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Original research article

Comparative assessment of the values of IOP measured by GAT and NCT with special emphasis on CCT

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Abstract

Aim: The present study was undertaken to compare the values of IOP measured by GAT and NCT with special emphasis on CCT.

Methods: It was a cross sectional observational study done on patients attending Ophthalmology OPD, Ballari during the period of January 2021 to June 2022 applying the following inclusion and exclusion criteria. 150 cases were included in the present study.

Results: Out of 150 patients, 70 were male and 80 were female patients, that is, 46.7% were male and 53.3% were female patients. The majority of them were in the age group of 51 to 60 years. The mean ± SD IOP measured by the GAT was 14.47 mmHg ± 3.17 mmHg. The mean ± SD IOP measured by the NCT was 17.68 mmHg ± 2.91 mmHg. The mean ± SD CCT was 508.95 ± 33.79 microns. The difference between mean levels of IOP measured by NCT and GAT at different levels of CCT was statistically significant ($p<0.001$). The correlation between IOP measured by GAT and NCT was assessed among the various CCT groups. IOP measured by NCT and GAT significantly correlated among all the CCT groups ($p<0.001$).

Conclusion: IOP measurement being the only modifiable risk factor in the management of glaucoma needs to be measured with great accuracy. In this study, there was a tendency for the NCT to overestimate IOP at lower and normal ranges and to underestimate IOP at the higher range when compared to GAT. NCT readings were significantly higher than the GAT readings but have shown a statistically significant moderate positive correlation with GAT. CCT significantly correlates with both the methods of tonometry, with the NCT showing a relatively stronger correlation.

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

Introduction

Measurement Intra-ocular pressure (IOP) is a crucial part of comprehensive and routine eye care especially in the management of glaucoma as it only a 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 an 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 were based on CCT presumption of 520 µm. As NCT measurements based on larger surface of cornea and corneal deformation by airpuff, 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 [6-8].

Noncontact (also called air-puff) tonometer uses a puff of air to applanate the cornea. IOP is measured by the amount of force by air puff required to flatten the cornea to a fixed level. NCT facilitates quick measurements without the requirement of topical anesthesia and fluorescence and can be performed by ancillary staff [9]. The reason of NCTs gaining popularity is they eliminate the risk of contaminated disease transmission, and are free from operator bias. As GAT is considered the gold standard for IOP measurement, all the tonometers are compared to the GAT for accuracy and repeatability. Measurements of IOP by GAT and NCT are influenced by central corneal thickness (CCT). Measurement of IOP by GAT is based on CCT presumption of 520µm. As NCT measurements are based on larger surface of cornea and corneal deformation by air puff, it is more affected by CCT [3, 10, 11]. 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].

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Therefore, knowledge about the quantitative effect of CCT on different IOP measuring techniques is very essential to attain higher accuracy. The techniques used for IOP measurement should be safe, accurate, time saving and should cause least inconvenience to the patient.
The present study was undertaken to compare the values of IOP measured by GAT and NCT with special emphasis on CCT.

Materials and Methods
It was a cross sectional observational study done on patients attending Ophthalmology OPD, Ballari during the period of January 2021 to June 2022 applying the following inclusion and exclusion criteria. 150 cases were included in the present study.

Inclusion criteria
1. Age between 20 to 80years.

Exclusion criteria
1. Known Glaucoma patient.
2. Previous history of ocular surgery, ocular trauma.
3. Corneal pathology.
4. Inflammatory diseases of the eye.
5. Patients who are unable to maintain fixation.
6. Astigmatism >/= 3D

Written informed consent was taken from each study participant after giving detailed information about the study and the procedure. Information about the socio- demographic profile, symptoms and past history of surgery, illness and ophthalmic disease was collected through interview. History, vision and refraction, slit lamp examination to rule out any corneal pathology, fundus evaluation to rule out glaucomatous changes will be done. IOP measurements were done in sitting position, first by non-contact tonometry. After 10 minutes, central corneal thickness was measured by specular microscopy followed by IOP measurement with Goldmann Applanation Tonometer. NCT was performed before the GAT to avoid the known mild reduction of IOP by anterior chamber compression with GAT. All the measurements of IOP by both the methods were performed during the fixed time (OPD timing i.e. between 9am to 1pm) to avoid day time fluctuations.
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

Table 1: Demographic details

Gender	No of Cases	Percent
Male	70	46.7
Female	80	53.3
Total	150	100.0
Age		
20-30	28	18.7
31-40	27	18
41-50	28	18.7
51-60	38	25.3
61-70	20	13.3
71-80	9	6.0
Total	150	100.0

A total of 300 eyes of 150 patients were included in the study. Out of 150 patients, 70 were male and 80 were female patients, that is, 46.7% were male and 53.3% were female patients. Majority of them were females. Of the study population, 28 patients (18.7%) were in the age group of 20 to 30 years, 27 patients (18%) were in the age group of 31to 40 years, 28 patients (18.7%) were in the age group of 41 to 50 years, 38 patients (25.3%) were in the age group of 51 to 60 years, 20 patients (13.3%) were in the age group of 61 to 70 years, 9 patients (6%) were in the age group of 71-80 years. Majority of them were in the age group of 51 to 60 years.

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Table 2: Mean values of various clinical parameters

Variable	Mean	SD
Age (years)	47.12	15.05
NCT (mmHg)	17.68	2.91
GAT (mmHg)	14.47	3.17
CCT (µ)	508.95	33.79

Mean age of the patients was 47.12 years with the standard deviation of 15.05 years. The mean ± SD IOP measured by the NCT was 17.68 mmHg ± 2.91 mmHg. The mean ± SD IOP measured by the GAT was 14.47 mmHg ± 3.17mmHg. The mean ± SD CCT was 508.95 ± 33.79 microns.

Table 3: Comparison of Mean IOP measured by NCT and GAT

Parameters	Mean	Std. Deviation	Mean Difference	Paired t test
NCT (mmHg)	17.68	2.91	3.209	P<0.001
GAT (mmHg)	14.47	3.17		

The difference between the mean value of IOP measured by NCT and GAT was 3.209mmHg, which was clinically significant (p<0.001). The mean IOP measured by NCT was higher than GAT value.

Table 4: Comparison of Mean Intraocular pressure measured by GAT and NCT among various corneal thickness groups

CCT(µm)	NCT (mmHg)	GAT (mmHg)	Mean Difference	P Value
≤ 499	16.83 ± 2.59	13.7 ± 2.89	3.13 ± 3.00	P<0.001
500 – 529	17.86 ± 2.89	14.68 ± 3.21	3.18 ± 3.01	P<0.001
≥ 530	18.66 ± 3.04	15.32 ± 3.27	3.35 ± 2.98	P<0.001

The mean IOP readings of NCT and GAT were stratified into different CCT groups (≤ 499µ, 500-529µ and ≥530µ). Mean IOP readings of NCT and GAT were compared among these groups. Mean IOP by NCT and GAT at CCT (≤499µ) were 16.83 and 13.7mmHg respectively. Mean IOP by NCT and GAT at CCT (500-529µ) were 17.86 and 14.68 mmHg respectively. Mean IOP by NCT and GAT at CCT (≥530µ) were 18.66 and 15.32mmHg respectively. The difference between mean levels of IOP measured by NCT and GAT at different levels of CCT were statistically significant (p<0.001). The mean IOP measurement by NCT was consistently higher than the GAT values among all the CCT groups and the difference between the mean IOP by NCT and GAT kept increasing with the increasing CCT.

Table 5: Mean intraocular pressure difference between non-contact tonometer and Goldmann applanation tonometer in different ranges of intraocular pressure

Intraocular pressure ranges (GAT)	Intraocular pressure (mean ± standard deviation)		Mean difference of intraocular pressure (Sd)	Paire d t Test p-value	Pearson correlat ion (r Value)	p- value for r
	NCT	GAT				
≤ 12 (87)	16.01 ± 2.63	10.96±1.12	5.05 ± 2.28	0.001	0.500	0.001
13 - 20 (205)	18.18 ± 2.60	15.57±1.92	2.59 ± 2.82	0.001	0.253	0.001
≥ 21 (8)	23.13 ± 1.55	24.25±2.71	-1.11 ± 3.51	0.399	-0.301	0.468
Overall (300)	17.68 ± 2.91	14.47±3.17	3.21 ± 2.99	0.001	0.517	0.001

The IOP readings taken by GAT was divided into 3 groups *viz.* group1 (≤12mmHg), group2 (13-20mmHg), group3 (≥21mmHg) to check the difference in IOP measurements by two tonometers at different levels of IOP. Number of patients in group1, group2 and group3 were 87, 205 and 8 respectively. Differences in the IOP levels were 5.05. 2.59 and -1.11 respectively. Difference between IOP levels measured by GAT and NCT was statistically significant for group1 and group2 and there was a positive correlation between GAT and NCT among these groups. Difference between IOP level measured by GAT and NCT was statistically insignificant in group3 and there was no correlation between NCT and GAT in this group. There was a tendency for the NCT to overestimate IOP at lower and normal ranges and to underestimate IOP at higher range when compared to GAT.

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Table 6: Correlation between IOP measured by GAT and NCT among various corneal thickness groups

CCT(µm)	Tonometer	Correlation coefficient	P Value
< 499	NCT	0.404	P<0.001
	GAT		
500-529	NCT	0.517	P<0.001
	GAT		
≥ 530	NCT	0.554	P<0.001
	GAT		

The mean IOP readings of NCT and GAT were stratified into different CCT groups (≤ 499µ, 500-529µ and ≥530µ). The correlation between IOP measured by GAT and NCT was assessed among the various CCT groups. IOP measured by NCT and GAT significantly correlated among all the CCT groups (p<0.001). The strongest correlation was found in the CCT (≥ 530µ). The Pearson correlation coefficient (r) between GAT and NCT IOP in CCT (≤499µ) was 0.404, in CCT (500-529µ) was 0.517 and in CCT (≥530µ) was 0.554.

Discussion

Glaucoma is an optic neuropathy of multivariate etiology wherein intraocular pressure is the most important and only modifiable risk factor. The accurate measurement of IOP has a very important role in diagnosis as well as management of glaucoma. IOP measurement is largely influenced by the technique of measurement and central corneal thickness (CCT). Goldmann Applanation Tonometer (GAT) and Noncontact Tonometer (NCT) are widely used methods. But IOP measurements through these methods influenced by corneal properties.

In our study majority of them were in the age group of 51 to 60 years. The mean age was 47.12 years with 15.05 years SD. In the study conducted by Shubhangi Pimprikar *et al*., percentage of cases belonging to 18 to 25, 26 to 35, 36 to 45, 46 to 55 and more than 55years were 7%, 20%, 39%, 16%, 18% respectively. Majority of the cases were in the age group of 36 to 45 years. The mean age was a 54.69±14.86 year ranging from 18 to 78 years [12]. A total 150 patients were included in this study. Out of 150 patients, majority were females constituting 53.3% (80 patients) and males constituting 46.7% (70 patients). In the study conducted by Ajit K Joshi *et al*. females constituted 48% and males constituted 52% [13]. In the study conducted by Tarannum Mansoori *et al*. females constituted 51.75% and males constituted 48.25% [14].

In this study the mean ± SD IOP measured by the NCT was 17.68 mmHg ± 2.91mmHg. The mean ± SD IOP measured by the GAT was 14.47 mmHg ± 3.17mmHg. The mean ± SD CCT was 508.95 ± 33.79 microns. In the study conducted by Shubhangi Pimprikar *et al*., the mean ± SD IOP measured by the NCT was 22.422 mmHg ± 9.17mmHg. The mean ± SD IOP measured by the GAT was 19.186 mmHg ± 6.89 mmHg. The mean ± SD CCT was 547.36 ± 53.26 microns [12].

In this study, the difference between the mean value of IOP measured by NCT and GAT was 3.209 mmHg, which was clinically significant (p<0.001). The mean IOP measured by NCT is higher than GAT value. In the study conducted by Sood *et al*., statistically significant difference (3.99mmHg) was found between mean levels of IOP measured by NCT(22.02mmHg) and GAT (17.35mmHg) [15]. The above results correlate with our study. In this study, the mean IOP measurement by NCT was consistently higher than the GAT values among the all the CCT groups and the difference between them was statistically significant among all the CCT groups. The mean IOP by NCT and GAT kept increasing with the increasing CCT. In Shubhangi Pimprikar *et al*. study, the IOP levels measured with GAT and NCT significantly differed at all the levels of CCT [12] in accordance with our study.

In our study, the mean NCT was higher than GAT in the IOP levels lower than 21 mmHg whereas the NCT values were lower than GAT values in IOP levels more than 21mmHg. The NCT overestimated IOP at lower and normal ranges and underestimated IOP at higher range when compared to GAT. In the study conducted by Farhood *et al*., NCT and GAT were not well correlated, and NCT measurements gave higher IOP results. When the GAT measurement exceeded 24 mmHg, the difference in the readings between the two instruments increased. Farhood reported that lower the IOP measured by GAT, the more reliable the corresponding NCT readings [16]. In this study the overall mean IOP measured by NCT and GAT show good correlation which was clinically significant (p<0.001).The correlation coefficient was 0.517 which is moderate positive correlation. The study also shows good correlation between NCT and GAT among all the corneal thickness groups ((≤499µ, 500-529µ, ≥530 µ) with the correlation coefficient values of 0.404, 0.517, 0.554 respectively which was moderately significant. In the study conducted by Ajit K Joshi *et al*., the NCT and GAT measurements revealed good agreement. The correlation among various corneal thickness groups (≤499µ, 500-529µ, ≥530 µ) was clinically significant. The correlation coefficient was 0.988(for CCT ≤499µ) and 0.998 (for CCT 500-529µ and ≥530µ) which is extremely significant (p<0.001) [13] in accordance with our study.

The present study shows that CCT correlates with NCT and GAT with NCT showing slightly stronger correlation. The correlation coefficient values of CCT with NCT and GAT were .0283 and 0.255

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respectively and it was clinically significant. In the study conducted by Ajit K Joshi *et al*., CCT was found to be more significantly correlated with the NCT than with the GAT with the correlation coefficient values of 0.704 and 0.584 respectively[13] in accordance with our study.

Conclusion

IOP measurement being the only modifiable risk factor in the management of glaucoma needs to be measured with great accuracy. In this study, there was a tendency for the NCT to overestimate IOP at lower and normal ranges and to underestimate IOP at higher range when compared to GAT. NCT readings were significantly higher than the GAT readings but have shown statistically significant moderate positive correlation with GAT. CCT significantly correlates with both the methods of tonometry, with the NCT showing relatively stronger correlation. Considering this and being a non-invasive and non-contact technique which can be performed by ancillary staff, without the requirement of topical anesthesia and fluorescence, by applying appropriate correction factor for CCT, NCT can be used routinely as a screening procedure for IOP measurements in out-patient department (OPD) and mass screening camps.

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