SHORT REPORT

Comparison between the values of intra-ocular pressure measured by Goldmann applanation tonometer and Air-Puff non-contact tonometer and their relationship with central corneal thickness

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Abstract

Glaucoma is a sight threatening disorder in which measuring intra-ocular pressure (IOP) with accuracy plays a fundamental role. This study aimed to compare the IOP values air-puff of non-contact tonometer(APT) and Goldmann applanation tonometer (GAT) along with their relationship to central corneal thickness (CCT), in various IOP groups. Three hundred and eleven patients were enrolled using convenience sampling in this cross-sectional, prospective study. IOP was measured with Keeler 3000 APT and GAT along with CCT using TOMEY EM-4000. Data was analysed using Bland-Altman, Spearman's and intra-class correlation analysis of APT, GAT and CCT on SPSS 24.0. The median IOP by APT and GAT was 14 mmHg (range:37) and 12 mmHg (range:16) whereas the median CCT was 534μ (range: 44), respectively. At low (<10 mmHg) and normal IOP (10-20 mmHg) both the instruments showed similar results but GAT was found to be more accurate ($p \leq 0.001$) at higher IOP (21-30 mmHg). However, at moderate and higher groups of IOP, APT revealed overestimation of IOP compared to GAT. CCT also plays a significant role.

Keywords: Intraocular Pressure, Tonometry, Glaucoma, Corneal Thickness Measurement.

DOI: https://doi.org/10.47391/JPMA.11-1978

Introduction

Tonometry, i.e. measurement of intra ocular pressure (IOP), is one of the significant examination steps in every ophthalmic clinic. IOP is determined by the balance between the rate of production of aqueous humour and its outflow.[1] IOP is of pivotal importance for the diagnosis and management of glaucoma which is a sight-threatening disorder. Increase in IOP worsens the irreversible damage to the retinal ganglion cells. IOP is, therefore, the only modifiable risk factor for the control of optic nerve damage.[2]

Tonometers are generally classified as contact and non-contact, including Goldmann applanation tonometer (GAT) and non-contact air puff (APT) tonometer. GAT, a non-contact tonometer, was developed in 1950s and is considered the gold standard method of tonometry. The principle of GAT involves flattening of a small central corneal area of 3.06 mm^2 and measuring the force required to flatten that area (Imbert Fick's principle). Non-contact tonometers, like the Air-puff tonometer, uses force of air generated from a pneumatic system to flatten the same area of the cornea. Recent advances in corneal topography have established that central corneal thickness (CCT) also plays an important role in labelling a patient of "glaucoma".[3] With this study, the authors wished to evaluate the reliability of non-contact tonometry and to compare their results with GAT along with their relation to CCT.

Patients/Methods and Results

This was a cross-sectional, prospective, comparative study conducted at the department of Ophthalmology, Patel Hospital, Karachi, between July 2020 and October 2020, after the approval of the Institutional Review Board. Three hundred and eleven patients of both genders, aged between 14 to 90, were included in the study using convenience sampling technique. Patients with a history of corneal and/or refractive surgery, corneal scars, any inflammatory pathology and anterior chamber dysgenesis were excluded. After the instillation of topical anaesthetic drops along with fluorescein strips, two different doctors took the measurements to avoid operator bias. First, IOP was obtained using the APT and then with GAT in order to avoid the probable reduction of IOP due to applanation. IOP was taken for both eyes, first right then left, however, only right eye IOP was used to minimise systematic bias. Keeler 3000 APT was used for three readings and their mean was recorded. CCT was measured using TOMEY EM-4000. IOP was divided into four groups: low (< 10 mmHg), normal (10-21 mmHg), moderately elevated (22–30 mmHg), and high (> 30 mmHg). Informed verbal consent was obtained from all the participants. Descriptive statistics for demographic and quantitative variables by median were reported. The test for normality was measured using the Kolmogorov-Smirnov test. To verify the substantial difference between qualitative and quantitative variables,

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the Kruskal-Wallis test was applied. Pearson correlation and Intraclass correlation were used. To test the agreement Bland-Altman analysis was applied with CCT as the primary outcome measure. A p-value of 0.05 or less was taken as significant. Data was analysed using SPSS version 24.

Out of the total 311 patients, 153 were males and 158 were females with the median age of 51 years [range of 15-82 years, interquartile range (IQR) 67]. Mean age was 48.44±15.85 years. The median IOP measured by APT and GAT was 14 (range:37, IQR 12-16) and 12 (range:16, IQR 11-14) whereas the median CCT was 534 (range:44, IQR 525-539), respectively. Most of the observations were with an IOP between the normal range. No significant difference was noticed between the IOP measured by the two methods in low and normal group. However, in moderately high group, there was a significant difference between the two methods ($p \leq 0.001$). The IOP measured by GAT was significantly higher than with APT.

With GAT as reference, the mean difference (Δ) of APT-GAT in low group was 2.72±1.57 (95% CI: 1.5–3.9). In normal group, the mean difference (Δ) of APT- GAT was 1.25±1.93 (95% CI: 1.03–1.47) and in moderately high group the mean difference (Δ) of APT- GAT was 14.43±8.02 (95% CI: 5.4–34.3).

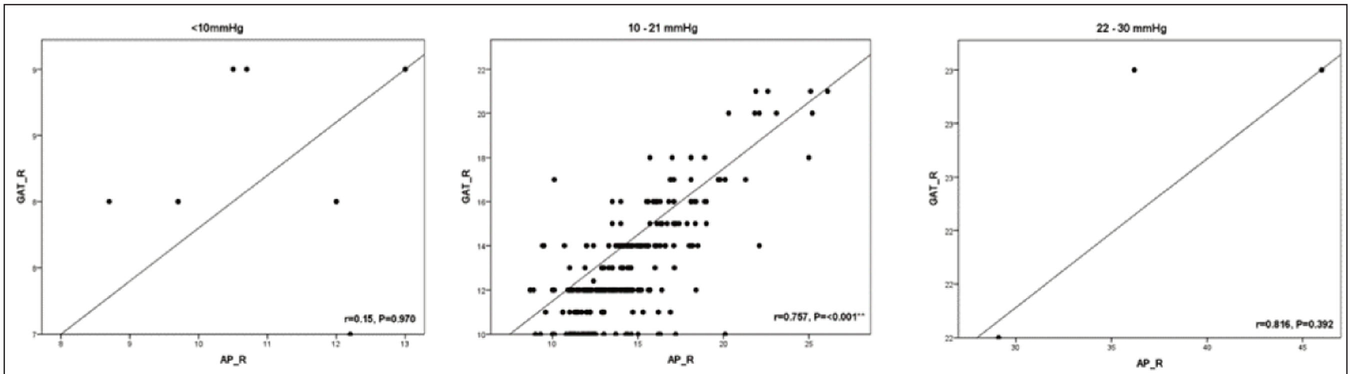
Compared with the GAT measurements, the proportional distribution of the agreements of within ±3 mmHg measured by APT was 56, 85, 0 and 0% in four IOP groups. Besides, the percentages of over ±5 mmHg deviation from GAT measurement in four IOP groups was 11, 4, 0.3, and 0% measured by APT, respectively.

Spearman's correlation showed a significant correlation between the two devices in the moderately high group ($p \leq 0.001$). Intraclass correlation coefficient (ICC) also showed strong consistency in IOP group 21– 30 mmHg between two measurement instruments as shown in Table. The agreements between the two measurements are illustrated in Figure 1 & 2 as Bland-Altman plots in IOP groups, respectively.

Table: Patient-related factors that increase caregiver burden.

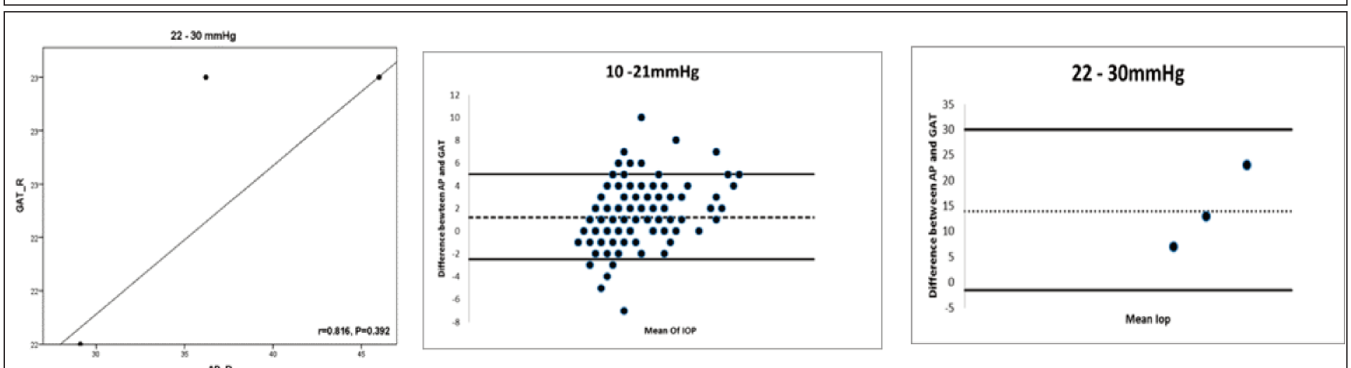
		IOP < 10 mm of Hg	**IOP 10-21** mm of Hg	**IOP 22-30** mm of Hg	**IOP >30** mm of Hg
		GAT			
R	APT	0.056	0.692	0.866	*
ICC		0.011	0.742	0.333	*

APT: Air Puff Tonometer; GAT: Goldmann Applanation Tonometer; CCT; Central Corneal Thickness; ICC: Intraclass Correlation Coeffecient; r; correlation.



<10 mm of Hg | 10-21 mm of Hg | 22-30 mm of Hg

Figure-1: Correlation between the two IOP measurements in four IOP groups.



<10 mm of Hg | 10-21 mm of Hg | 22-30 mm of Hg

Figure-2: Bland-Altman plot of mean against the difference between IOP measured by GAT and APT.

The median CCT was 534 with range 44. APT and GAT were significantly correlated with CCT (p<0.001). GAT showed high correlation with CCT (r= 0.92), whereas, APT showed moderate correlation with CCT (r=0.61).

Discussion and Conclusion

In literature review, it has been observed that in the normal IOP range, both tonometers are considered well-correlated. However, in the elevated IOP groups, APT may be less accurate as noted by Hashemi et al.[4] In our study, APT tended to overestimate IOP in higher IOP group. Chen et al also concluded the same results.[5] This may signify,as noticed in our study, that overestimation of IOP in higher groups by APT may pose a substantial risk of labelling non-glaucomatous eyes as glaucomatous. Lanza et al compared IOP values among three contact tonometers and two non-contact devices and found that overall, GAT values showed significantly lower values.[6] Similar results were reported by Taranum et al.[7] On the other hand, it was noted to have overestimation in normal and lower IOP group, which was not the case in our study. Our findings show effect modification according to IOP groups in superiority of the two test in contrast to other studies.[6]

Local studies by Channa et al and Bhatti et al showed that CCT plays a major role in the interpretation of IOP. They had results similar to our study with the inference that thinner corneas underestimate, whereas thicker corneas overestimate IOP.[8,9] GAT seemed to be influenced the most by CCT, followed by APT. Previously, Guler et al and Kato et al also reported a positive correlation between IOP measured by APT and GAT with CCT.[10,11] Zhang et al also found that the IOP difference increased with an increasing CCT.[12] The deviation of IOP readings affected by CCT have shown different results in different studies.[13]

GAT showed a high degree of agreement over a wide range of IOP compared with APT. The IOP measurement of APT and GAT were significantly correlated with CCT. GAT showed greater correlation than APT with CCT. Thick and hydrated corneas lead to higher IOP readings on GAT. IOP adjustment and correction tables have been cited in the literature.[14]

From the results of this study, the authors would like to recommend clinical practitioners along with ophthalmologists to overcome the inertia and consider APT as a screening tool in the normal IOP group, while keeping in mind the effect of CCT.

Limitations

The wide age range used in our study presented as a limitation. Further studies with a larger sample size and concise age range may add to the results of our study.

Disclaimer: None

Conflict of interest: None

Funding disclosure: None

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