 1: Association between Intra-ocular pressure (IOP) by tonometers among sociodemographic groups of study participants (n=200)

		GAT (mmHg)	NCT (mmHg)	Difference	P-value
Age group (years)	18-25 (n=14)	18.98	21.11	2.13	Not significant
	26-35 (n=40)	17.75	20.63	2.88	Significant*
	36-45(n=78)	17.05	19.21	2.16	Not significant
	46-55 (n=32)	20.46	23.99	3.53	Significant*
	>55 (n=36)	21.69	27.17	5.48	Not significant
Gender	Male (n=107)	19.586	22.882	3.296	Not significant
	Female (n=93)	18.786	21.962	3.176	Not significant

*P<0.0001; GAT: Goldmann applanation tonometer, NCT: Non-contact tonometer; CCT: Central corneal thickness.

Table 2: Mean values of various clinical parameters

Variable	Mean	SD	Range
GAT (mmHg)	19.186	6.89	09 to 43
NCT (mmHg)	22.422	9.17	09 to 46
CCT (micrometer)	547.36	53.26	495 to 559
Age (years)	54.69	14.86	18 to 78

GAT: Goldmann applanation tonometer, NCT: Non-contact tonometer; CCT: Central corneal thickness

Table 3: Comparison of Mean Intraocular Pressure (IOP) measured by GAT and NCT

Group	GAT (mmHg)	NCT (mmHg)	Difference	Statistical significance
G1 (<12 mmHg)	9.95	11.39	1.44	Not significant
G2 (12-21 mmHg)	16.9	19.34	2.44	Significant*
G3 (>21 mmHg)	30.69	36.54	5.85	Significant*

*P<0.0001

Table 4: Comparison of Mean Intraocular Pressure (IOP) measured by GAT and NCT in different corneal thickness group

CCT (µm)	GAT (mmHg)		NCT (mmHg)		Statistical significance
	Mean	SD	Mean	SD	
≤518	17.576	6.02	20.907	8.02	Significant*
519-551	18.966	6.28	22.007	7.34	Significant*
552-569	20.136	4.92	23.517	6.28	Significant*
≥570	20.076	6.58	23.257	8.22	Significant*
Entire group	19.186	6.89	22.422	9.17	Significant*

*P<0.0001; GAT: Goldmann applanation tonometer, NCT: Non-contact tonometer; CCT: Central corneal thickness.

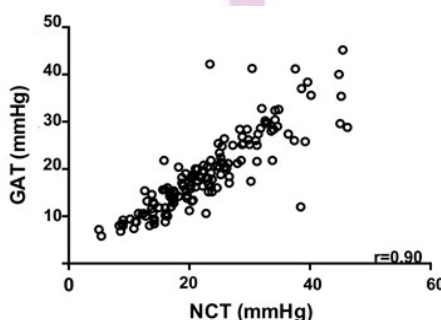


Figure 1: Correlation between between IOP Value GAT and NCT

DISCUSSION

IOP measurement largely influenced by the technique of measurement and central corneal thickness (CCT). Goldmann Applanation Tonometer (GAT) and Non-contact Tonometer (NCT) are widely used methods. But IOP measurements through these methods influenced by

corneal properties. In present study, most of cases were of age between 36 to 45 years with average age of 54.69 years and male to female ratio was 0.87:1. IOP increased with age measured through GAT and NCT. Average IOP among males (19.58) was more when compared with females (18.78) by both method. Study done by Sood *et al.*⁹

reported 33% cases from 33 to 45 years age group, 42.06 years as mean age and 52.7% males in their study. In present study, difference in mean IOP levels of GAT and NCT was statistically significant in 26 to 35 years, and 46 to 55 years of age but same was not true for males as well as females as difference between IOP by two tonometers was not statistically significant. Sood *et al.*⁹ reported comparable findings. Study done by Chakrabarty *et al.*¹⁰ reported 57% females and 44% were males with mean age of 52.48 years (range: 25 to 83 years). In current study, mean levels of IOP measured with NCT (22.42) was higher than that of GAT (19.18), so the difference was 3.236 mmHg and this difference was statistically significant ($p < 0.0001$). Study done by Sood *et al.*⁹ reported, statistically significant difference (3.99 mmHg) between mean levels of IOP measured with GAT (17.35) and NCT (22.02). Ahmad *et al.*¹¹ and Pande *et al.*¹² reported similar findings in their studies. They reported statistically insignificant effect of age, gender or laterality of eyes on IOP measurements through GAT or NCT. Studies done by Gunvant *et al.*¹³, Foster *et al.*¹⁴ and Christopher *et al.*¹⁵ reported mean IOP between 12.6 to 16 mmHG and mean CCT between 495 and 559 micrometer. In present study, difference between mean levels of IOP measured through GAT and NCT increased as the IOP increased. These differences were statistically significant in IOP more than 12 mmHg and not significant for IOP levels lower than 12 mmHG. So use of NCT over GAT for higher IOP levels should be cautiously done. Study done by Sood *et al.*⁹ reported, significant difference in IOP levels measured through both techniques at all levels of IOP. Studies done by Qasim *et al.*¹⁶ and Rochchina *et al.*¹⁷ reported that, in cases where IOP (measured by GAT) levels is in the lower range (< 12 mmHg), in such cases IOP measurement by NCT are more reliable than in IOP (measured by GAT) levels is in the higher range (> 12 mmHg). This was in comparison with present study findings. Highest number of cases had IOP levels between 12 to 21 mmHg in study done by Chakrabarty *et al.*¹⁰ Present study reported similar finding. Different findings were reported by some studies which reported, NCT overestimates IOP at lower values and underestimates at higher values when compared with GAT.¹⁸⁻²¹ In present study, IOP levels measured with GAT and NCT significantly differed at all levels of CCT. CCT affects IOP values measured with both techniques but effect on NCT was more pronounced than GAT. Study done by Sood *et al.*⁹ reported, positive correlation between IOP measurement of both methods and CCT. They reported coefficient of correlation for NCT-CCT was 0.318 and for GAT-CCT was 0.325. So these findings were similar to findings reported by current study. Hiroki *et al.*²² found in their study that, for every 10 μ m change in the CCT, the IOP changed by 0.23 mmHg with the GAT and

0.29 mmHg with the NCT. Nair *et al.*²³ and Gupta *et al.*²⁴ also reported comparable findings. Chakrabarty *et al.*¹⁰ reported good positive correlation between GAT and NCT IOP measurements at all levels of CCT. Most studies done by many authors have also reported NCT to be affected more by CCT.^{2,4,25} Very strong positive correlation found between IOP levels measured by GAT and NCT with correlation coefficient (r) of 0.90 which was statistically significant ($p < 0.0001$). Sood *et al.*⁹ also found statistically significant positive correlation between GAT and NCT ($r = 0.882$; $p < 0.0001$). Chakrabarty *et al.*¹⁰ reported a significant correlation between NCT and GAT ($r = 0.95$, $p < 0.001$) and positive correlation with CCT with a regression of 0.35 mmHg per 10 μ m for both GAT and NCT which is comparable with current study. Previous studies reported good correlation between GAT and NCT [r : 0.27 to 0.9 ($p = 0.03$ to $p < 0.001$)].¹⁸⁻²¹

CONCLUSION

Out of two techniques for measurement of IOP GAT is the gold standard but being an invasive procedure which requires contact with cornea, it increases risk of cross infection and corneal abrasions. Iso it takes long time to conduct so less useful in places where case load is high. NCT had shown statistically significant moderate to strong positive correlation with GAT in current as well as previous studies. Considering this and being a non-invasive and non-contact technique, NCT can be used routinely as a screening procedure for IOP measurements in out-patient department (OPD) and mass screening camps. However, in certain cases like patients with CCT, adjustment of IOP readings measured with NCT should be done to avoid underestimation or overestimation.

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