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COMPARISON OF IOP MEASUREMENT BY GOLDMANN APPLANATION TONOMETER AND NON-CONTACT TONOMETER IN GLAUCOMA PATIENTS

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ABSTRACT

Introduction and objective: Intraocular pressure (IOP) measurement is important in the diagnosis and management of glaucoma. Goldmann applanation tonometer (GAT) is regarded as the ''gold standard'' for measuring IOP. The non-contact tonometer (NCT) is commonly used in ophthalmological practices and has potential advantages as the minimum risk of infection. This study was undertaken to compare IOP measured by GAT and NCT in different ranges of IOP. **Methods:** This was a cross-sectional, observational analytic study wherein glaucoma patients visiting a hospital were included. IOP measurements were performed using GAT and NCT. Subjects were grouped into low <21 mmHg) IOP and high (≥ 21 mmHg) IOP. The tonometer inter-method for IOP values were compared and analyzed using a paired t-test. Agreement between the instruments was calculated by Bland Altman plots. **Results:** The IOP of 82 glaucomatous eyes was measured (46 eyes in the lower IOP group and 36 eyes in the higher IOP group). The mean of the paired difference between GAT and NCT in the low IOP group was 0.22±2.5 mmHg ($p>0.05$) and in the high IOP group was 1.68±4.1 mmHg ($p<0.05$). The NCT underestimated GAT measurement in 67% of eyes in the high IOP level group. Bland-Altman plot showed a good NCT-GAT agreement in the lower IOP group. **Conclusion:** Pressure readings of GAT and NCT were comparable in the subjects with a lower IOP range

INTRODUCTION

Intraocular pressure (IOP) measurement is important in the detection and management of glaucoma.[1] Elevation of the IOP is one of the primary risk factors for progressive changes in the visual field and optic nerve damage.[2] IOP remains the only modifiable risk factor in the management of glaucoma.[3]

Many different IOP measurement devices are available, such as the Goldmann applanation tonometer (GAT), Schiotz tonometer, tono-pen, non-contact, or air-puff tonometer (NCT).[1,3,4,5] The recognized gold standard device is the GAT. It's considered to be the most accurate tonometer, although some limitations of the instruments have been reported.[6,7]

NCT introduced by Grolman in 1972, is commonly used in ophthalmological practices.[4] It uses a puff of air to deform the cornea and measures the time or force of the air puff that is required to create a standard amount of corneal deformation.[3,7] NCT has certain advantages over conventional applanation as corneal anesthesia and staining of the tear film are not required and infection risks are reduced. It is important to determine whether the NCT is sufficiently accurate and precise compared to the gold standard device.[8]

This study aimed to compare the IOP measurement by GAT and NCT in glaucoma patients and assess the agreement of these 2 methods in different ranges of IOP.

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MATERIAL AND METHODS

This study was a cross-sectional observational study, approved by an institutional review board.

The study was conducted in the glaucoma clinic at National Diponegoro Hospital, Semarang, from September to October 2024. Samples were glaucoma patients who underwent a routine follow-up at the clinic, chosen by a purposive sampling method.

After taking anamnesis about the history of the disease, IOP was measured twice using NCT and GAT with recovery of about 15 minutes between methods. IOP measurement using NCT undergone by a single observer, measurement using GAT undergone by another single observer on a single slit lamp unit. The observers were masked from the other readings. We took all precautions in recording the readings, explaining the procedure to the subject, and discarding the first reading in each section.

NCT was taken using a Tomey non-contact tonometer (FT-1000). GAT was taken using a Shin-Nippon applanation tonometer (SL-TM B-45). Both instruments were periodically calibrated. A drop of tetracain hydrochloride 0.5% and Fluorescein strip were applied to the eye before GAT measurement. Three readings were taken with each instrument. The mean of the three readings was used for comparison between methods.

Subjects were grouped into lower (<21 mmHg) IOP (group 1) and higher (≥ 21 mmHg) IOP (group 2) according to the IOP measurement using NCT.

Statistical analyses were performed in SPSS for Windows version 18.0. Comparison between NCT and GAT in both groups was analyzed using a paired t-test. Agreement between the instruments was calculated by Bland Altman plots.

RESULT

There were a total of 82 eyes included in the study. 46% were males and 54% were females. 46 eyes were in group 1 and 36 eyes were in group 2. The distribution of the status of the eye in each group was listed in Table 1 and Table 2 accordingly. All eyes were on anti-glaucoma medication.

Table 1. Distribution of glaucoma status in lower IOP group

Diagnosis	n (%)
PACK	33
PACS	15
POAG	33
JOAG	2
Secondary glaucoma	13
Absolute glaucoma	4
Total	100

Table 2. Distribution of glaucoma status in higher IOP group

Diagnosis	n (%)
PACK	23
PACS	5
POAG	19
JOAG	0
Secondary glaucoma	31
Absolute glaucoma	22
Total	100

PACG and POAG were the most common diagnoses found in the lower IOP group. Secondary glaucoma was common in the higher IOP group.

The Mean IOP of all subjects measured by NCT was 24.2 mmHg. Mean of IOP measured by GAT was 24.7 mmHg. The distribution of IOP measurements in each group is shown in Table 3.

Table 3. Distribution of IOP measurement in Group 1 and Group 2

Group 1	Mean	SD
NCT (mmHg)	14.20	3.40
GAT (mmHg)	13.97	2.90
Group 2	**Mean**	**SD**
NCT (mmHg)	36.84	10.01
GAT (mmHg)	38.52	11.91

A comparison between the method and between the two IOP groups was analyzed. The mean of the paired difference between NCT and GAT in group 1 and group 2 were 0.22 mmHg (r 0.553, p >0.05) and 1.68 mmHg (r 0.019, p<0.05) accordingly. Significant differences were found both in NCT and GAT measurements between the two groups. NCT and GAT measurements were not significantly different in the lower IOP group. A statistically significant difference of measurement between NCT and GAT was found in the higher IOP group (Table 4).

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Bland-Altman plot was constructed for comparison between methods (figure 1). The 95% confidence limits of agreement were depicted between -5 and 5. Group 1 shows a good agreement between methods.

Table 4. Correlation of tonometers in different IOP group

Variables	Entire group (absolute difference, correlation, value)	Group 1 (absolute difference, correlation, value)	Group 2 (absolute difference, correlation, value)
NCT-GAT	0.61, 0.108, p >0.05	0.22, 0.553, p >0.05	1.68, 0.019, **p<0.05**
NCT-NCT	22.6, 0.000, **p <0.05**	-	-
GAT-GAT	24.9, 0.000, **p <0.05**	-	-

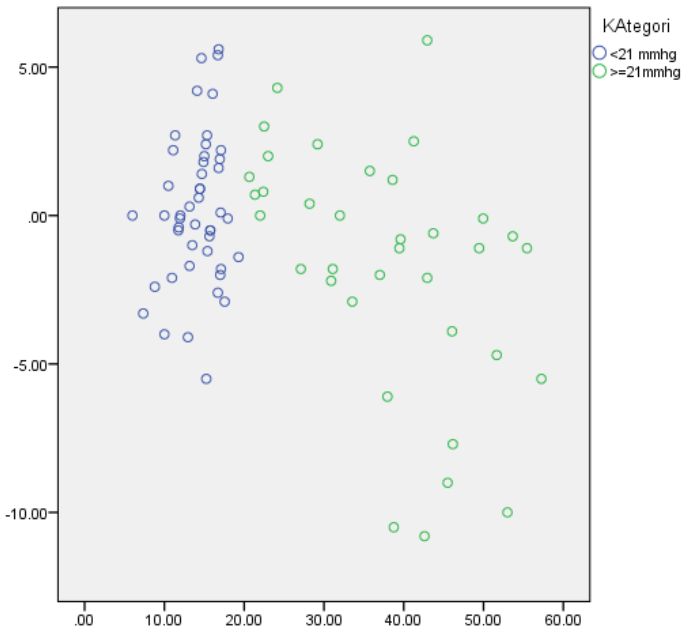

Figure 1. Bland-Altman plot of the agreement between intraocular pressure measurements of GAT and NCT. The blue dots were in agreement between NCT and GAT in group 1. The green dots were an agreement between NCT and GAT in Group 2

DISCUSSION

The technique of IOP measurement is an important factor that influences IOP measurement.[3] Both GAT and NCT are widely used methods. GAT is the gold standard tonometer but associated problems are attachment with the slit lamp, needing a skilled examiner, and requires touching the cornea and staining with fluorescein.[5,6] The non-contact tonometer (NCT) is commonly used in ophthalmological practices and has potential advantages as the minimum risk of infection.[3]

A previous study has recommended not to take NCT after GAT because it may demonstrate lower IOP readings due to delayed IOP reduction by the GAT. So, in our study, the NCT was done before GAT.[5]

In this study, three readings were taken with each instrument. The mean of the three readings was used for comparison between methods. The previous study recommended excluding the first IOP readings, due to factors involved in measurement.[9]

In the present study, NCT and GAT measurements showed a significant difference in the lower IOP group. A significant difference was presented in the higher IOP group. It was suited to the Bland-Altman plot that showed good agreements of the two devices in the lower IOP group, proving that both are reliable methods of measuring IOP.

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The previous study showed that the mean of paired difference in IOP was lesser in the lower IOP range.[3] It indicated that in most of the patients, the NCT measured IOP correctly if it was within normal range but has to become consistent if the measured IOP is 18 mmHg or above. The study of 144 glaucomatous and non-glaucomatous eyes showed that NCT and GAT measurements showed good agreements.[3]

Similar to some previous studies, in the present study, underestimation of IOP measurement was found by NCT in 67% of subjects in IOP above 21 mmHg. The past study has shown that NCT overestimates IOP at lower values and underestimates at higher values when compared with GAT.[11] The other previous study showed that NCT underestimated IOP at values below 15 mmHg and overestimated it at values about 15 mmHg.[12] Factors such as central corneal thickness (CCT) may contribute to relative IOP overestimation at higher measured IOP levels.[3, 4,10]

CONCLUSION

In conclusion, the present results concur with the previous studies indicating that pressure readings of GAT and NCT were comparable in the subjects with lower IOP range. In subjects with a higher IOP range, NCT cannot replace the gold standard GAT. Large population-based studies are necessary to validate the factors that influence the IOP reading in the high IOP range.

ETHICAL APPROVAL

The research was conducted after obtaining ethical clearance from the Ethics Committee in Health and Medical Research (KEPK) Faculty of Medicine, Diponegoro University, Semarang, with No. (EC No. 560/EC/KEPK/FK-UNDIP/X/2024)

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