Original Research Paper

Volume - 12 | Issue - 04 | April - 2022 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Ophthalomology

COMPARISON OF NONCONTACT TONOMETRY, GOLDMANN APPLANATION TONOMETRY WITH AND WITHOUT FLUORESCEIN

Dr. Aastha Garg

Dr. Rashmi G

Dr. Reshma Ravindra

Dr. Chaitra MC

ABSTRACT

Aims: This study aimed to compare the Intraocular Pressure (IOP) measurements with noncontact tonometer and Goldmann Applanation Tonometer with and without fluorescein.

Settings And Design: This cross-sectional study included 61 eyes attending the Ophthalmology Outpatient Department of a tertiary care hospital in South India. IOP using three techniques i.e. Noncontact Tonometry (NCT), Goldmann Applanation Tonometry (GAT) with and without fluorescein were recorded for each patient, at a gap of twenty minutes. The three values for each eye were noted and compared using appropriate statistical methods.

Results: The mean IOP values obtained with Noncontact Tonometer (NCT), non-fluorescein GAT (nGAT), and fluorescein GAT (fGAT) were 12.02 ± 5.56, 9.64 ± 3.7 and 10.3 ± 3.63 mmHg respectively. IOP values measured by NCT were found to be higher than both non-fluorescein GAT, and fluorescein GAT values; this was statistically significant (P=0.01). There was no statistical significant difference between nGAT and fGAT values.

Conclusion: Non-fluorescein GAT (nGAT) can be a useful substitute to fluorescein GAT (fGAT) and thus can prevent the complications associated with fluorescein staining while not compromising the standardization of GAT. Non-contact tonometer can be used as a mass screening device.

KEYWORDS : Intraocular pressure, Noncontact tonometer, Goldmann Applanation Tonometry, Fluorescein

INTRODUCTION

Glaucoma is a progressive disease of the optic nerve which has multiple etiologies[1]. The most important feature is depletion of ganglion cells which damages the optic nerve head (ONH)[1].

Amongst the various risk factors associated with glaucoma, intraocular pressure (IOP) is the only modifiable risk factor[1]. A reduction in IOP retards damage of ONH and the progression of visual field defects[2-4]. Precise measurement of IOP is therefore vital for the diagnosis, monitoring of progression and treatment of glaucoma[2-5].

Ideally IOP measuring device should be easy to use, fast, safe, precise, and uninfluenced by posture or age, patient friendly and with no examiner variability[1]. Clinically, Goldmann applanation tonometry (GAT) is the gold standard for measuring IOP[1-7].

GAT is based on the principle of Imbert Fick Law. It is a measurement of the force required to flatten 3.06 mm diameter area of the cornea. When the head of plastic bi-prism is fully applanated, corneal inelasticity and tear film meniscus capillary resistance, which act as opposing forces, are neutralised. The image formed is split into two equal semicircles by the tonometer head for a better visualisation of the cornea under cobalt blue light. A precise measurement of IOP is obtained by aligning the inner edge of the two semicircles in the centre of their split[1].

Visualization of the semicircles is enhanced by use of fluorescein dye[1]. An increase in lacrimation, itching, discoloration of conjunctiva, patient discomfort, variable size of semicircles recording due to inadvertent use of fluorescein; are the clinical drawbacks associated with its use[1,6]. These may lead to an inaccurate IOP measurement and thus a need to repeat the procedure, causing an increased contact time with patients[1].

Non-Contact Tonometer (NCT) is another method of IOP measurement used widely these days.

Non-Contact Tonometer (NCT) works on the principle of using an impulse of air to indent the cornea[3,4,8]. It measures the alteration of the corneal light reflex that cascades on light sensitive diodes within the instrument, electronically[9]. Since contact with cornea doesn't occur and topical anaesthesia is not required, risk of microbial cross-infection is reduced[4,5].Even though the working principle of Pulsair noncontact tonometer (NCT) is the same as GAT; disparities between races and influence of CCT have been found to be more significant with the use of NCT, thus it is pertinent to compare the two[3].

This study aims to compare the IOP measurements with NCT and GAT with (fGAT) and without flouerescein (nGAT).

Subjects And Methods:

This cross-sectional study included 61 eyes attending the Ophthalmology Outpatient Department of a tertiary care hospital in South India. The study was conducted from September 2020 to December 2020. Approval from institutional ethics committee was obtained. The patients above the age of 18 years including both glaucomatous and non-glaucomatous patients were enrolled in the study. Patients with corneal pathologies (such as keratoconus and dystrophy), ocular trauma in the past, infectious and inflammatory diseases of the eye and those unable to maintain fixation were excluded.

A written informed consent was obtained from all the participants. Patient data was collected as per the predesigned proforma. IOP was measured first by Pulsair NCT followed by Goldmann Applanation Tonometry to avoid corneal abrasion which might affect the IOP readings by NCT. The subjects were made to sit with face placed on chin rest and forehead touching the head rest. Once the correct alignment of the instrument with the cornea was done by the observer, a pulse of air automatically fired from the machine. A digital reading of the IOP was given. Four recordings were taken for each patient, and the average of the three was used for analysis as studies have shown that first reading of a pulsair NCT are higher than the consecutive lower readings.

Measurement by GAT: the applanation tonometry was done by a slit lamp mounted applanation tonometer. The prism was disinfected with isopopyl alcohol 70% (methylated spirit) or sodium hypochlorite 1% before each recording. The prism was wiped dry with a clean swab as residue of the disinfectant may cause a caustic burn on the cornea. The graduation marked 'zero' on the measuring prism was aligned with the white marker point on the tonometer head. The magnification of the slit lamp was set at 10X. The cornea was anesthetized with a topical 0.5% proparacaine preparation. With the cornea and biprism illuminated by a cobalt blue light from the slit lamp, the biprism was brought into gentle contact with the apex of the cornea. The semicircles were viewed through the biprism and adjusted until the inner edges of the two semicircles overlap. The same procedure was then repeated by

staining the tear film with a sterile 1mg fluorescein sodium ophthalmic strip in the lower cul-de-sac. The IOP was read directly from a scale on the tonometer housing.

Between each IOP measurement, the subjects were allowed a 20-minute rest period to recover from the aqueous outflow and to avoid error introduced by topical anaesthesia.

Statistical Methods

IOP measurement was considered as primary outcome variable. Without fluorescein Goldmann Applanation Tonometry (nGAT), with fluorescein Goldmann Applanation Tonometry (fGAT) and Noncontact Tonometry (NCT) were the three different techniques considered as explanatory parameters. Age and gender were considered as study relevant variables. Descriptive statistics were used to analyse the data in accordance with the study's objectives. Data was expressed as the mean, 95% confidence interval (CI; lower and upper bounds), median, and percentage, where appropriate. For normally distributed Quantitative parameters, association between outcome variable across three different techniques was assessed by ANOVA test by comparing mean values. If a significant association was found, post-hoc test was performed to report pairwise differences and significance. Data was also represented using Trend line diagram. P value < 0.05 was considered as statistically significant. IBM SPSS (IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp) was used for statistical analysis.

RESULTS:

The data were obtained from 61 eyes of 31 patients.

Table 1 and 2 show that the average age of the study population was 64.91 years with maximum patients aged above 60 years (75.4%).

Table 1: Descriptive Analysis Of Age In Study Population (n=61)

Parameter	Mean ± SD	Median	Minimum	Maximum
Age	64.92 ± 7.73	65.00	42.00	80.00

Table 2: Descriptive Analysis Of Age Wise Split In Study Population (n=61)

Age group	Frequency	Percentages
41-60 years	15	24.6%
>60 years	46	75.4%

Table 3 and Figure 1 show that among the subjects included in the study, 36 eyes were of females and 25 eyes were of males.

Table 3: Descriptive Analysis Of Sex In The Study Population (n=61)

Gender	Frequency	Percentages
Female	36	59.02%
Male	25	40.98%

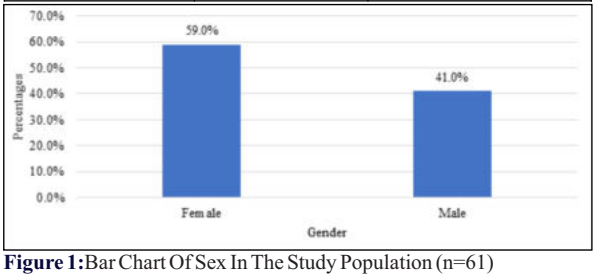

Figure 1: Bar Chart Of Sex In The Study Population (n=61)

Table 4, Figure 2 and Table 5 compare the intraocular pressure (IOP) measured by three different techniques i.e. Goldmann Applanation Tonometry (GAT) without and with fluorescein and Noncontact Tonometer. It can thus be summarized that, NCT values were higher than nGAT and fGAT and values, and there was a statistically significant difference between NCT values and nGAT and fGAT values (p= 0.01, Anova test).

Table 4: Descriptive Analysis Of IOP With Different Techniques In Study Population(n=61)

Parameter	Mean ± SD (in mmHg)	Median (in mmHg)	Minimum (in mmHg)	Maximum (in mmHg)
IOP without fluorescein GAT (nGAT)	9.64 ± 3.7	10.00	6.00	26.00
IOP With fluorescein GAT (fGAT)	10.3 ± 3.63	10.00	6.00	28.00
IOP with NCT	12.02 ± 5.56	11.00	6.00	40.00

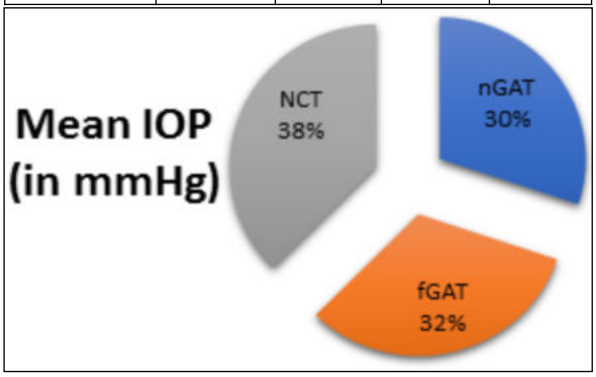

Figure 2: Mean IOP With Different Techniques

Table 5: Comparison Of IOP Across 3 Different Techniques (ANOVA) In Study Population (n=61)

Group	IOP (in mmHg) Mean ± SD	95% CI		P value
		Lower	Upper	
Without fluorescein GAT (nGAT)	9.64 ± 3.7			0.01
With fluorescein GAT (fGAT)	10.3 ± 3.63	-0.91	2.22	
Noncontact Tonometer (NCT)	12.02 ± 5.56	-3.95	-0.81	

Table 6 and Figure 3 summarize a pairwise comparison between the three techniques. A statistically significant relationship was found in comparing NCT to fGAT (p= 0.003) and NCT to nGAT (p= 0.032). However, there was no statistically significant difference between fGAT and nGAT values (p=0.410).

Table 6: Comparison Of IOP Pairwise Between Different Techniques (ANOVA) In Study Population (n=61)

Group	IOP Mean ± SD	Mean difference	95% CI		P value
			Lower	Upper	
Without fluorescein GAT (nGAT)	9.64 ± 3.7	NA			0.01
With fluorescein GAT (fGAT)	10.3 ± 3.63				
Noncontact Tonometer (NCT)	12.02 ± 5.56				
Pair wise comparisons					
nGAT vs fGAT		0.66	-0.91	2.22	0.410
NCT vs nGAT		1.72	0.15	3.29	0.032
NCT vs fGAT		2.38	0.81	3.95	0.003

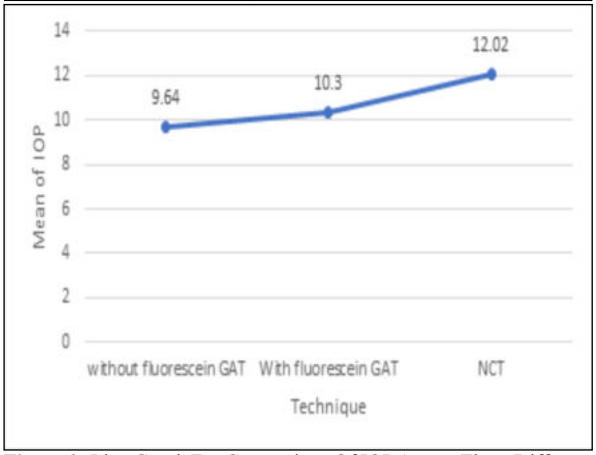

Figure 3: Line Graph For Comparison Of IOP Across Three Different Techniques (n=61)

DISCUSSION:

IOP is the equilibrium between the rate of aqueous formation and drainage[5] . NCT provides a quick evaluation of IOP and thus can be used by internists to measure IOP under supervision[1]. The advantage to patients is that this technique does not require the use of topical anaesthesia and fluorescein thus causing less discomfort to the patient[1]. Unlike GAT, it does not involve contact with cornea and thus issues of sterilization do not arise[3].

NCT gives a precise measurement of IOP among other benefits but previous studies have shown that IOP values are higher with NCT than GAT[1,5,7,10-12]. In a study by Erdogan et al on 188 eyes of 94 subjects showed a statistically significant difference in IOP measurements by NCT and Ngat which was 5 ± 1mmHg and 5.2 ± 1mmHg between NCT and Fgat[1]. A study by Pande AS et al also showed a statistically significant difference between IOP measured by the two techniques. IOP measured by NCT was 2.12 ± 0.03mmHg higher than GAT[5]. Chen et al compared three techniques of IOP measurement in all patients namely NCT, iCare Pro and GAT. They divided the patients into 4 groups based on the IOP values measured by GAT. It was concluded that a statistically significant difference in the IOP values between NCT and GAT, was found only for the patients who had moderately elevated IOP (22-30mmHg group)[7]. Eraslan et al performed a study in paediatric age group comparing tonopen, NCT and GAT. They concluded that IOP was lower than GAT by Tonopen and higher by NCT. A statistically significant difference was noted between all three[11]. A study by Farhood et al also reported a significant difference of 2.72 ± 2.34 mmHg between NCT and GAT[12].

Similar to the above studies, in our study, the IOP measured with NCT was higher than GAT values. These values were statistically significant (p=0.01). The mean difference between NCT vs nGAT (without fluorescein GAT) was 1.72 ± 0.849mmHg. The difference between NCT vs fGAT (with fluorescein GAT) was 2.38± 0.782mmHg. The difference between the values of NCT compared to both the techniques of goldmann applanation tonometry i.e., nGAT and fGAT were noted to be statistically significant (0.032 and 0.003 respectively). This denotes that values of IOP measured by NCT were significantly higher than those measured by GAT. However, these findings differ from a study done by Mohan S et al where IOP measured by GAT was higher than NCT, but, the difference was not statistically significant (p=0.62)[3]. A study by Chakrabarty L, showed a statistically significant comparable relationship in IOP recordings by GAT and NCT[9]. A study by Zareei et al showed the difference between IOP values of GAT and NCT to be 0.2±4.8mmHg which was not clinically or statistically significant[13].

GAT has been considered the gold standard for IOP measurement[1,3,14]. It was seen from our study that there was a difference of only 0.66mmHg between the Goldmann Applanation Tonometry without fluorescein (nGAT) and Tonometry with fluorescein (fGAT) values, with lower values obtained for nGAT. Since the difference between the two is not statistically significant (p=0.410), it can be deduced that nGAT can be useful substitute to fGAT. This will avoid the complications associated with fluorescein staining and be less time consuming. It was found to be consistent with a study done by Erdogan et al where no statistical significance was found between Fgat and Ngat[1]. These findings were different from a study done by Elzein and Saleem on 797 eyes which reported a statistically significant difference of 2.08mmHg between the two in non-glaucomatous eyes and 3.41mmHg in glaucomatous eyes[15]. A study by Arend et al on 400 eyes reported a statistically significant difference of 1.4 mmHg[1,15]. In both studies, higher values were noted with fGAT[15]. This difference might be due to a large sample size considered in both the studies. A study by Bright et al done on 100 patients reported that the tonometry values obtained without fluorescein was 7.01 mmHg lesser than that with fluorescein. However, such high difference in the values was purported to the fact that the study group might have included patients with undiagnosed glaucoma or ocular hypertension. It was also reported that this was because higher IOP values will give greater errors[16]. Thus, from the literature review it can be concluded that the IOP measured without fluorescein is lower compared to that measured with fluorescein.

Central corneal thickness (CCT) has known to influence the tonometry values[1,3,4,5,7,13,17,18,19]. NCT values are affected more by corneal thickness than GAT[1,3,5]. A 10µm increase in CCT can increase the IOP by 0.6-0.9mmHg in NCT and by around 0.3mmHg in GAT[7,17]. Thus higher values may be recorded by NCT than with GAT. This would be one of the reasons as to why the values of GAT were found to be lower in our study. A study done by Erdogan et al showed that, no statistical significant relationship existed between CCT and GAT values. Discrepancy between various studies might be based on different corneal hysteresis and rigidity for the same corneal thickness values[1]. In this study central corneal thickness was not calculated and thus was a limitation of our study.

Varying results have been found about the impact of keratometry readings on IOP values. A study done by Harada et al reported that no correlation existed between NCT and corneal curvature, and a negative correlation between GAT and corneal curvature. The difference between NCT and GAT showed a positive correlation with corneal curvature[20]. However, Erdogan et al reported no correlation between the two[1]. Similar results were reported by Ko YC and fellows[17]. A study by Eysteinsson et al showed no significant relationship between corneal curvature and IOP on linear regression analysis[21]. These differences may also attribute to differing corneal rigidity[1].

Studies done previously have indicated that myopic eyes reported higher IOP[1,22]). However, in the study by Erdogan et al no relationship could be established between the two[1]. In our study, the refractive status of the patients could not be determined as majority of the study population presented with senile immature/mature cataract and thus, the auto refractometer showed no data recording.

Limitations of our study include a small sample size; a larger study population would help in a better understanding of the different techniques. In our study we could not use dynamic contour tonometer and rebound tonometer to measure IOP. More accurate results can be obtained by comparing different techniques to the gold standard goldmann applanation tonometry with and without fluorescein. Another limitation in our study is that the refractive status of our study population could not be assessed. This may have a varying effect on the IOP values.

Thus, it can be concluded that, Goldmann Applanation tonometry without fluorescein (nGAT) can be a useful substitute to goldmann applanation tonometry with fluorescein (fGAT) thereby preventing the complications associated with fluorescein staining and not compromising the standardization of GAT. Non-contact tonometer can be used as a mass screening device as it is less time consuming and a safer option, especially in the time of COVID-19 pandemic where use of applanation tonometry can be a risk factor for the transmission of virus.

REFERENCES:

1. Erdogan H, Akingol Z, Cam O, Sencan S. A comparison of NCT, Goldman application tonometry values with and without fluorescein. Clinical Ophthalmology. 2018;12:2183-8.
2. Yaoeda K, Fukushima A, Shirakashi M, Miki A, Fukuchi T. Factors associated with fluctuations in repeated measurements of intraocular pressure using the Goldmann applanation tonometer in Japanese patients with primary open-angle glaucoma. Clinical Ophthalmology. 2018;12:1473–8.
3. Mohan S, Tiwari S, Jain A, Gupta J, Sachan SK. Clinical comparison of Pulsair non-contact tonometer and Goldmann applanation tonometer in Indian population. Journal of Optometry. 2014;7:86-90.
4. Tonnu PA, Ho T, Sharma K, White E, Bunce C, Heath DG. A comparison of four methods of tonometry: method agreement and interobserver variability. Br J Ophthalmol. 2005;89:847–50.
5. Pande AS, Godbole VV, Halikar SS, Dudhbhate AD. Comparison of Noncontact Tonometer with Goldmann Applanation Tonometer for Intraocular Pressure Measurement in Non-Glaucomatous Patients in Central India. ISSN. 2014;4:1-3.
6. Bamdad S, Vatan Y. Goldmann Applanation Tonometry: Using a Red-Free Filter for Mass Screening. Med Hypothesis Discov Innov Ophthalmol. 2017; 6: 22-3.
7. Chen M, Zhang L, Xu J, Chen X, Gu Y, Ren Y, et al. Comparability of three intraocular pressure measurement: iCare pro rebound, non-contact and Goldmann applanation tonometry in different IOP group. BMC ophthalmology. 2019;19:1-10.
8. Fisher JH, Watson PG, Spaeth G. A new handheld air impulse tonometer. Eye. 1988;2:238-42.
9. Vernon SA. Non-contact tonometry in the postoperative eye. Br J Ophthalmol. 1989;73:247-9.
10. Lee M, Ahn J. Effects of central corneal stromal thickness and epithelial thickness on intraocular pressure using goldmann applanation and non-contact tonometers. PLoS One. 2016;11:2-9.
11. Eraslan M, Çerman E, Sümmen S. Comparison of intraocular pressure measurements in healthy pediatric patients using three types of tonometers. Turk J Ophthalmol. 2017;47:1-4.
12. Farhood QK. Comparative evaluation of intraocular pressure with an air-puff tonometer versus a Goldmann applanation tonometer. Clinical ophthalmology. 2013;7:23-7.
13. Zareei A, Razeghinejad MR, Nowroozzadeh MH, Mehrabi Y, Aghazadeh-Amiri M. Intraocular pressure measurement by three different tonometers in primary congenital glaucoma. Journal of ophthalmic & vision research. 2015;10:43-8.
14. Patel KJ, Jain SP, Kapadia PR, Patel NV, Patel S, Patel V. Can higher end tonometers be used interchangeably in routine clinical practice?. Indian J Ophthalmol. 2016;64:132-5.
15. Elzein I, Saleem M. Comparison of goldmann applanation tonometry measurements with and without fluorescein among adult sudanese glaucomatous and nonglaucomatous population 2018. Albasar Int J Ophthalmol. 2017;4:93-8.
16. Bright DC, Potter JW, Allen DC, Spruance RD. Goldmann applanation tonometry

without fluorescein. American Journal of Optometry and Physiological Optics. 1981;58:1120-6.
17. Ko YC, Liu CL, Hsu WM. Varying effects of corneal thickness on intraocular pressure measurements with different tonometers. Eye. 2005;19:327-32.
18. Chakrabarty L. Goldmann applanation tonometry versus non-contact tonometry: a comparative study. International Journal of Research in Medical Sciences. 2016;4:4683-7.
19. Nejabat M, Heidary F, Talebnejad MR, Salouti R, Nowroozzadeh MH, Masoumpour M, et al. Correlation between intraocular pressure and central corneal thickness in Persian children. Ophthalmol Ther. 2016;5:235-43.
20. Harada Y, Hirose N, Kubota T, Tawara A. The influence of central corneal thickness and corneal curvature radius on the intraocular pressure as measured by different tonometers: noncontact and goldmann applanation tonometers. J Glaucoma. 2008;17:619–25.
21. Eysteinsson T, Jonasson F, Sasaki H, Arnarsson A, Sverrisson T, Sasaki, et al. Central corneal thickness, radius of the corneal curvature and intraocular pressure in normal subjects using non-contact techniques: Reykjavik Eye Study. Acta Ophthal Scand. 2002;80:11-5.
22. Fukuoka S, Aihara M, Iwase A, Araie M. Intraocular pressure in an ophthalmologically normal Japanese population. Acta Ophthalmol. 2008;86:434-9.