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Research Article

Comparative assessment of intra ocular pressure (IOP) measurements obtained using Goldmann Applanation Tonometer and Non-Contact Tonometer: A cross-sectional study from Maharashtra.

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Abstract

Background: Goldmann's applanation tonometer has received a great importance because this method is independent of ocular rigidity it is little influenced by variations in corneal curvature and it records IOP by directly inflating the cornea in Goldmann's applanation tonometry surface tension of the tear film and force required to bend the cornea cancel each other thus making the Imbert flicking law applicable in this method. Goldmann's applanation tonometer shows no topographic effect and thereby gives reproducible measurements on repeated measurements. **Objective:** To compare the IOP measurements obtained using Goldmann Applanation Tonometer and Non-Contact Tonometer. **Methodology:** It is a cross-sectional analytical observational study involving 180 patients. Ocular examinations were performed and patients underwent IOP measurement by Noncontact tonometer as well as Goldmanns applanation tonometer._IOP measured using non contact tonometer topcon machine and GAT. **Results:** The 21-30 age group has the highest number of patients, with 29 females (16.11%) and 18 males (10.00%) and total being 47 patients (26.11%). Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes. Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes. **Conclusion:** Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes in males, as indicated by p-values greater than 0.05. Although NCT showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant. Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes in females, as indicated by p-values greater than 0.05. Although NCT showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant.

Key words: IOP, Goldmann Applanation Tonometer, Non-Contact Tonometer

Introduction

Glaucoma is now the second leading cause of blindness globally, after cataracts, according to World Health Organization.[1] Approximately 11.2 million Indians above 40 years suffer from glaucoma [2] with over 90% of the cases being diagnosed only after significant vision loss has occurred. Glaucoma, previously defined as a state of raised intra ocular pressure, is today better understood to be an irreversible and progressive optic neuropathy resulting from a variety of risk factors.

The most prominent among these is raised intra ocular pressure (IOP) and is the only risk factor amenable to treatment, provided it is detected early. Thus, blindness resulting from glaucoma is largely preventable, if adequate measures to control levels of intra ocular pressure are taken early enough in the pathogenesis of the disease. This makes the early detection of glaucoma suspects and cases very crucial.

However, poor awareness among the general public and low detection rates pose a problem. Therefore, intra ocular pressure measurement is essential in ophthalmological assessment along with the examination of the optic nerve head and an assessment of the visual fields by ophthalmologists. Measurement of intra ocular pressure at the primary health care level can go a long way in detecting cases as well as screening suspects from the general population.[3]

Goldmann's applanation tonometer has received a great importance because this method is independent of ocular rigidity it is little influenced by variations in corneal curvature and it records IOP by directly inflating the cornea in Goldmann's applanation tonometry surface tension of the tear film and force required to bend the cornea cancel each other thus making the Imbert flicking law applicable in this method. Goldmann's applanation tonometer shows no topographic effect and thereby gives reproducible measurements on repeated measurements. But it needs topical anaesthesia, fluorescence staining and a specialist to do procedure, so it is a cumbersome instrument for screening purposes. Corneal factors, like astigmatism, corneal curvature and central corneal thickness affect the accuracy of applanation tonometer. [4]

Objective: To compare the IOP measurements obtained using Goldmann Applanation Tonometer and Non-Contact Tonometer.

Materials and methods

Type of Study – Cross-sectional analytical observational study

Sample Size –

Calculated sample size is **180** with 95% confidence level and power 80%.

$$n = 2 \times \frac{S^2(Z1+Z2)^2}{(M1-M2)^2}$$

M1	Mean IOP by NCT	15.78
M2	Mean IOP by GAT	17.02
S1	Standard deviation of M1	4.15

S2	Standard deviation of M2	4.24
S	Pooled SD	4.195241
AH	One sided=1, Two sided =2	2
1-α	Set level of confidence.	0.95
1-β	Set level of power of test.	0.8
Z1	Z value associated with alpha **	1.959964
Z2	Z value associated with beta	0.841621
n1	Minimum sample size	180

Duration of Study– July 2023 - June 2025

A total of 180 patients were included in this study.

All patients were explained about the nature and purpose of the study.

Ethical clearance was taken from ethics committee of Institute and written informed consent was taken from all the patients. Personal details of each patient were noted in the proforma

- **Inclusion Criteria**
    1. Both males and females
    2. Age above 20 years
- **Exclusion Criteria**
    1. Age < 20 years.
    2. A diagnosed case of glaucoma
    3. Scarred or hazy corneas
    4. History of previous corneal surgery including refractive surgery
    5. Microphthalmos
    6. Blepharospasm
    7. Manifest nystagmus
    8. Keratoconus
    9. History of major ocular trauma
    10. Any current conjunctival or corneal infections
    11. History of hypersensitivity to topical fluorescein dye

Equipment required:

1. Slit lamp
2. Slit lamp mounted Goldmann's tonometer
3. Anaesthetic eye drops
4. Fluorescein strips
5. Cotton swabs
6. Topcon Noncontact tonometer

Examination of patient

1. A complete ocular examination was done for all patients.
2. The study included patients in ophthalmology Out Patient Department (OPD) as per inclusion and exclusion criteria.
3. Information sheet was given.
4. Informed consent was taken.
5. Ocular examinations were performed and patients underwent IOP measurement by Noncontact tonometer as well as Goldmanns applanation tonometer.
6. IOP measured using non contact tonometer topcon machine.
7. For measuring IOP using GAT
   - After anaesthetizing the cornea with a drop of 2% xylocaine and staining the tear film with fluorescein patient is made to sit in front of slit-lamp.
   - The cornea and biprisms are illuminated with cobalt blue light from the slit lamp.
   - Biprism is then advanced until it just touches the apex of cornea. At this point, two fluorescent semicircles are viewed through the prism.
   - Then, the applanation force against cornea is adjusted until the inner edges of the two semicircles just touch this is the end point.
   - The intraocular pressure is determined by multiplying the dial reading with ten.

Statistical analysis plan

The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software ver 21.0. The presentation of the Categorical variables was done in the form of number and percentage (%). On the other hand, the presentation of the continuous variables was done as mean ± SD and median values. For statistical significance, p value of less than 0.05 was considered as significant.

Table 1: Distribution of the individuals according to age and sex

Age Group (In years)	Gender		Total
	Female	Male	
21-30	29(16.11%)	18(10.00%)	47(26.11%)
31-40	13(7.22%)	12(6.67%)	25(13.89%)
41-50	17(9.44%)	21(11.67%)	38(21.11%)
51-60	20(11.11%)	16(8.89%)	36(20.00%)
61-70	17(9.44%)	17(9.44%)	34(18.89%)
Total	**96(53.33%)**	**84(46.67%)**	**180(100.00%)**

The 21-30 age group has the highest number of patients, with 29 females (16.11%) and 18 males (10.00%) and total being 47 patients (26.11%). 31-40 age group shows a fairly balanced distribution with 13 female patients (7.22%) and 12 male patients (6.67%) and total being 25 patients (13.89%). In the 41-50 age group, male patients (21 patients, 11.67%) outnumber female patients (17 patients, 9.44%) and total being 38 patients (21.11%). The 51-60 age group has more female patients (20 patients, 11.11%) than male patients (16 patients, 8.89%) and total being 36 patients (20.00%). The 61-70 age group has an equal distribution of male and female patients, with 17 females (9.44%) and 17 males (9.44%) and total being 34 patients (18.89%).

Table 2: Mean Intraocular Pressure between GAT & NCT (in mm Hg) among females by age

Age Group (In years)	No. of patients	Right Eye					Left Eye				
		GAT		NCT		p Value	GAT		NCT		p Value
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
21-30	29	15.18	4.7	16.66	4.51	0.228	15.28	4.81	16.07	4.57	0.522
31-40	13	15.99	3.98	16.77	4.04	0.626	16.48	4.46	16.62	4.89	0.940
41-50	17	15.24	4.94	16.59	4.27	0.401	15.94	5.05	15.88	5.05	0.975
51-60	20	15.87	4.19	15.85	4.8	0.988	15.66	4.46	16.55	4.94	0.550
61-70	17	15.09	3.69	14.88	5.31	0.896	15.52	4.09	15.82	4.49	0.836

The table presents the mean intraocular pressure (IOP) between Goldmann Applanation Tonometry (GAT) and Non-Contact Tonometry (NCT) among female patients across different age groups, including standard deviations (SD) and p-values for statistical comparison calculated using One-Way ANOVA test.

In the 21-30 years age group, the mean IOP in the right eye was 15.18 ± 4.7 mmHg with GAT and 16.66 ± 4.51 mmHg with NCT (p = 0.228), while in the left eye, the mean IOP was 15.28 ± 4.81 mmHg with GAT and 16.07 ± 4.57 mmHg with NCT (p = 0.522). Since both p-values are greater than 0.05, the difference between GAT and NCT was not statistically significant in this group.

For the 31-40 years age group, the mean IOP in the right eye was 15.99 ± 3.98 mmHg with GAT and 16.77 ± 4.04 mmHg with NCT (p = 0.626), whereas in the left eye, it was 16.48 ± 4.46 mmHg with GAT and 16.62 ± 4.89 mmHg with NCT (p = 0.940). Both p-values indicate that the differences were not statistically significant.

In the 41-50 years age group, the mean IOP in the right eye was 15.24 ± 4.94 mmHg with GAT and 16.59 ± 4.27 mmHg with NCT (p = 0.401), and in the left eye, it was 15.94 ± 5.05 mmHg with GAT and 15.88 ± 5.05 mmHg with NCT (p = 0.975). Since the p-values exceed 0.05, the differences were not statistically significant.

Among patients aged 51-60 years, the mean IOP in the right eye was 15.87 ± 4.19 mmHg with GAT and 15.85 ± 4.8 mmHg with NCT (p = 0.988), while in the left eye, it was 15.66 ±

4.46 mmHg with GAT and 16.55 ± 4.94 mmHg with NCT (p = 0.550). Both p-values suggest that the differences were not statistically significant.

In the 61-70 years age group, the mean IOP in the right eye was 15.09 ± 3.69 mmHg with GAT and 14.88 ± 5.31 mmHg with NCT (p = 0.896), whereas in the left eye, it was 15.52 ± 4.09 mmHg with GAT and 15.82 ± 4.49 mmHg with NCT (p = 0.836). Again, both p-values show no statistically significant difference.

Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes, as indicated by p-values greater than 0.05. Although NCT showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant.

Table 3: Mean Intraocular Pressure between GAT & NCT (in mm Hg) among males by age

Age Group (In years)	No. of patients	Right Eye					Left Eye				
		GAT		NCT		p Value	GAT		NCT		p Value
		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
21-30	18	15.6	3.42	16.22	3.57	0.597	15.28	4.23	16.33	4.37	0.466
31-40	12	14.87	4.13	15.42	4.38	0.754	15.18	5.05	16.58	5.4	0.516
41-50	21	16.4	3.78	17.76	4.27	0.281	15.95	4.71	16.05	4.6	0.944
51-60	16	15.11	3.84	17.38	4.27	0.124	14.97	4.62	15.63	4.24	0.678
61-70	17	15.85	4.58	17.06	4.34	0.436	16.46	4.6	17.47	5.09	0.547

The table presents the mean intraocular pressure (IOP) between Goldmann Applanation Tonometry (GAT) and Non-Contact Tonometry (NCT) among male patients across different age groups, including standard deviations (SD) and p-values for statistical comparison calculated using One-Way ANOVA test.

In the 21-30 years age group, the mean IOP in the right eye was 15.6 ± 3.42 mmHg with GAT and 16.22 ± 3.57 mmHg with NCT (p = 0.597), while in the left eye, the mean IOP was 15.28 ± 4.23 mmHg with GAT and 16.33 ± 4.37 mmHg with NCT (p = 0.466). Since both p-values are greater than 0.05, the difference between GAT and NCT was not statistically significant in this group.

For the 31-40 years age group, the mean IOP in the right eye was 14.87 ± 4.13 mmHg with GAT and 15.42 ± 4.38 mmHg with NCT (p = 0.754), whereas in the left eye, it was 15.18 ± 5.05 mmHg with GAT and 16.58 ± 5.4 mmHg with NCT (p = 0.516). Both p-values indicate that the differences were not statistically significant.

In the 41-50 years age group, the mean IOP in the right eye was 16.4 ± 3.78 mmHg with GAT and 17.76 ± 4.27 mmHg with NCT (p = 0.281), and in the left eye, it was 15.95 ± 4.71 mmHg

with GAT and 16.05 ± 4.6 mmHg with NCT (p = 0.944). Since the p-values exceed 0.05, the differences were not statistically significant.

Among patients aged 51-60 years, the mean IOP in the right eye was 15.11 ± 3.84 mmHg with GAT and 17.38 ± 4.27 mmHg with NCT (p = 0.124), while in the left eye, it was 14.97 ± 4.62 mmHg with GAT and 15.63 ± 4.24 mmHg with NCT (p = 0.678). Both p-values suggest that the differences were not statistically significant.

In the 61-70 years age group, the mean IOP in the right eye was 15.85 ± 4.58 mmHg with GAT and 17.06 ± 4.34 mmHg with NCT (p = 0.436), whereas in the left eye, it was 16.46 ± 4.6 mmHg with GAT and 17.47 ± 5.09 mmHg with NCT (p = 0.547). Again, both p-values show no statistically significant difference.

Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes, as indicated by p-values greater than 0.05. Although NCT showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant.

Discussion

Goldmann applanation tonometer is highly accurate and reliable but requires slit lamp, disadvantages of touching the cornea, staining with fluoresceine, risk of infection, risk of corneal abrasion and need for a skilled examiner. At the same time NCT does not require touching the cornea and can be used safely in early post operative cases, as the risk of infection is minimal and any resident or health care personal (a non-ophthalmologist) can be trained to measure IOP with NCT. In this study, with the principle aim to correlate the intraocular pressure by the non-contact tonometer with the Goldmann's applanation tonometer, total 180 participants aged more than 20 years were included.

All 180 participants were subjected to two methods of tonometry – Non-Contact Tonometry and Goldmann's Applanation Tonometry (under topical anaesthesia with 0.5% Proparacaine eye drops). Non-Contact Tonometer readings were recorded first, then Goldmann's tonometer.

Out of total 180 patients, majority were females i.e. 96(53.33%) whereas males being 84(46.67%). In age wise distribution, maximum number of patients i.e. 47 (26.11%) were in 21-30 years age group. 38 (21.11%) patients were in 41-50 years group followed by 36 (20.00%) patients in 51-60 years & 34 (18.89%) patients in 61-70 years group and remaining 25 (13.89%) patients were in 31-40 years group.

Mean intraocular pressure for females in the right eye for the age groups of 21-30 years, 31-40 years, 41-50 years, 51-60 years, and 61-70 years with GAT and NCT were 15.18 mmHg, 15.99 mmHg, 15.24 mmHg, 15.87 mmHg, 15.09 mmHg and 16.66 mmHg, 16.77 mmHg, 16.59 mmHg, 15.85 mmHg, 14.88 mmHg respectively for both tonometers, with p-values of 0.228, 0.626, 0.401, 0.988, 0.896. There was no significant difference between the two tonometers in these age groups.

Mean intraocular pressure for females in the left eye for the age groups of 21-30 years, 31-40 years, 41-50 years, 51-60 years, and 61-70 years with GAT and NCT were 15.28 mmHg, 16.48 mmHg, 15.94 mmHg, 15.66 mmHg, 15.52 mmHg and 16.07 mmHg, 16.62 mmHg, 15.88

mmHg, 16.55 mmHg, 15.82 mmHg respectively for both tonometers, with p-values of 0.522, 0.940, 0.975, 0.550, 0.836. Again, there was no significant difference between the two tonometers in these age groups.

Mean intraocular pressure for males in the right eye for the age groups of 21-30 years, 31-40 years, 41-50 years, 51-60 years, and 61-70 years with GAT and NCT were 15.6 mmHg, 14.87 mmHg, 16.4 mmHg, 15.11 mmHg, 15.85 mmHg and 16.22 mmHg, 15.42 mmHg, 17.76 mmHg, 17.38 mmHg, 17.06 mmHg respectively for both tonometers, with p-values of 0.597, 0.754, 0.281, 0.124, 0.436. There was no significant difference between the two tonometers in these age groups.

Mean intraocular pressure for male in the left eye for the age groups of 21-30 years, 31-40 years, 41-50 years, 51-60 years, and 61-70 years with GAT and NCT were 15.28 mmHg, 15.18 mmHg, 15.95 mmHg, 14.97 mmHg, 16.46 mmHg and 16.33 mmHg, 16.58 mmHg, 16.05 mmHg, 15.63 mmHg, 17.47 mmHg respectively for both tonometers, with p-values of 0.466, 0.516, 0.944, 0.678, 0.547. Again, there was no significant difference between the two tonometers in these age groups.

With respect to the findings of mean IOP mentioned above in females, males and together (female-male) through all age group for right as well as left eye, we found out that there was no significant difference between the GAT and NCT.

Similar to study by **Salim S et al. (2022)** [5] compared mean IOP found that the portable PT 100 NCT provides IOP measurements comparable to GAT, with over 92% of measurements within 3 mmHg of GAT. **Bang S et al. (2017)** [6] Found that while different NCTs showed varying biases in IOP measurements, all had a positive correlation with GAT, indicating differences based on tonometer model. **Yilmaz I et al. (2014)** [7] Showed that NCT and Tono-Pen XL measurements were comparable to GAT in normotensive eyes, indicating that these methods are suitable for IOP measurement.

L**ohiya S et al. (2020)** [8], **Yildiz A et al. (2022)** [7], and **Chakraborty L et al. (2016)** [9] all found significant correlations between NCT and GAT for IOP measurements, with variations influenced by CCT and suggesting the need for adjustments in certain cases. However, our study supports correlation between NCT and GAT but we did not compare CCT in our study so we cannot comment about its correlation.

Our study supports the findings of **Farhood Q et al. (2023)** [10], as both suggest no significant difference between GAT and NCT. However, it differs from studies by **Mohan S et al. (2014)** [11] and **Ahmad J et al. (2011)** [12], which highlight variations in reliability and accuracy between GAT and NCT, particularly at higher IOP ranges.

Conclusion

Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes in males, as indicated by p-values greater than 0.05. Although NCT showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant.

Across all age groups, there was no statistically significant difference in IOP between GAT and NCT for both eyes in females, as indicated by p-values greater than 0.05. Although NCT

showed slightly higher IOP values than GAT in most age groups, these differences were not statistically significant.

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