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# A Comparative Study of Intraocular Pressure Measurement by Different Tonometer in Patients Attending Tertiary Care Hospital

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## Abstract

**Background and Objectives:** Raised intraocular pressure is a well-known causative risk factor for the development of glaucoma. It is also the only component of glaucoma that is amenable to medical or surgical intervention, provided it is detected early enough. The measurement of intraocular pressure has evolved over time with the advent of a myriad of newer tonometers – one such being the non-contact tonometer. This study has been embarked upon with the objective of comparing the non-contact tonometer with the gold standard. Goldmann applanation tonometer versus the Schiotz tonometer, one of the most popularly used tonometers in the developing world. It also aims to establish the value of the non-contact tonometer as a screening tool. **Materials and Methods:** 200 purposively selected patients were subjected to three methods of tonometry; Goldmann applanation tonometry, Perkins Tonometry and Schiotz indentation tonometry (with the 5.5g, 7.5g and 10g weights); on both eyes. Three recordings were obtained with each method and the arithmetic mean taken as the intraocular pressure. The data was statistically analyzed using the intra-class correlation coefficient. **Results:** The non-contact tonometer showed excellent agreement with the Goldmann applanation tonometer compared to the Schiotz tonometer which showed only a fair agreement. Interestingly, the left eyes showed better agreement on non-contact tonometry than the right eyes, a phenomenon we attribute to apprehension of the patients on their first experience with the air puff. The non-contact tonometer also scored high as an effective screening tool. **Conclusion:** The non-contact tonometer compares favorably with the Goldmann applanation tonometer and can be reliably used as a screening tool. However, in view of the varying degrees of comparison between the two eyes, its role in monitoring glaucomatous eyes needs to be further evaluated.

**Keywords:** Goldmann Applanation Tonometer, Perkins Tonometer, Schiotz Indentation Tonometer, Screening Tool

## 1. Introduction

Glaucoma was probably recognized as a disease entity in the 17th Century where the term was derived from the Greek term glaukЄoma meaning cataract or opacity of the lens implying the lack of understanding of this disease process. Today we understand that glaucoma is a group of diseases with common end point characteristics affecting the optic nerve. It is defined as an optic neuropathy characterized by specific structural findings in the optic disk (increased Vertical Cup Disk Ratio (VCDR) or VCDR asymmetry > 97.5 percentile) and particular functional deficits in automated visual field testing[1].

It is estimated that there are more than 60 million cases of glaucoma worldwide and it will increase to 80 million by 2020[2]. The estimated prevalence of glaucoma is 2.65% in people above 40 years of age[3].

This disease of considerable magnitude can be best dealt

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by early diagnosis & treatment. But it is very unfortunate that ignorance on the part of patients or insufficient attention of ophthalmologists in many cases especially in borderline cases permit the disease to advance, resulting into blindness.

Despite the great increase in our understanding of disease during past 30-40 yrs; we often have difficulty in establishing an early diagnosis due to many factors, such as "ocular rigidity". The use of tonometry in the diagnosis of glaucoma depends upon the fact of elevated Intra Ocular Pressure (IOP) which is one of the characteristic of this disease process except in normal tension glaucoma. There are various methods to measure the IOP, for example, digital tonometry, tonometry, Schiotz tonometry, Applanation tonometry, electronic tonometers, etc.

The two most practicable methods are Schiotz and Applanation tonometry. The principal objection to indentation type of tonometers (Schiotz tonometer) is that such tonometers do not offer a direct measure of IOP Moreover, measurement of IOP by Schiotz tonometry is significantly affected by scleral rigidity[4]. The importance of scleral rigidity must be kept in mind when Schiotz tonometer is being used.

Friedenwald (1937) and others have devised many methods for estimating the coefficient rigidity, but none is satisfactory, which leads one to conclude that there is considerable variability. In actual practice, it is very difficult to determine the initial IOP value and ocular rigidity using two Schiotz weights (Differential tonometry) since each measurement is subject to appreciable error.

The major development which brought new levels of accuracy to tonometric measurement was the Goldmann applanation tonometer developed in the 1950s. This allowed the flattened area of the cornea to be observed through a slit lamp and through the transparent cone on the eye and using the fixed prismatic Vernier measurement system in the cone, a very accurate measurement method was established, which also allowed the patient to remain in a sitting position. The Goldmann tonometer is still the yardstick by which all other tonometers are judged[4].

In most of the cases the IOP value is simply taken from a single measurement and interpreted by means of calibration table, which is valid only for eyes with an average coefficient of ocular rigidity. Controversy still exists regarding the relationship of Schiotz and Applanation tonometry. This study has been undertaken to compare the results of IOP by Schiotz Tonometer and applanation tonometer so that an early and reliable diagnosis of the glaucoma can be done in general population screening and the possible chance of developing blindness in the future because of glaucoma can be minimized.

## 2. Materials and Methods

It was a comparative observational study conducted at a tertiary care hospital. The period of study was from November 2015 to October 2017 and these patients were examined in the Department of Ophthalmology. Total 200 patients (400 eyes) were taken into our study.

Data was collected using a proforma, with the informed consent of the patient. Detailed history was taken from each patient after which he/she was subjected to a routine ophthalmological examination including visual acuity testing, anterior segment and fundus examination.

Each patient was subjected to three methods of tonometry – Goldmann applanation tonometry, Perkins applanation tonometry and Schiotz tonometry in that order. Three readings were taken for each eye for each tonometry method. In case of Schiotz tonometry, 5.5g, 7.5g and 10g weights were used, with three readings being taken for each of the weights in each eye. In all cases, a 5-min interval was ensured between any two methods of IOP measurement. The procedures were performed by three different observers, all of whom were masked.

First, after anaesthesizing patient's cornea with topical application of 0.5% proparacaine hydrochloride, the tear film was stained with sodium fluorescein impregnated paper strip. With the patient in a sitting position, under cobalt blue light illumination on a slit lamp, the biprism of Goldmann tonometer was brought into gentle contact with the center of the cornea. The fluorescein semicircles were viewed through the biprism, and the calibrated dial was adjusted till the inner edges overlapped. Dial readings were multiplied by 10 for the IOP value.

Then, again after 5 mins interval the patients corneal was anaesthesized with topical application of 0.5% proparacaine hydrochloride, the tear film was stained with sodium fluorescein impregnated paper strip. With the patient in a sitting position, under cobalt blue light illumination, the biprism Perkins tonometer was brought into gentle contact with the center of the cornea. The fluorescein semicircles were viewed through the biprism, and the calibrated dial was adjusted till the inner edges overlapped. Dial readings were multiplied by 10 for the IOP value.

Finally, the patient was placed in a supine position and asked to fix at a target. Zero error of Schiotz indentation tonometer was taken by placing the footplate on the test block provided. The eyelids were separated by hand without exerting pressure on the globe, and the tonometer foot plate with 5.5 gm weight was placed on the anaesthetized cornea so that the plunger moved freely vertically. The scale reading was noted. The same was repeated for 7.5 gm and 10 gm. These readings were converted to IOP measurement in mm of Hg by using Friedenwald's table.

The results were analyzed by SPSS statistical software. The IOP measurements of Goldmann tonometer, which was accepted to be gold standard was compared with Perkins Tonometer and Schiotz's Tonometer.

## 3. Result

In this study, 200 patients were subjected to the three methods of tonometry-Goldmann applanation tonometry, Schiotz indentation tonometry and Perkins applanation tonometry. The analysis of the data obtained showed the following results:

### 3.1 Age Distribution

The mean age of the participants was 44.50 years, the youngest participant being 19 years of age and the oldest 78 years old (Table 1).

**Table 1.** Age distribution of study participants (in completed years)

| AGE | | | | |
|---|---|---|---|---|
| Mean | Median | STDEV | Min | Max |
| 44.50 | 43.50 | 15.84 | 19 | 78 |

### 3.2 Gender Distribution

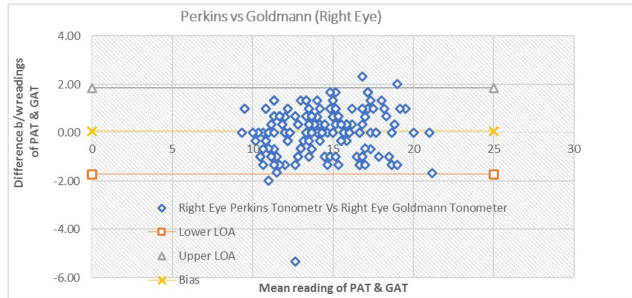
From a total of 200 subjects, 85 (42.5%) were females and 115 (57.5%) were males (Table 2).

**Table 2:** Gender distribution

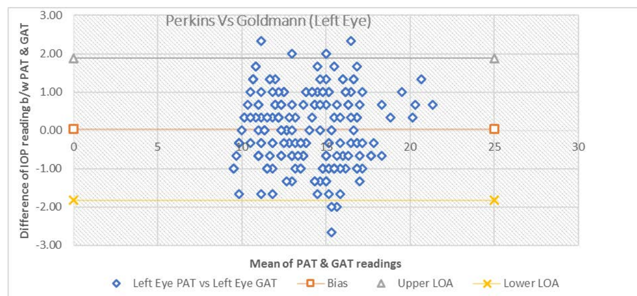
| Gender | Frequency | Percentage |
|---|---|---|
| Male | 115 | 57.5 |
| Female | 85 | 42.5 |
| Total | 200 | 100 |

The Bland–Altman Plot[5] has become the universally-adopted statistical method technique for comparison of measurement methods. Limits of agreement are defined as two standard deviations either side of the mean difference between values given by each method.

The bias between Perkins and Goldmann IOP readings Right Eye was 0.06 mmHg (SD: 0.91 mmHg). The limits of agreement were calculated as -1.72301 to + 1.850806 mmHg (1.96 SD either side of the bias) and for Left Eye bias between Perkins and Goldmann IOP readings was 0.03 mmHg (SD: 0.94 mmHg). The limits of agreement were calculated as -1.82418 to + 1.880709 mmHg (1.96 SD either side of the bias) (graph 1&2).




**Graph 1.** Bland-Altman plot of the difference between IOP-GAT and IOP-PAT,versus the mean of each pair of values.

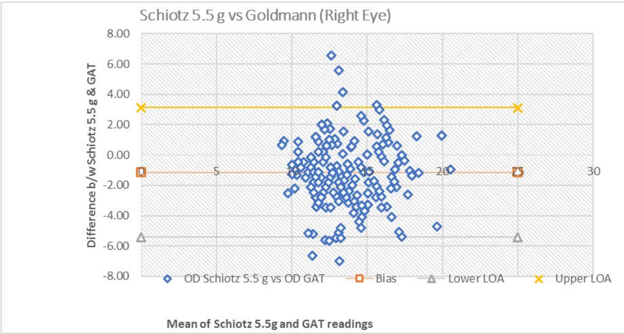



**Graph 2.** Bland–Altman plot of the difference between IOP-GAT and IOP-PAT, versus the mean of each pair of values.

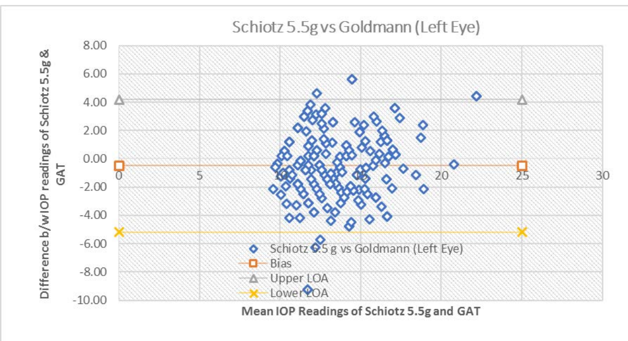
Our results show a suitably compact grouping of difference values within the defined Bland–Altman limits of agreement. Various reports show that the Perkins applanation tonometer measures IOP to a much closer level of comparability than other tonometer types.[6–8]

On Bland Altmann Plot the bias between Schiotz 5.5 g and Goldmann IOP readings for Right Eye was -1.14 mmHg (SD: 2.18 mmHg). The limits of agreement were calculated as -5.41 to + 3.133 mmHg (1.96 SD either side of the bias)Average difference between readings of Schiotz 5.5g vs Goldmann Tonometer (Right Eye) was coming around 1.98 mmHg and similarly for Left Eye on Bland Altmann Plot the bias between Schiotz 5.5g and Goldmann IOP readings was -0.50 mmHg (SD: 2.39 mmHg). The limits of agreement were calculated as -5.19 to + 4.18 mmHg (1.96 SD either side of the bias). Average difference between readings of Schiotz vs Goldmann Tonometer (Left Eye) was coming around 1.92 mmHg (Graph 3,4).

On Bland Altmann Plot the bias between Schiotz 7.5 g and Goldmann IOP readings for Right Eye was -1.61 mmHg (SD: 2.22 mmHg). The limits of agreement were calculated as -5.9 to + 2.75 mmHg (1.96 SD either side of the bias). Average difference between readings of Schiotz 7.5g vs Goldmann Tonometer (Right Eye) was

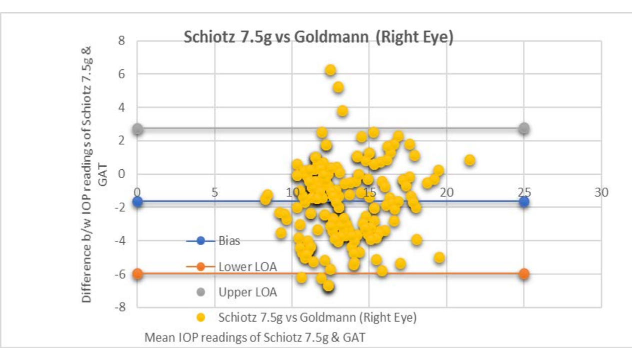



**Graph 3.** Bland-Altman plot of the difference between IOP-GAT and IOP-Schiotz 5.5g, versus the mean of each pair of values.

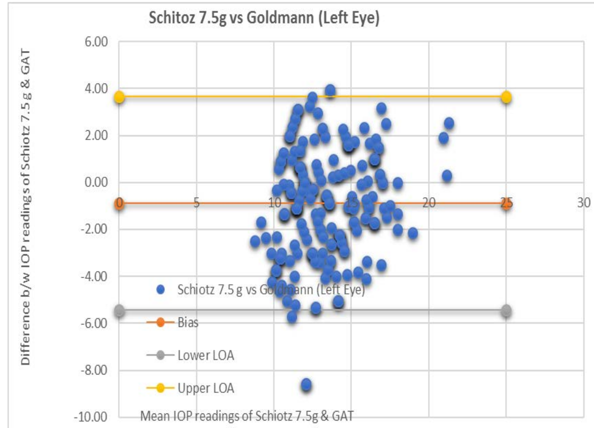



**Graph 4.** Bland–Altman plot of the difference between IOP-GAT and IOP-Schiotz 5.5g, versus the mean of each pair of values.

coming around 2.18 mmHg. Similarly, for Left Eye on Bland Altmann Plot the bias between Schiotz 7.5 g and Goldmann IOP readings was -0.88 mmHg (SD: 2.32 mmHg). The limits of agreement were calculated as -5.43 to + 3.67 mmHg (1.96 SD either side of the bias). Average difference between readings of Schiotz 7.5g vs Goldmann Tonometer (Left Eye) was coming around 1.98 mmHg (Graph 5,6).

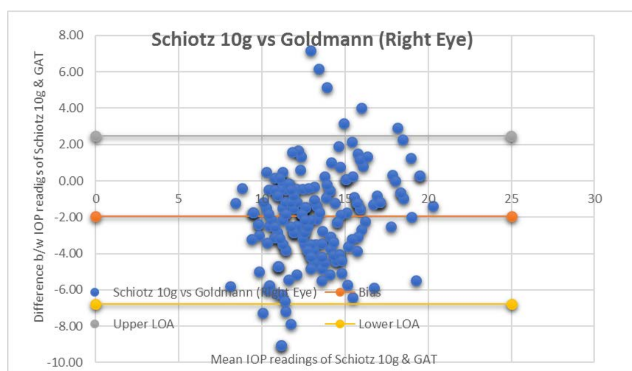



**Graph 5.** Bland–Altman plot of the difference between IOP-GAT and IOP-Schiotz 7.5g,versus the mean of each pair of values.

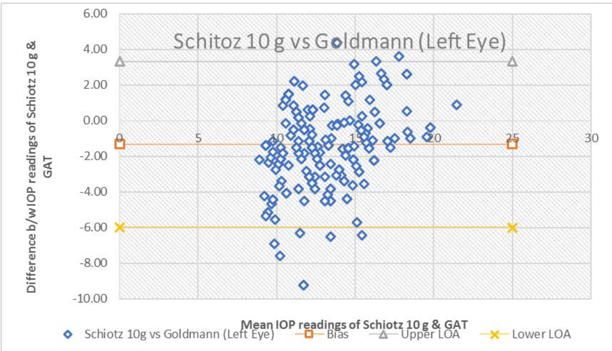



**Graph 6.** Bland–Altman plot of the difference between IOP-GAT and IOP-Schiotz 7.5g, versus the mean of each pair of values.Graph 1: Bland–Altman plot of the difference between IOP-GAT and IOP-PAT, versus the mean of each pair of values.

On Bland Altmann Plot the bias between Schiotz 10 g and Goldmann IOP readings for Right Eye Bias was -1.32 mmHg (SD:2.37 mmHg). The limits of agreement were calculated as -5.98 to + 2.33 mmHg (1.96 SD either side of the bias). Average difference between readings of Schiotz 10 g vs Goldmann Tonometer (Right Eye) was coming around 2.16 mmHg. Similarly, for Left Eye Bland Altmann Plot the bias between Schiotz 10g and Goldmann IOP readings was -0.88 mmHg (SD:2.32 mmHg). The limits of agreement were calculated as -5.43 to + 3.67 mmHg (1.96 SD either side of the bias). Average difference between readings of Schiotz 7.5g vs Goldmann Tonometer (Left Eye) was coming around 1.98 mmHg (Graph 7,8).




**Graph 7.** Bland–Altman plot of the difference between IOP-GAT and IOP-Schiotz 10 g, versus the mean of each pair of values.




**Graph 8.** Bland–Altman plot of the difference between IOP-GAT and IOP-Schiotz 10 g, versus the mean of each pair of values

## 4. Discussion

The current understanding of glaucoma is inclusive of three entities - the optic nerve head, the visual field and intraocular pressure. While optic nerve head damage and a consequent field loss are pre-requisites for the diagnosis of glaucoma, raised intraocular pressure while commonly being associated with glaucoma, is not necessary for designating an eye as glaucomatous. Visual field loss and degenerative optic neuropathy can occur without an elevation in intraocular pressure as seen in the normotensive glaucoma patients. Conversely, a good number of eyes with pressures above the accepted normal of 21 mmHg have failed to demonstrate glaucomatous optic nerve head changes or visual field defects.

However, raised intraocular pressure has been demonstrated to cause damage to the optic nerve head and its reduction has consequently retarded the progression of such damage.[9] Thus tonometry has gained importance and has become the mainstay of glaucoma screening and monitoring.

While an array of tonometers are available today, the tonometer used for screening should be feasible in the screening set up viz. camps and primary eye care providers. The Schiotz tonometer as well as Perkins Tonometer are portable tonometers.

The Schiotz tonometer is a user-friendly instrument available for use by both the ophthalmology trainee and the optometrist with twin advantages of portability and affordability. However, the results of Schiotz tonometry are known to be affected by factors such as scleral rigidity, compressibility of the vascular content of the eye, the ease with which the fluid is expressed through the drainage channels and “Moses effect”[10].

Perkins tonometer, albeit, being an excellent alternative to the GAT is prohibitively expensive for use in a community screening setting. Further, the Perkins handheld applanation tonometer requires a trained ophthalmologist for accurate measurements and needs to be sterilized after each reading[11].

The results of our study support the use of Schiotz tonometer as a screening tool for IOP measurement in a community ophthalmology setting. In most outreach camps, a major part of the screening will be done by either the ophthalmology trainee or the optometrist due to resource and manpower constraints. The relative ease of use and the reasonable cost make the Schiotz tonometer a readily available screening tool for community screening programmes. Though, this tonometer needs repeated sterilization of the instrument tip with ether or sodium hypochlorite after each case, not much time is lost.

With Perkins tonometer and Schiotz tonometer, averages of first two, and averages of first three reading were estimated. Averages of first two readings were compared with averages of first three. It is found that the average of two readings is not different from average of three in 95% of individuals with equivalence defined as +1mmHg.

The statistical parameter used to analyze the data and the correlation of the study tonometers to the gold standard was the intra-class correlation coefficient (ICC) and Bland Altmann Plot. The t test was thought to be inferior to the intra-class correlation coefficient with regards to this study. While the t test gives the statistical significance of the difference between the two test methods, it does not take into consideration the difference between the study and test measurements on a one on one basis; rather it gives an overall picture. The Pearson correlation coefficient on the other hand assesses the agreement between the measurements obtained by the two methods, comparing the measurements with the study method to the measurements with the test method in the same eye.

### 4.1 The Perkins Applanation Tonometer versus The Goldmann Applanation Tonometer

In this study, Perkins Applanation Tonometer on the right eyes, compared favorably with the Goldmann applanation tonometer as evidenced by a p value of 0.3228 being insignificant and Pearson Correlation Coefficient of 0.9361 meant there was only an excellent agreement between the two tonometers.

On the left eyes of the subjects, the difference between the two tonometers was insignificant with a p value of 0.6718. Interestingly, the Pearson Correlation Coefficient in these eyes was very high (0.9282) showing excellent, almost perfect agreement with the Goldmann tonometer.

Thus, the Perkins Applanation tonometer was found to compare well with the gold standard tonometer.

### 4.2 The Schiotz Indentation Tonometer versus The Goldmann Applanation Tonometer

Jackson had observed that the Schiotz tonometer provided measurements of the intraocular pressure which varied widely from those with the Goldmann applanation tonometer and thus provided only a range of pressures within which the actual IOP lay[12]. In this study, his findings were confirmed as the Schiotz tonometer with all three weights, in both eyes, showed statistically significant differences with the Goldmann applanation tonometer, demonstrated by p values of 0.0

The Pearson Correlation coefficient however was slightly more favorable, showing the tonometer to be in fair agreement with the gold standard. Moreover, the mean pressures obtained by the Schiotz tonometer were about 1-2 mmHg lower than the mean Goldmann pressures, indicating that the tonometer tended to read lower than the Goldmann tonometer, confirming previous studies.[13]

## 5. Conclusion

The current study shows that the Perkins tonometer compares favorably with the Goldmann applanation tonometer showing excellent agreement with it, while Schiotz is having fair agreement with Goldmann tonometer, the results of our study also supports the use of Schiotz tonometer as a screening tool for IOP measurement in a community ophthalmology setting and it also encourage to take at least two to three readings by Perkins or Schiotz tonometer before coming at the final reading which is average of the above readings.

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