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Original Article

Comparison of Air Puff Tonometer with Gold Standard Applanation Tonometer for Measurement of Intraocular Pressure in Adult Population

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ABSTRACT

Detecting and treating glaucoma early is vital to prevent vision loss. Two main instruments, the Air Puff Tonometer and the Gold Standard Applanation Tonometer, are used to measure Intraocular Pressure (IOP). However, there is ongoing debate among ophthalmologists regarding the accuracy and reliability of these devices. **Objective:** To evaluate and contrast the measurements of intraocular pressure obtained through Air puff tonometry and Goldmann applanation tonometry. **Methods:** A cross-sectional comparative study was conducted upon 900 patients of Glaucoma, selected through purposive sampling technique, attending the Eye OPD of Isra University Hospital, Hyderabad. Patients with age more than 18 years, of both genders who provided consent for eye examination and treatment, were included in the study while patients with corneal disease or prior surgery, ocular trauma, or those presenting with active infection or ocular disease were excluded from the study. **Results:** 396 (44.0%) of patients were males and 504 (56.0%) were females. The results indicate that the mean IOP measurement for air puff tonometry (17.43 mm Hg) is significantly higher (p-value=0.0001) than the mean measurement obtained by Goldman tonometry (13.84 mm Hg). Overall, the distribution of IOP was similar for both types of tonometry, with a slightly higher proportion having high IOP values (19-22 mmHg) with Goldman tonometry compared to air puff tonometry. **Conclusions:** The findings of this research demonstrated a noteworthy contrast between the two techniques, where the air puff tonometry produced noticeably elevated intraocular pressure measurements in comparison to the widely accepted applanation tonometry.

INTRODUCTION

One of the major controllable and irrevocable cause of blindness in world is Glaucoma [1-3]. It is a multifactorial and chronic advanced optic neuropathy which is depict by impairment to Retinal Nerve Fiber Layer (RNFL) and optic disc, which results in complete and irreversible Visual Field (VF) loss [2-4]. About 3.5 % of worldwide population between the ages of 40 to 80 are estimated to have any sort of glaucoma [5]. The projection was that around 76 million individuals would be pretentious by glaucoma by 2020, and this figure is anticipated to escalation to 111.8 million by the conclusion of 2040 [6]. The common risk factors of glaucoma are age (older), race, family history, myopia, diabetes mellitus, hypertension and smoking [7, 8]. Glaucoma can also fall into the categories of angle closure or open angle glaucoma [9-11]. The most prevalent form of glaucoma globally is Primary Open Angle Glaucoma (PAOG) [12]. The typical pressure inside the eye, known as Intraocular Pressure (IOP), ranges between 10 to 21 mm Hg, and the average IOP is 16 mm Hg [13]. There are two theories regarding the pathogenesis of glaucoma. One is mechanical theory and other is Ischemic theory [14]. IOP plays important role in both theories. In mechanical theory, raised IOP results in disturbing of axoplasmic transport in the nerve fiber due to compression and this leads to loss of retinal ganglion cells [15]. While the ischemic theory states that raised IOP causes compression of blood vasculature leading to inefficient blood supply to optic nerve and ultimately leading to blindness [16, 17]. Different methods

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has been tried and used for IOP measurement but there is no yet perfect instrument [18]. Tonometry is done to measure the pressure of fluid inside the eye i.e. IOP [19]. Different types of method can be used to check the IOP such as Schiotz Tonometer, Goldman Applanation tonometer, Air-puff tonometer, Tono pen, Perkins tonometer, Dynamic contour tonometer etc. [20, 21]. The Goldman Application Tonometer (GAT) is a globally recognized tonometer that is utilized for measuring Intraocular Pressure (IOP). It comprises of a dual prism and is attached to a slit lamp apparatus [19-22]. The fundamental concept behind GAT is the Imbert-Fick law. This law stipulates that the pressure per unit area inside the eye, when a sphere is flattened, must match the pressure per unit area applied to flatten the sphere [22]. Air Puff (AP) tonometer is also build on principle of Application, where jet of air flattens the central cornea and IOP is measured. It is has got edge over GAT as that they are non-invasive/non-contact and there is no risk of infection [23]. As both instruments, the Air Puff Tonometer and the Gold Standard Applanation Tonometer, are used to measure Intraocular Pressure (IOP), but there is ongoing debate among ophthalmologists regarding the accuracy and reliability of these devices.

Therefore, this study was aimed to evaluate and contrast the measurements of intraocular pressure obtained through Air puff tonometry and Goldmann applanation tonometry.

METHODS

The cross-sectional comparative study was conducted at the Department of Ophthalmology at Isra University Hospital. Over a period of six months following approval of the study protocol, a sample size of 900 patients was calculated using the Formula n=N/ 1+ N (e) ^{2}, considering a margin of error (e) as 5%. This sample size was attained by assuming that frequency of five patients per day over the course of 180 days, resulting in a cumulative total of 900 patients. Patients were divided into 2 groups; Group A (N=450) whose IOP was measured by Goldman Applanation Tonometer and Group B whose (N=450) IOP was measured by Air Puff Tonometer. Adult patients of age more than 18 years and of both genders who provided consent for eye examination and treatment, were included in the study via purposive sampling technique while patients with corneal disease or prior surgery, ocular trauma, or those presenting with active infection or ocular disease were excluded from the study. Ethical approval was obtained from Ethical Review Committee of Isra University Hospital vide Letter No: IUH/ASST-DEAN (CS)/27/04/31 dated: 28/04/2022. The study was conducted from June 2022 to December 2022. Data collection involved measuring IOP using both Goldman Applanation Tonometer (GAT) and Air Puff Tonometer (AP) in all patients, with noting of any differences present. For GAT, eyes were anesthetized using Alcaine® 0.5% eye drops and a fluorescein strip applied to the conjunctival fornix. Goldman Applanation Tonometer operates on the Imbert-Fick principle, whereby pressure within the eye is determined by the force required to flatten its surface. The patient's head was positioned correctly, and the slit lamp was adjusted. The tonometer probe was aligned with the central cornea, and a controlled force was applied to applanate a small area of the cornea, flattening it slightly. The force required to achieve applanation, which correlated with the intraocular pressure, was determined by observing the mires through the microscope. Conversely, Air Puff Tonometer utilizes a brief surge of airflow to flatten the cornea, with intraocular pressure estimated by assessing the strength of the air burst. The instrument was used by directing a controlled puff of air at the cornea, causing momentary deformation. The device measured this deformation, estimating intraocular pressure. Data analysis was conducted using SPSS version 26.0, with categorical variables such as gender and IOP presented as numbers and percentages, and quantitative variables analyzed using independent sample t-test to compare measurements obtained by GAT and AP. P-value < 0.05 was considered statistically significant.

RESULTS

This study included 900 patients. Among 900 patients, 396 (44.0%) were males and 504 (56.0%) were females. The mean age of the population is 35.39 $\pm$ 12.25 years which suggests that there is a significant amount of variability in the ages of the population (Table 1)

Table 1: Descriptive Statistics of Participants (N = 900)

Variables	Frequency (%)
Gender	
Females	504 (56%)
Males	396 (44%)
Age (Years)	
Mean $\pm$ SD	35.39 $\pm$ 12.25
Minimum	18
Maximum	80
Range	18-80

The results indicate that the mean IOP measurement for air puff tonometry (17.43 mm Hg) is significantly higher (p-value=0.0001) than the mean measurement obtained by Goldman tonometry (13.84 mm Hg) in a Group A. Additionally, the standard deviation of the IOP measurements obtained by both methods is similar, indicating that the difference in mean IOP measurement is not simply due to variation in the data. The minimum and maximum IOP measurements for air puff and Goldman

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tonometry were also recorded, with air puff having a wider range (12-22 mm Hg) compared to Goldman tonometry (10-21 mm Hg). In general, these findings indicate a notable distinction in IOP evaluations acquired through air puff and Goldman tonometry techniques, with air puff tonometry consistently yielding higher readings within this particular sample (Table 2).

Table 2: Mean Value of IOP by Air Puff and Goldman Application Tonometer

IOP (Mm/Hg) Measurements	Groups		p-value
	Group A GAT (N = 450)	Group B AP (N = 450)	
Mean ± SD	13.84 ± 2.29	17.43 ± 2.3	0.0001
Minimum	10.0	12.0	
Maximum	21.0	22.0	
Range	10-21	12-22	

The table 3 shows the distribution of intraocular pressure (IOP) in two categories, measured using Goldman tonometry and air puff tonometry. For Goldman tonometry, 8.22% (37) of participants had an IOP of 7-10 mmHg, 27.33% (123) had an IOP of 11-14 mmHg, 35.62% (160) had an IOP of 15-18 mmHg, and 28.88% (130) had an IOP of 19-22 mmHg. For air puff tonometry, 1.37% (6) of participants had an IOP of 7-10 mmHg, 20.55% (92) had an IOP of 11-14 mmHg, 53.42% (240) had an IOP of 15-18 mmHg, and 24.66% (112) had an IOP of 19-22 mmHg. The distribution of IOP was similar for both types of tonometry, with a slightly lower proportion of participants having low IOP values with air puff tonometry (7-10 mmHg) and a slightly higher proportion having high IOP values (19-22 mmHg) with Goldman tonometry.

Table 3: Different Categories of Intra-Ocular Pressure

IOP (Mm/Hg) Categories	Group A GAT (N = 450)	Group B AP (N = 450)
	Frequency %	Frequency %
7-10	37 (8.22%)	6 (1.37%)
11-14	123 (27.33%)	92 (20.55%)
15-18	160 (35.62%)	240 (53.42%)
19-22	130 (28.88%)	112 (24.66%)

DISCUSSION

The IOP readings recorded by the AP tonometer are slightly higher than those obtained from the GAT. There have been numerous studies comparing the IOP of GAT and APT [24, 25]. According to Friat *et al.*, results obtained with GAT are slightly lower than those obtained with non-contact tonometer [24]. As a result of Martinez-de-la-casa and colleagues' study, AP tonometer results were found to be higher than GAT results [26]. It was found that Tonnu *et al.*, measured different IOPs by using two different methods by 0.7 mm Hg [27]. APT offered more accuracy when IOP was over 20 mm Hg, according to Rao [28]. An APT measurement of IOP > 20 mm Hg or 30 mm Hg is unreliable, according to Osman EA *et al.*, [25]. The intraocular pressures of non-glaucomatous subjects were measured using NCTs and a GAT in a study by Bang *et al.*, which compared Goldmann applanation tonometer with three non-contact tonometers [29]. This study found that the Nidek NT-530P recorded lower intraocular pressure (IOP) readings than the Goldmann applanation tonometer, while the Topcon CT-IP and Canon T x 20P tonometers measured higher IOP readings [29]. According to research carried out by Sana Nadeem and colleagues, it was found that the amount of IOP in healthy adults was similar and showed a strong correlation [30]. The results suggest that APT could serve as an effective tool for identifying glaucoma in patients. Other research suggests that the non-contact air puff tonometer can be a speedy and valuable tool for initial screening and the IOP readings obtained from the non-contact tonometer with either one or three puffs (NCT 1 and NCT 3) were comparable to those from the Goldmann applanation tonometer [30]. However, due to the wide range of limits of agreement (LoA), it may not be feasible to use NCT (both 1-puff and 3-puffs) and GAT interchangeably, especially in patients with primary open angle glaucoma [31]. The results indicated that both techniques for measuring Intraocular Pressure (IOP) were linked to Central Corneal Thickness (CCT) in a favorable manner. Nonetheless, NCT was found to be more impacted by CCT than GAT when the CCT changed by ten microns. The expected change in IOP using NCT was 0.47 mm Hg, while with GAT, it was 0.29 mm/Hg [32]. The Goldman Application Tonometer and Air Puff Tonometer are frequently used in daily ophthalmic clinics [33]. The general consensus is that the Goldman Applanation Tonometer is more dependable and superior. Presently, it is the most commonly utilized device for measuring IOP and is regarded as the gold standard [34]. However, the findings of our study showed Air Puff Tonometer as almost equal when compared with the Goldmann Applanation Tonometer. Although the GAT is valuable, it has two limitations. The first one is that it necessitates direct touch between the sensor and the cornea, which may raise the chance of infection. Secondly, local anesthetics are necessary for its use, which some patients, especially children, may find difficult to tolerate. The study initiate that intraocular pressure readings obtained by a non-contact tonometer are clinically comparable to those obtained by a Goldman application tonometer in people with intraocular pressure within the normal range [35]. Previous investigations have indicated that the non-touch tonometer and GAT yield comparable outcomes among individuals with normal blood pressure. In a preceding research endeavor, the PT100 and GAT apparatuses were compared, revealing a significant concurrence between

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them, notwithstanding the non-touch tonometer's inclination to generate elevated IOP readings compared to the GAT for pressures below 21 mmHg. According to the research conducted by Salim and colleagues, there was a similar level of concordance between the two tools within the typical range of Intraocular Pressures (IOPs) [35]. However, as the measurements grew in magnitude, there was more significant variability observed. Additionally, another study found that both types of tonometers produced identical mean IOP results, with no notable difference in this research [36]. The PT100 non-contact tonometer is a handy device for measuring Intraocular Pressure (IOP) in children because it's easy to carry and use. But both it and the Goldmann applanation tonometer can be affected by corneal properties, especially the non-contact tonometer, which is more influenced by central corneal thickness. One study found that both methods reliably measure IOP within the same session and over multiple sessions, with no significant differences in readings between techniques. However, another study showed a significant difference in IOP measurements between two different instruments. Yet, when comparing the Canon TX10 NCT and GAT instruments, there were no significant differences in IOP readings. Both devices also showed good agreement between each other. Despite variations in central corneal thickness, there was no correlation found between CCT and IOP readings. The repeatability coefficients for GAT and TX-10 tonometers were 3.70 mmHg and 3.41 mmHg, respectively [37, 38].

CONCLUSIONS

The air puff tonometry method showed notably higher intraocular pressure readings compared to the gold standard applanation tonometry method. Thus, it's crucial to recognize the constraints and possible inaccuracies associated with using air puff tonometry for measuring intraocular pressure in clinical settings.

Authors Contribution

Conceptualization: YS
Methodology: YS, AJ
Formal analysis: YS, AJ
Writing, review and editing: AJ

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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