

# A study to assess interobserver agreement for measuring the intraocular pressure using Goldmann applanation tonometry by two ophthalmologists



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## ABSTRACT

**Background:** Precise use of Goldmann applanation tonometry (GAT) in the measurement of intraocular pressure (IOP) requires significant training since inaccuracies are common in the hands of untrained ophthalmic observer. **Aims and Objectives:** This study was conducted with the objective to measure interobserver agreement between two ophthalmologists in measuring the IOP using GAT in suspected glaucoma patients. **Materials and Methods:** This prospective observational study evaluated the agreement between the two observers for the measurement of the IOP using the GAT. The observers recorded IOP readings for 100 patients during two visits; both right and left eyes of the patients were examined during these visits. Pearson's correlation coefficient, intraclass correlation coefficient (ICC), and Bland-Altman plot were used to interpretate the results as statistical measure. A  $P < 0.05$  was considered significant. All statistical analyses were performed using the Statistical Package for the Social Sciences. **Results:** In the present study, 100 subjects were examined for measuring the IOP using GAT. The range of the study subjects varies from 32 to 83 years. ICC (95% CI) values were more than 0.9, indicating excellent intraobserver reliability of the two observers. A fair correlation ( $r > 0.90$ ) was observed among the two observers. The agreement limit for the right eye and left eye during the first visit was (2.68, -2.18) and (2.32, -2.38), respectively. Agreement limit for the right eye and left eye during the second visit was (2.73, -2.11) and (1.83, -2.36), respectively. **Conclusion:** On seeing the Bland-Altman plot, it was found that there was excellent agreement between observers 1 and 2 since mostly observation lie within  $\mu \pm 1.96 * \sigma$ . Since there was fine agreement found between the two trained observers. This indicates proper training of ophthalmologists can increase the precision in measuring IOP using GAT.

**Key words:** Bland-Altman; Intraocular pressure; Glaucoma; Inter observer

## INTRODUCTION

The intraocular pressure (IOP) is the only "modifiable" risk factor in glaucoma, so accurate assessment and monitoring of the IOP are of paramount importance for the diagnosis and management of glaucoma. With the advancement in the technology, different methods of measuring IOP have been formulated, with Goldmann applanation tonometry (GAT) still being the gold standard.<sup>1</sup>

To obtain IOP using GAT, we need trained staff, for accurate and precise results limiting its use to health-care workers. There is an influence of biomechanical properties and central corneal thickness on the readings of IOP adding to its limitation. Topical anesthetic is unpleasant for the majority of patients due to stinging and reflex closure of the eye makes accurate measurements difficult to obtain in a some of patients. While obtaining the IOP measurement, it may induce a subjective component to

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IOP reading and recording, frequent calibration, and use by experienced clinicians for accurate measurements.<sup>2-5</sup>

### Aims and objectives

The objective of our study was to assess interobserver agreement between two ophthalmologists in measuring the IOP using GAT in suspected glaucoma patients.

## MATERIALS AND METHODS

This study was conducted on 100 glaucoma suspects who visited the outpatient department of Ophthalmology at Jaya Arogya (J.A.) Group of Hospitals in Gwalior, Madhya Pradesh, India, from January 2020 to June 2021.

### Study design

In this hospital-based prospective observational study, the patients' IOP values were recorded at baseline and second visit arranged at interval of 15 days. The values were measured by two trained observer using the GAT.

### Inclusion criteria

Glaucoma suspects who aged above 18 years and provided their consent to participate in the study were included.

### Exclusion criteria

Patients, who refused to participate, were unable to follow the protocol or had any anterior or posterior segment pathology, history of trauma, or any intraocular procedures performed were excluded.

### Sample size

The sample size was calculated using the intraclass correlation coefficient (ICC) formula<sup>6</sup>:

$$n = 8 * Z_{\alpha/2} * \{(1 - \tilde{\rho}1)^2 (1 + (k - 1)\tilde{\rho}1)^2\} / \{k(k - 1)w^2\} + 1$$

$Z_{\alpha/2}$  is the point on a standard normal distribution exceeded with probability ( $Z_{\alpha/2}=1.96$ ; at 5% level of significance);  $\tilde{\rho}1$  is the anticipated ICC; here ICC ( $\tilde{\rho}1$ ) is 0.80 with desired width ( $w=0.12$ ); and  $k$  is the number of observers ( $k=3$ ). The sample size calculated using the above formula was 100. Therefore, the total number of patients included in the study was 100.

### Ethical approval of the study

This study was approved by the Institutional Ethical Committee (Ref Number: D.No:446/IEC-GRMC/2019 dated May 01, 2020) following good clinical practice. Informed consent forms explaining the objective and procedure involved were distributed to all the participants,

and consent was obtained from them before the commencement of the study.

### Methodology

The instruments required to measure IOP using the GAT were as follows: slit lamp-mounted Goldmann's tonometer, applanation prism, 70% alcohol, proparacaine hydrochloride 0.5% eye drops, fluorescein strips, and sterile cotton swabs. The procedure was performed as follows.

### Preparation of GAT

First, the applanation prism was cleaned with 70% alcohol and then wiped dry with a sterile swab. Next, the graduation marked "0" on the dial of the prism was aligned with a white mark. The dial was set at 10 mmHg. The patients were seated correctly and comfortably, and the procedure was explained to them. The slit lamp was set at  $\times 10$  magnification.<sup>7</sup>

### Method of using the GAT

After the application of proparacaine hydrochloride 0.5% eye drops and fluorescein, the cobalt blue light was turned on. To measure the right eye, the light was made to come from the patient's right side, and for the left eye, the beam was made to come from the patient's left side. The light was kept at a maximum angle of  $45^\circ$  between the light and the microscope. The patient was then asked to sit still with their eyes open. Subsequently, the blue light was directed at the prism head. Afterward, the tonometer tip was moved forward to rest on the cornea and slowly applanated at its center. The dial was then slowly turned until the two semicircles visualized just touched each other at their inner margins, and the dial reading was noted. The tip resting on the cornea was removed, washed with disinfectant, and dried to be used in the other eye. The same steps were repeated in the other eye.<sup>8-10</sup>

### Observation and observers

After obtaining the participants' demographic details, such as the best-corrected visual acuity using the Snellen visual acuity chart, slit lamp examination, and IOP measurement with the GAT, the calibration of the GAT was carried out 15 days apart. Two observers independently measured IOP using the GAT. These observers represented ophthalmology consultant and trained ophthalmology resident. Each observer recorded IOP for both eyes using the GAT on two occasions and was masked to the findings of the other observer.

### Statistical analysis

The Pearson's correlation coefficient was calculated to see correlation among the observers during two visits for both the eyes. To see interobserver agreement, Bland-Altman plot was drawn. Difference in the IOP measurement between the observer was calculated and created as new

variable, for which  $\mu \pm 1.96 * \sigma$  limits were determined. In Bland–Altman plot, on x-axis, average IOP for two observers was measured and difference in IOP was measured by them on y-axis. Mean ( $\mu$ ) and  $\mu \pm 1.96 * \sigma$  were plotted parallel to x-axis. After creating the Bland–Altman plot, agreement between the observers was decided by seeing the observations. Statistical analysis was done using the Statistical Package for the Social Science software version-22.

## RESULTS

In the present study, 100 subjects were examined for measuring the IOP using GAT, maximum number of subjects were in the age group of >50–60 years that is 30%, followed by age group of >40–50 (29%) years, >60 years (23%), and 30–40-year age group (18%). The range of the study subjects varies from 32 to 83 years. The mean age of the study subjects was  $51.94 \pm 10.59$  years in which the mean age for male  $56.66 \pm 9.35$  and for female  $48.66 \pm 10.22$ . Out of hundred subjects taken for the study, 59 (59%) were female and 44 (44%) were male.

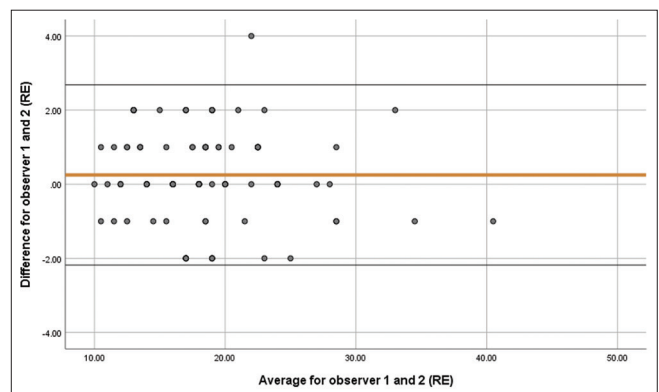
The intraobserver variation ICC was calculated as for the right eye; the ICCs measured by the first observer were 0.96 for the first visit and second visit; for the left eye, the values were 0.95. The ICCs measured by the second observer for the right eye were 0.95 for the first visit and second visit; for the left eye, the values were 0.96. The Cronbach’s alpha and ICC (95% CI) values were more than 0.9, indicating excellent intraobserver reliability of the two observers.

A fair correlation ( $r > 0.90$ ) was observed among the two observers. After analyzing the data (right eye), Pearson’s correlation coefficient for observer 1 and observer 2 was 0.973 with a  $P = 0.000$  ( $< 0.005$ ); for males, it was 0.976 and among females, it was 0.968. For the same visit, IOP was measured for the left eye by two observers. The Pearson’s correlation coefficient for observer 1 and observer 2 was 0.965 with a  $P = 0.000$  ( $< 0.005$ ), for male 0.971 and for female 0.963. After 15 days when all the 100 subjects were followed for IOP (right eye) recorded by GAT in visit 2 by two observers. The Pearson’s correlation coefficient for observer 1 and observer 2 was 0.961 with a  $P = 0.000$  ( $< 0.005$ ), for males, it was 0.977 and for females, it was 0.945. After 15 days when IOP was measured for the left eye by two observers, Pearson’s correlation coefficient for observer 1 and observer 2 was 0.967 with a  $P = 0.000$  ( $< 0.005$ ), for male 0.979 and female 0.958 (Table 1).

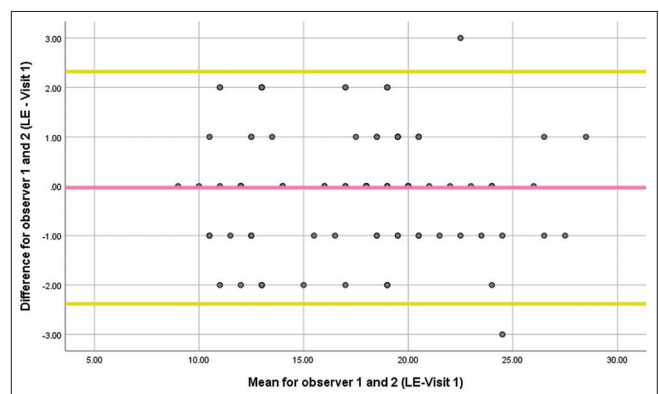
During the visit 1, for the right eye, difference in the IOP measurement between the observer 1 and 2 was calculated. Mean IOP difference was  $0.25 \pm 1.24$ ,  $\mu \pm 1.96 * \sigma$  as 2.68 and

**Table 1: Correlation among observers for IOP measurement in two visits**

Eye	Observation	Pearson’s correlation coefficient			
		Statistic	Male	Female	Overall
Right eye	Visit 1	R	0.976	0.968	0.973
		P-value	0.000	0.000	0.000
	Visit 2	R	0.977	0.945	0.961
		P-value	0.000	0.000	0.000
Left eye	Visit 1	r	0.971	0.963	0.965
		P-value	0.000	0.000	0.000
	Visit 2	r	0.979	0.958	0.967
		P-value	0.000	0.000	0.000



**Figure 1:** Bland–Altman plot for agreement between observer 1 and observer 2 for the right eye during the first visit



**Figure 2:** Bland–Altman plot for agreement between observer 1 and observer 2 for the left eye during the first visit

–2.18, respectively [Figure 1]. During visit 1, for the left eye, difference in the IOP measurement between observer 1 and 2 was calculated. Mean IOP difference was  $-0.03 \pm 1.20$ ,  $\mu \pm 1.96 * \sigma$  as 2.32 and –2.38, respectively [Figure 2]. During the visit 2, for right eye, difference in the IOP measurement between the observer 1 and 2 was calculated. Mean IOP difference was  $0.31 \pm 1.24$ ,  $\mu \pm 1.96 * \sigma$  as 2.73 and –2.11, respectively [Figure 3]. During the visit 2, for left eye, difference in the IOP measurement between the observer 1 and 2 was calculated. Mean IOP difference was  $-0.25 \pm 1.08$ ,  $\mu \pm 1.96 * \sigma$  as 1.83 and –2.36, respectively [Figure 4]. On seeing the Bland–Altman plot, it was clearly interpreting that

there was excellent agreement between the observers 1 and 2 since mostly points lie within  $\mu \pm 1.96 \cdot \sigma$  (Table 2).

## DISCUSSION

Accurate and consistent measurement of IOP remains a prime factor in the diagnosis and management of glaucoma and GAT is considered as the gold standard method of obtaining IOP. However, precise use of this instrument requires significant training, and inaccuracies are common in the hands of inexperienced examiners.<sup>5</sup>

This study shows that the GAT offers excellent agreement

in IOP measurements done by consultant and trained resident. The agreement was found to be excellent when computed for the measurement of interobserver. Study done by Mohankumar et al., compared agreement between GAT and I Care; they found confidence interval lies between 0.48 and 1.42 for the Bland–Altman plot and shown good agreement between GAT and I Care for the measurement of IOP.<sup>11</sup>

Tejwani et al., (2023) done study on 125 patients with normal IOP and biomechanical properties underwent IOP measurement on GAT, DCT, ORA, and Corvis ST; in four different sequences and shown that the Bland–Altman agreement of Corvis ST with GAT, corneal compensated IOP, and IOPg was 2 mmHg (−5.0–+10.3), −0.5 mmHg (−8.1–7.1), and 0.5 mmHg (−6.2–7.1), respectively.<sup>1</sup>

The ICC computed to estimate the intraobserver reliability of readings taken by the two observers during patient visits had an excellent agreement (>0.90). These results indicate negligible intraobserver variability and minimal inter-rater variability. Based on a study performed by Sudesh et al., (1993), optometrists verified the accuracy of the GAT in measuring the IOP among 16 glaucoma patients. Over a series of four readings taken from individual eyes, the IOP did not vary significantly.<sup>12</sup> Salim et al., (2013) analyzed 65 eyes with glaucoma, and the IOP was measured using RBT and GAT. The interobserver agreement appeared to be better with the GAT. The intraobserver correlation coefficients for the GAT were 0.989 (95% CI: 0.985–1.0) for the first examiner and 0.989 (95% CI: 0.986–1.0) for the second examiner.<sup>2</sup> In the study conducted by Ottobelli et al., (2015) to assess the repeatability (intraobserver variability) and reproducibility (interobserver variability) of IOP measurements found for the entire cohort, the intraobserver ICC was almost excellent in the entire cohort (0.90–0.91) and in glaucoma patients (0.91–0.93) but substantial in normal subjects (0.77–0.81).<sup>13</sup> The IOP measured by the ophthalmologist using the GAT demonstrated good agreement. Thus, the GAT is a consistent and reliable tool for IOP measurement by experienced and trained ophthalmologists with fine agreement between them.

### Limitations of the study

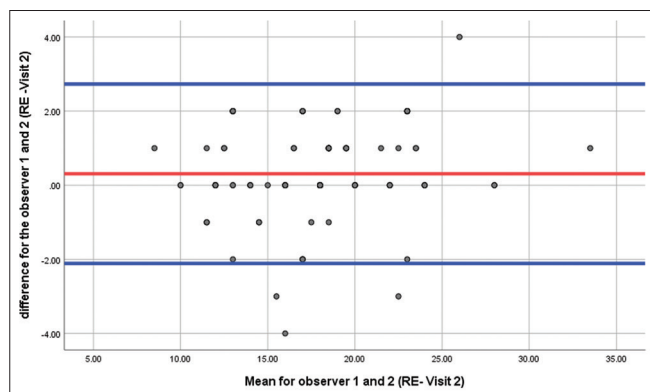
The limitation of this study was diurnal variation of IOP as all the readings were recorded during the hospital timings and availability of surgeons.

## CONCLUSION

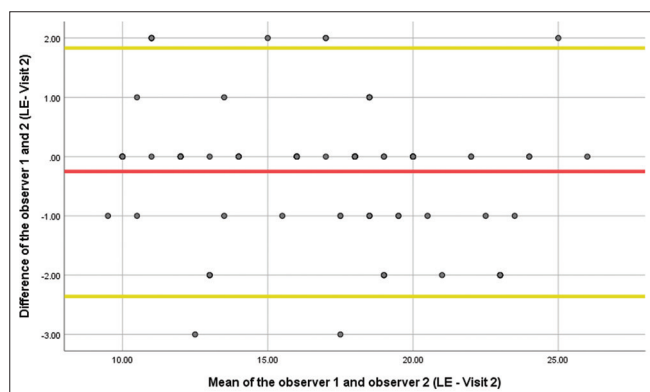
The GAT is the standard method for measuring IOP in clinical practice and for managing glaucoma. The process

**Table 2: Agreement table for two observers in two visits**

Eye	Observation	Difference for the IOP reading by the two observers			
		Mean	Standard Deviation	$\mu + 1.96\sigma$	$\mu - 1.96\sigma$
Right eye	Visit 1	0.25	1.24	2.68	-2.18
	Visit 2	0.31	1.24	2.73	-2.11
Left eye	Visit 1	-0.03	1.20	2.32	-2.38
	Visit 2	-0.25	1.08	1.83	-2.36



**Figure 3:** Bland–Altman plot for agreement between observer 1 and observer 2 for the right eye during the second visit



**Figure 4:** Bland–Altman plot for agreement between observer 1 and observer 2 for the left eye during the second visit



is subjective and requires a learning experience; its use outside clinical settings is limited by non-portability and by the need for a topical anesthetic, fluorescein dye, and slit lamp microscope for measurement purposes. The results show excellent interobserver agreement between the two observers.

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**HD-** Conceptualization, methodology, software, data curation, writing- original draft preparation; **DKS-** Supervision, editing; **DR-** Data curation, visualization, investigation; **DS-** Writing- reviewing, editing, methodology, and formal analysis.

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