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Original Research Article

Comparative evaluation of Goldman applanation tonometer, Perkins tonometer, and Non-contact tonometers in a tertiary care hospital

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ABSTRACT

Purpose: Measurement of intraocular pressure (IOP) is basic investigation in a general ophthalmic workup. We attempt to determine the agreement in the measurement of IOP obtained by Goldman applanation tonometer, Perkin's applanation tonometer, Non-contact tonometer in patients attending general ophthalmology OPD in a tertiary care centre in South India and its use in a community ophthalmology setting.

Materials and Methods: A cross-sectional analytical study in which IOP was measured in patients using the three tonometers. Central corneal thickness (CCT) was measured using Ultrasonic pachymetry. Bland Altman analysis was done to evaluate the agreement between instruments.

Results: 800 eyes of 400 patients were included in the study. By Bland Altman method, Perkin's tonometer was found to have better correlation to IOP obtained by Goldman applanation tonometer. Perkin's tonometer was found to be most accurate when CCT was in the range of 501–550 microns and noncontact tonometer was found to be least accurate when CCT was greater than 600 microns. On comparing correlation at different age groups, both the methods had better correlation at <40 years age group.

Conclusion: Both the tonometers showed a significant correlation with the gold standard technique GAT over a range of IOP and CCT with the Perkin's tonometer better than the NCT. This study proves that Perkin's tonometer can be recommended as a reliable screening tool in community outreach ophthalmology services. The twin advantages of portability and availability make the Perkin's tonometer a popular choice among ophthalmology trainees and optometrists in a developing country like India.

1. Introduction

Glaucoma is the world's second most common cause of irreversible vision loss, with a prevalence of 1.62 percent to 2.6 percent in South India.[1,2] Increased intraocular pressure, a chronic optic neuropathy characterised by structural and functional abnormalities in the optic nerve head, is a significant risk factor for glaucoma (IOP). IOP increases that last for a long time induce irreparable damage to the retinal ganglion cells and postganglionic nerve fibres. It is critical to maintain a normal IOP in order to keep the form and function of the eye. Detecting the IOP is crucial not just for initiating treatment but also for evaluating its efficacy.[1]

The most effective way to screen the populace for disabling vision diseases is to hold rural camps. Rural camps are the most effective measures to screen the population for debilitating vision disorders. Public sector health institutions in India primarily serve the underprivileged sections of society, and rural camps are the most effective measures to screen the population for debilitating vision

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disorders. In population screenings and rural camp settings for glaucoma detection, the tonometer's ease of use and cost are essential concerns. Due to a lack of labour, an optometrist is frequently used to do a quick IOP measurement. The precision of such a low-cost and user-friendly tonometer is preferable to the gold standard. As a result, determining how dependable these tonometers are, as well as how useful they are in specific settings, is critical.[3,4]

The goal of this study was to compare the effectiveness of Perkin's tonometer and non-contact tonometer (NCT) in measuring IOP to Goldmann applanation tonometer, as well as to determine the inter-instrument agreement of these tonometers with Goldmann applanation tonometer over a range of central corneal thickness (CCT). The tonometers' reliability with the Goldmann applanation tonometer during mass IOP screening in rural and community outreach eye camps was also investigated.[5,6]

2. Materials and Methods

This study was approved by the institute research board and ethical committee. Over a 12 month period (January – December 2021), patients of both sexes between the ages of 20–80 years attending the outpatient services were randomly screened and included in this study. Patients with preexisting corneal pathologies and nystagmus were excluded from the study. To avoid IOP lowering caused by contact, the IOP was measured by a single investigator using non-contact applanation tonometers, Perkins tonometer, and Goldman applanation tonometer in that order. In all situations, a 5-minute interval was maintained between any two methods of IOP measurement, and the final IOP acquired by that method was calculated as the average of three readings. After tonometric measurements, CCT was determined using the Altair Ultrasonic pachymeter.

Then the patient's cornea was anaesthetized with 0.5 percent proparacaine hydrochloride applied topically, and the tear film was stained with sodium fluorescein using fluorescein-impregnated paper strips. The biprism of Perkin's tonometer was gently brought into contact with the centre of the cornea while the patient was seated and under cobalt blue light illumination. The biprism was used to see the fluorescein semicircles, and the calibrated dial was adjusted until the inner edges overlapped. The IOP value was calculated by multiplying the dial reading by ten.

Similarly, the patient's cornea was anaesthetized with topical application of 0.5 percent proparacaine hydrochloride, and the tear film was stained with sodium fluorescein using paper strips impregnated with fluorescein for Goldmann applanation tonometry. The biprism was gently brought into contact with the centre of the cornea as the patient sat in front of the slit lamp with his chin on the chin rest, under cobalt blue light illumination. The biprism was used to see the fluorescein semicircles, and the calibrated dial was adjusted until the inner edges overlapped. The IOP value was calculated by multiplying the dial reading by ten. The ultrasonic pachymetry probe was inserted on the centre of the anaesthetized cornea after the IOP measurements were completed. The central corneal thickness was calculated by averaging three consecutive readings. The Los Angeles Latino Eye Study Group's findings were used to categorise CCT values.

The outcomes of all four diagnostic studies were analyzed for frequency distribution and percentages using the microsoft excel program. MedCalc for Windows was used to conduct statistical analysis. The Goldman applanation tonometer, which was thought to be the gold standard, was used to compare IOP data (Sensitivity, specificity, positive and negative predictive values). Regression analysis was also used to see if there was a link between the dependent and independent variables (Goldmann applanation Tonometer IOP; independent variables: Perkin's tonometer IOP, Noncontact tonometer IOP, age, gender, and CCT). To see if there was any systematic difference between the different tonometry approaches, a Bland–Altman plot was created.

3. Results

Both the eyes of all included patients have been studied. Therefore for our analysis, background characteristics were calculated based on sample size of 400 patients while the remaining analysis was based on 800 eyes.

The study population comprised of 56 per cent males with mean age of 56 years (95% CI 52.8–55.5, range 26–78 years) and 44 per cent females with mean age of 57.6 years (95% CI 54.7–56.7, range 20–80 years) (Figure 1). The mean age of all patients in this study was 56.7 years (95% CI 54.3–55.9 years).

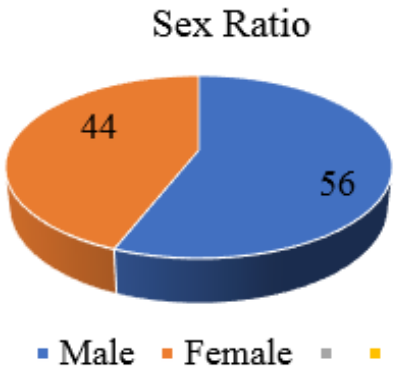

Fig. 1: Sex ratio

The mean CCT was 535.5 microns (95% CI 524.6–530.5) ranging between 360 micron and 646 micron.

Maximum eyes (n = 433) had CCT in the range of 505–558 micron and only 46 eyes had CCT above 600 micron.

The mean of IOP measured by Goldmann applanation Tonometer, Perkin'sTonometer and Non contact Tonometer was 13.4 mmHg (95% CI 13.4–14.8), 13.5 mmHg (95% CI 13.4–14.3) and 14.68 mmHg (95% CI 14.2–15.4) respectively (Figure 2). Most eyes (n = 487) had values between 11 and 20 mmHg while only 9.0% eyes (n = 72) had IOP of more than 21 mm Hg.

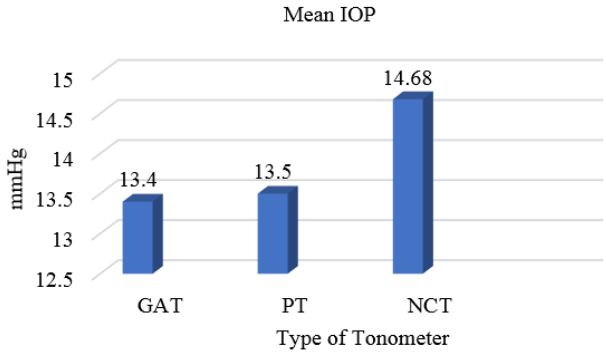

Fig. 2: Mean IOP in GAT, PT & NCT

GAT: Goldmann applanation tonometer.

PT: Perkin's tonometer

NCT: Noncontact tonometer

On evaluating the validity of the IOP measurements, both Perkin's and Non contact Tonometer were found to have high specificity and negative predictive value (Table 1).

Table 1: Perkin's tonometer and Noncontact tonometer when compared with the gold standard Goldmann applanation tonometer.

Parameters	Perkin's Tonometer Vs Goldmann Applanation tonometer	Noncontact Tonometer Vs Goldmann applanation Tonometer
Sensitivity	50% (95% CI: 37.6–62.3)	42.7% (95% CI: 30.7–55.2)
Specificity	98.9% (95% CI: 97.9–99.5)	99.5% (95% CI: 98.6–99.8)
Positive predictive value	80.9% (95% CI: 65.9–91.4)	87.8% (95% CI: 71.8–96.6)
Negative predictive value	95.5% (95% CI: 93.8–96.9)	94.9% (95% CI: 93.1–96.4)

According to the Bland Altman plot, the mean (±S.D.) measurement for Goldmann applanation tonometer was 13.4 mmHg (±5.2) compared with 13.5 mmHg (±5.2) for the Perkin's Tonometer method. (Figure 3)

GAT – Goldmann Applanation Tonometer

PT- Perkins Tonometer

The mean (±S.D) measurement for Goldmann applanation tonometer was 13.4 mmHg (±5.2) compared

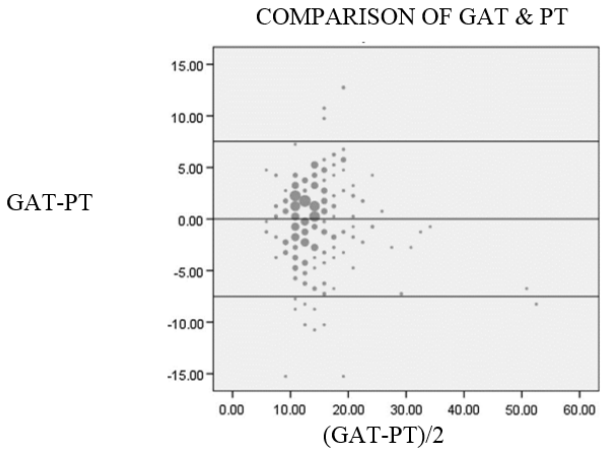

Fig. 3: Bland–Altman plot: Goldmann Applanation tonometer and Perkin's Tonometer.

with 14.68 mmHg (±4.1) for the Non contact Tonometer method. (Figure 4)

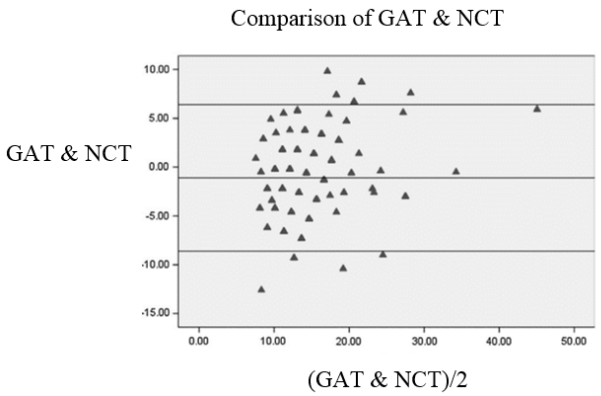

Fig. 4: Bland–Altman plot: Goldmann Applanation Tonometer and Perkin's tonometer

GAT-Goldmann Applanation Tonometer

NCT-Non contact Tonometer

Bland–Altman plot indicated that while both the Perkin's tonometer and Noncontact tonometer correlated with Goldmann applanation tonometer, the former was found to correlate marginally better (SD of 3.87 for Non contact tonometer versus SD of 3.91 for Perkin's when compared to Goldmann tonometer).

When compared over different CCT ranges, Goldmann and Perkin's tonometer were most accurate when the CCT was in the range of 501–550 microns. This correlation was significant at p value of 0.01 level (2-tailed) in almost all cases.

However, the accuracy of the Noncontact tonometer was poor when the CCT was greater than 600 micron (Pearson's correlation 0.22). On comparing correlation at different age

groups, both the tonometers had significant correlation with Goldmann applanation tonometer (significant at p value of 0.01 level, 2-tailed), with maximum correlation at <40 years of age group. Regression analysis with a standard error of 3.14 indicated that the independent variables could explain 57% of variation in IOP by Perkin's Goldmann applanation tonometer (R square: 0.57) (Table 2).

Table 2: Regression analysis.

	Coefficients	P-value
Intercept	2.8	0.1
Perkin's tonometer	0.5	2.28
Noncontact tonometer	0.4	7.33
Age	0.01	0.4
Gender	0.8	0.00
Central corneal thickness	-0.01	0.02
Laterality of eye	-0.63	0.01

Dependent variable- IOP by Goldmann Applanation tonometer.

Independent variable-IOP by Perkin's, NCT tonometer, age, gender, central corneal thickness and laterality of eye.

4. Discussion

Because the human eye reacts differently to changes in IOP, population screening for glaucoma based solely on IOP may not detect all cases. While there are additional risk factors for glaucoma, the IOP is the only one that can be controlled with pharmaceutical and surgical techniques.[7] The baseline IOP values will help the practitioner track the disease's progression and treatment response. While there are a variety of tonometers for measuring IOP, each has its own set of advantages and disadvantages.[8]

The escalating cost of contemporary tonometers, as well as the requirement for specialized training in order to operate them effectively, limit their application in rural camp settings and outreach mass screening programmes. Applanation tonometry is a technique for measuring IOP using equipment that flattens the corneal apex. The Goldman applanation tonometer (GAT) is the gold standard, whereas the Perkins tonometer is a portable variant of the GAT.[9]

The GAT, on the other hand, has a number of disadvantages. For starters, the probe of the device makes contact with the cornea, which can result in corneal abrasions and infection. Second, the requirement for local anaesthesia makes it inconvenient for people who refuse or accept medication administration.

Third, while the amount of fluorescein in the cul de sac influences measurement accuracy, other known sources of error in classical applanation tonometry include the CCT, corneal curvature, axial length, and the cornea's structural rigidity.

Finally, the GAT forbids its use in rural mass screening programmes, which are critical in developing nations like India.[10]

The noncontact tonometer (NCT) is a simple instrument that ophthalmology students and optometrists can use. The NCT has the advantage of indenting the cornea with an air puff, which reduces the danger of epithelial damage and cross infection, which can be a substantial benefit when employed in a mass screening camp setting. Despite this, the NCT's high cost prevents an ophthalmology student from using it in a community screening. The NCT is infamous for being difficult to use in individuals with poor fixation, and it has been demonstrated to substantially underestimate GAT readings at lower IOP while exaggerating them at higher IOP.[11]

In a community screening context, the Perkins tonometer is an effective alternative to the GAT. Furthermore, reliable measurements with the Perkins handheld applanation tonometer require a less experienced ophthalmologist or technician. Because of its portability and accuracy, it is also a good choice for use in hospitals and community settings. Perkin's Tonometer is less expensive than GAT since it does not require an expensive slit lamp and has nearly identical IOP reading accuracy.

In this work, we employed the Bland–Altman method to compare Perkin's tonometer and NCT to Goldmann Applanation tonometer in the same group of patients. The Perkin's tonometer agreed with Goldmann better than the NCT, implying that the IOP findings from the Perkin's tonometer are still clinically acceptable. Because the bias in comparing the two tonometers to the Goldmann Tonometer was found to be clinically acceptable, any one could be used to measure IOP instead of the Goldmann Applanation Tonometer.[11]

In outreach community ophthalmology camp scenarios when a large number of patients must be screened in a short length of time, the NCT and Perkin's tonometer are appropriate tools. Our findings imply that in a community ophthalmology setting, Perkin's tonometer can be utilised as a screening tool for elevated IOP. At most outreach camps, a major amount of the screening will be handled by either an ophthalmology trainee or an optometrist due to resource and labour constraints. Because of its relative ease of use and inexpensive cost, the Perkin's tonometer is a common screening tool for community screening programmes. Even though the tonometer's instrument tip must be sterilised with either or sodium hypochlorite after each case, there is minimal time spent.

Both approaches demonstrated a stronger correlation in this study in the 40-year-old age group. Our discovery that NCT was least accurate when CCT was more than 600 micron agrees with Tonnu et al's findings that NCT measurements are considerably more impacted by changes in CCT than GAT readings.[12,13]

The majority of those that came in for the screening were from low-income families. This is similar to the patient demographic serviced by the public health centre where the study took place. After LASIK, patient reporting is almost never encountered. As a result, only subjects with corneal thickness close to normal were included in the study, despite the fact that corneal thickness or post-LASIK were not listed as inclusion or exclusion criteria.[14]

Furthermore, because the majority of the patients had significant bilateral cataracts, the impact of refractive error on IOP measurements using various methods could not be studied. When both eyes are used for analysis, a Type I error (rejecting the true null hypothesis) can occur, which can be avoided by using a mixed model approach. During analysis, the data was also discovered to be slightly skewed, but the sample size was large enough to analyse using a normal distribution.[13]

5. Conclusion

Both tonometers showed a strong correlation with the gold standard technique (Goldmann applanation tonometer) over a wide range of IOP and CCT, with the Perkin's tonometer surpassing the NCT. It is recommended that people over the age of 40 who visit an ophthalmologist be tested for glaucoma to catch the condition early. The use of a less expensive Perkin's tonometer in conjunction with an examination of the optic disc as a glaucoma screening test may be acceptable due to a lack of funds and access to expert ophthalmology services.

In this study, Perkin's tonometer exhibited a high specificity, suggesting that it might be used as a screening tool for community outreach ophthalmology services. Patients with a suspected abnormal IOP should undergo a GAT, visual fields evaluation, and an examination of the optic nerve head for confirmation and follow-up.

6. Conflict of Interest

The authors declare that there are no conflicts of interest in this paper.

7. Source of Funding

None.

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