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## Original Research Article

# Comparison of non contact tonometry with goldmann applanation tonometry and its correlation with central corneal thickness

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### ABSTRACT

**Aim:** The aim of this research was to see how GAT and NCT are compared in different IOP ranges and its correlation with CCT.

**Materials and Methods:** Topcon CT 800 was used for NCT, and the GAT model was a Slit lamp mounted Optilasa, S.L(Avenida de Manoteras, 22 Madrid, Spain). Topcon SP-1P Specular microscope was used to measure the CCT.

**Results:** A total of 50 patients (100 eyes) were included in the study. Out of 50 patients, 48% were females and 52% were males. NCT and GAT readings were analyzed in three IOP groups of less than 12 mmHg (n=16), 13-24 mmHg (n=73) and more than 25 mmHg (n=11). Most of the NCT and GAT readings were found to be in 13-24 mmHg group. Both NCT and GAT are significantly correlated with CCT (p<0.001) however, NCT has a stronger correlation as  $r=0.704$  vs GAT  $r=0.584$ .

**Conclusion:** IOP measurement of NCT was consistently higher than GAT and corneal thickness affects NCT more than GAT and by applying appropriate correction factor for CCT, NCT can be considered as a good screening tool for evaluation of glaucoma.

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## 1. Introduction

The only controllable risk factor in glaucoma management is intraocular pressure (IOP).<sup>1</sup>

IOP is one of the important parameters that help in the glaucoma diagnosis. In 1954, the Goldmann Applanation Tonometer (GAT) was introduced, and till today it is considered as the gold standard test for the calculation of IOP.<sup>1</sup>

Goldmann's theory of tonometry was based on modified Maklakoff-Fick law, which is commonly known as the Imbert-fick law. In 1972, Grolman introduced the Non-contact tonometer (NCT), which is now utilized widely by the ophthalmologists for the measurement of IOP. NCT changes the shape of cornea, by directing a puff of air

towards the cornea and determines the time required or effort needed for achieving a standard deformation.<sup>1</sup> Few of the drawbacks of applanation tonometry are overcome by the NCT like there is no requirement of corneal anesthetic or staining of the tear film for IOP calculation by NCT. Also the risk of transmission of infection is very low by NCT.<sup>2</sup>

From previous studies it has been known that Central corneal thickness (CCT) is an important confounding factor in the calculation of both GAT and NCT.<sup>3</sup> The average CCT of 520 $\mu$ m is considered for the mathematical formula for Goldmann applanation tonometry.<sup>1</sup> NCT is more vulnerable for the changes in CCT as it acts on a larger corneal surface for IOP measurement.<sup>4</sup>

A lot of variation is noticed in the values of IOP and CCT in the normal population. The aim of this research was to see how GAT and NCT are compared in different IOP ranges. Another aim of study is to know how CCT

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affects IOP measurements taken with these two regularly used tonometers.

## 2. Materials and Methods

At Bharti Hospital (Deemed to be University), a six-month prospective cross-sectional study was carried out. Prior written informed consent to participate in study was obtained from all study patients. The study was conducted after the approval of the ethical committee of the hospital [IEC number:- BV(DU)MC&H/Sangli/IEC/370/19].

Measurements of IOP were obtained from 100 adult eyes. Both glaucomatous and non-glaucomatous eyes were included.

### 2.1. Inclusion criteria

1. All patients visiting Ophthalmology Department with age more than 18 years.
2. All patients giving consent to participate in the study.

### 2.2. Exclusion criteria

1. Patients having following corneal diseases are excluded from the study: Corneal dystrophies, Keratoconus, Stevens Johnson Syndrome, Severe dry eyes, Corneal scars.
2. History of conjunctivitis, keratitis and uveitis
3. History of ocular trauma
4. Any abnormality in which IOP readings are unreliable (High corneal astigmatism, uncooperative subjects etc)
5. History of hypersensitivity to topical fluorescein

Topcon CT 800 was used for NCT, and the GAT model was a Slit lamp mounted Optilasa, S.L(Avenida de Manteras, 22 Madrid, Spain). Topcon SP-1P Specular microscope was used to measure the CCT. All instruments were calibrated on a regular basis.

A thorough and detailed history of patients was taken. Any relevant or systemic medical information was also gathered.

Ophthalmic examination, including visual acuity assessment with illuminated Snellen's chart, slit lamp bio-microscopic examination of the anterior segment and fundus examination with direct ophthalmoscope was performed in all patients. The patients were then subjected to IOP measurement by both methods of tonometry i.e NCT and GAT. This was followed by measurement of CCT by Non-Contact Specular Microscopy. A gap of fifteen-minute was taken between the measurements of NCT, GAT and CCT as it the safe interval. All the readings were documented on a proforma.

The measurement IOP by the method of NCT was done by an experienced ophthalmologist. After that, the IOP was measured by GAT mounted on a slit lamp by another experienced ophthalmologist. Measurement of CCT

was done by other experienced ophthalmologist. A mean of three consecutive readings of NCT and GAT for IOP measurement and mean of three consecutive readings of CCT was considered for the study. Care was taken not to disclose the reading of first procedure to other two observers and vice versa to prevent subjective bias.

NCT was calculated with the help of Topcon CT-800 NCT. It can measure the NCT with a range of 0–60 mmHg. The tonometer has a inbuilt which produces puff made of room air. While this puff of air is projected towards the cornea, an another inbuilt programme of the tonometer called the optoelectronic monitoring device projects a light beam at corneal centre. The air puff directed towards the cornea, applanates the cornea and this moment of appplanation is detected by a sensor located in the tonometer. At the same time, another light sensor monitors the time taken for the light beam to reach the microcomputer which is located in the monitoring device. The speed at which this beam of light is reflected back to the sensor in the tonometer determines the IOP. The measurements of the IOP along with their average are displayed in digital format on the screen of NCT. In this study, mean of three IOP readings by NCT was considered for analysis.

Measurement of IOP by GAT was done by applanation tonometer mounted on slit-lamp. The biprism is connected by a rod to a housing which carries a coil spring and series of levers which are used to modify the force of the biprism against the cornea. The examiner observes the applanation of cornea through the biprism. The circular area of corneal contact is converted into two semicircles by the two beam splitting prisms. The prisms are arranged so that inner margins of the semicircles overlap when 3.06mm (diameter) of cornea is applanated. The ideal size of the semicircle is when the width and height of the semicircle is same.

The whole procedure of IOP measurement by GAT was explained to the subjects. The subjects were sitting comfortably on the slit-lamp. After instilling topical anesthetic eye drops, the conjunctiva was stained with a sterile strip of 1% fluorescein which was applied to the inferior fornix of eye. Biprism illuminated with cobalt blue light at 60° to biprism, temporal with high intensity and low magnification. Adjusting knob was set at 1. Patient was asked to look straight in front. Examiner holds eyelids against the bony orbit and the biprism was brought near the apex of cornea. There was a gentle contact with the corneal apex while observing through the slit lamp by monocular view.

Fluorescein of stained tears facilitate visualization of tear meniscus at the margin of contact between the biprism and cornea. The biprism knob is adjusted till inner edges overlap. Reading on the dial multiplied by 10 gives the IOP. Average of three IOP readings was taken for the analysis.

### 2.3. Statistical analysis

The sample size was measured using a 5% alpha error and a study power of 90%. Stata 11 was utilized as the statistical program (StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP). Pearson's correlation coefficient was used to calculate the correlation between NCT and GAT with CCT.

The NCT and GAT values were evaluated in different CCT ranges. The role of CCT in IOP measurement by each method was investigated using linear regression analysis. After graphing IOP against CCT, a regression equation was generated. P value of less than 0.05 was considered as statistically significant.

### 3. Results

A total of 50 patients (100 eyes) were included in the study. Out of 50 patients, 48% were females and 52% were males. The distribution of eyes (non-glaucomatous and glaucomatous) and the mean of GAT, NCT and CCT categorically are tabulated (Table 1). There were 45 eyes on antiglaucoma medications.

NCT and GAT readings were analyzed in three IOP groups of less than 12 mmHg (n=16), 13-24 mmHg (n=73) and more than 25 mmHg (n=11). Most of the NCT and GAT readings were found to be in 13-24 mmHg group (Table 3). There was a significant correlation between NCT and GAT. The mean of paired difference between GAT and NCT was  $0.67 \pm 1.22$  mmHg for CCT  $\leq 499$ .

Both NCT and GAT are significantly correlated with CCT ( $p < 0.001$ ) however, NCT has a stronger correlation as  $r = 0.704$  vs GAT  $r = 0.584$ . Age is significantly correlated to CCT  $r = -0.858$  ( $p < 0.001$ ) (as age increases CCT decreases) The Mean CCT value was  $515.35 \mu\text{m}$ . The linear regression plot shows positive correlation. (Diagrams 1 and 2).

**Table 1:** Demographic and clinical data

	Mean	Std. Deviation	Minimum	Maximum
Age (years)	41.88	13.09	21	68
CCT (micron)	515.35	20.01	486	548
NCT (mm Hg)	18.23	4.45	10	28
GAT (mm Hg)	17.00	3.28	11	26

(CCT: Central Corneal Thickness, NCT: Non Contact Tonometry, GAT: Goldmann Applanation Tonometry)

### 4. Discussion

IOP measurement is affected by CCT and by different methods that used for IOP measurement. The two commonly used methods for measurement of IOP are GAT and NCT and both are influenced by corneal characteristics.

**Table 2:** Correlation of CCT

Variables	Correlation coefficient	P value
CCT vs Age	-0.858	<0.001
CCT vs NCT	0.704	<0.001
CCT vs GAT	0.584	<0.001

(CCT: Central Corneal Thickness, NCT: Non Contact Tonometry, GAT: Goldmann Applanation Tonometry)

**Table 3:** Correlation of tonometers in different IOP group

NCT (mm Hg)	GAT (mm Hg)			Total
	< 12	13 to 24	> 25	
< 12	14	2	0	16
13 to 24	1	72	0	73
> 25	0	6	5	11
Total	15	80	5	100

(NCT: Non contact Tonometry, GAT: Goldmann Applanation Tonometry)

**Table 4:** Correlation of tonometers in different corneal thickness group.

CCT (micron)	GAT (mm Hg)	NCT (mm Hg)	GAT-NCT mean diff	p value
$\leq 499$ (n=34)	14.23 $\pm 2.6$	13.55 $\pm 2.2$	0.67 $\pm 1.22$	< 0.01
500 to 529 (n=32)	18.18 $\pm 2.6$	19.18 $\pm 2.7$	$1 \pm 0.1$	< 0.05
$\geq 530$ (n=34)	18.64 $\pm 2.6$	$22 \pm 3.17$	-3.35 $\pm 1.59$	< 0.01

(CCT: Central Corneal Thickness, NCT: Non contact Tonometry, GAT: Goldmann Applanation Tonometry)

**Table 5:** Correlation between GAT and NCT with CCT.

CCT	Tonometer	Correlation Coefficient	P Value
CCT $\leq 499 \mu\text{m}$	NCT	0.988	<0.001
	GAT		
CCT 500-529 $\mu\text{m}$	NCT	0.998	<0.001
	GAT		
CCT > 530 $\mu\text{m}$	NCT	0.998	<0.001
	GAT		

(CCT: Central Corneal Thickness, NCT: Non contact Tonometry, GAT: Goldmann Applanation Tonometry)

The NCT and GAT measurements in this study revealed good agreement, which indicates that both GAT and NCT are reliable methods for measurement of IOP. Many previous studies have also reported good agreement, with correlation values ranging from 0.27 to 0.9 ( $p = 0.03$  to  $p < 0.001$ ).<sup>2,4,5</sup>

The correlation coefficient in this investigation was 0.988 (for CCT < 499) and 0.998 (for CCT 500-529 and > 530 group), which is extremely significant ( $p < 0.001$ ).

NCT noticed a minor overestimation of IOP measurement in all IOP ranges in our study. A good

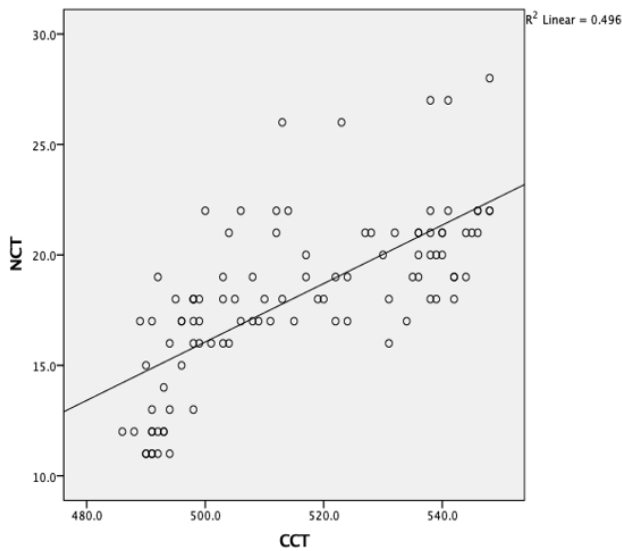


Diagram 1: Linear regression plot for intraocular pressure measurement by Non contact tonometer (NCT IOP) versus central corneal thickness (CCT).

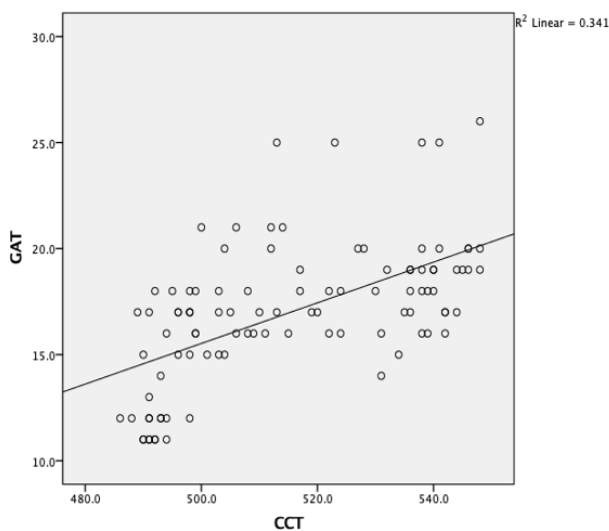


Diagram 2: Linear regression plot for intraocular pressure measurement by Goldman applanation tonometer (GAT IOP) versus central corneal thickness (CCT).

link was found between GAT and NCT at all IOP ranges. According to previous studies, NCT overestimates IOP at lower values and underestimates it at higher values when compared with GAT.<sup>5–8</sup> Tonnu et al. were the only authors to show that NCT underestimated IOP at lower IOP ranges and overestimated it at higher IOP ranges while utilizing the Canon model of NCT.<sup>9</sup>

The majority of studies have found that CCT has a greater impact on NCT.<sup>2,4,9,10</sup> Similar results were obtained in our study. Efforts such as taking an average of multiple

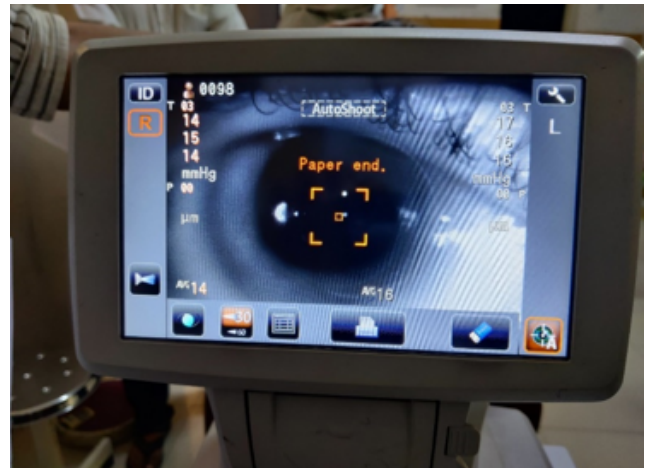


Fig. 1: IOP measurement by NCT



Fig. 2: Measurement of CCT

readings and masking were made to reduce the observer bias. The use of topical medications may cause a change in CCT. Both glaucomatous and non-glaucomatous patients make up our sample population. Eyes on anti-glaucoma drugs have been included in several earlier research. The effect of antiglaucoma therapy on the cornea’s moisture qualities was neglected as that was not the objective of the study.

### 5. Conclusion

The current findings support earlier research, demonstrating that if taken correctly, NCT can be considered as a safe alternative to GAT. IOP measurement of NCT was consistently higher than GAT and corneal thickness affects NCT more than GAT and by applying appropriate correction factor for CCT, NCT can be considered as a good screening tool for evaluation of glaucoma.

## 6. Ethical approval

The study was approved by the Institutional Ethics Committee.

## 7. Conflict of Interest

The authors declare that they have no conflict of interest.

## 8. Source of Funding

None.

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