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Non-contact Tonometry Versus Pachymetry Corrected Intraocular Pressure: Any Difference? A Case for Pachymetry during Glaucoma Screening

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Authors' contributions

This work was carried out in collaboration between both authors. Author EA designed the study, wrote the protocol, part of the literature search and the first draft of the manuscript. Author AAO wrote part of the literature searche, performed the statistical analysis, managed the analyses and wrote the final draft of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Objective: This study sets out to determine if there is any statistical difference in the results of measuring intraocular pressure (IOP) uncorrected for Central Corneal Thickness with Air Puff Tonometry and corrected with pachymetry for clients undergoing screening for glaucoma at the department of Ophthalmology, University of Port Harcourt Teaching Hospital (UPTH), Nigeria.

Methods: One hundred and thirty-two (132) adults were screened for glaucoma during the 2019 World Glaucoma week in UPTH Port Harcourt, they had their IOPs measured with Air Puff (Non-contact) Tonometer (Pulsair intelliPuff Tonometer, Keeler), after which they underwent pachymetry (Sonomed Escalon PacScan Plus) to determine corneal thickness after which the corrected IOP was determined by using a correction factor for adjusting IOP based on corneal thickness [1]. The results were analyzed using SPSS version 20 to determine statistical differences.

Results: There was a statistically significant difference between intraocular pressure (IOP) measurements when corrected with pachymetry than when it is uncorrected. In our study the mean uncorrected IOP RE and LE was 14.53 mmHg and14.75 mmHg respectively while Corrected IOP RE and LE was 16.37 mmHg and 16.72 mmHg respectively.

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Conclusion: Intra ocular pressure measurement adjusted with pachymetry for corneal thickness may be a better option for tonometry and we propose this be considered during intra ocular pressure measurement.

Keywords: Intraocular pressure; corrected with pachymetry; uncorrected intraocular pressure.

1. INTRODUCTION

Glaucoma is the leading cause of irreversible blindness worldwide and elevated intraocular pressure is an important modifiable risk factor. Higher intraocular pressure (IOP) is an established risk factor associated with the development and progression of glaucoma [2,3]. With elevated IOP, the optic nerve function and the integrity of the visual pathway may be impaired to the extent of causing characteristic optic nerve degeneration and visual field loss.

High intraocular pressure (IOP) is associated with glaucomatous damage and progression of Glaucoma disease condition, therefore screening and detecting patients with raised intraocular pressure is essential for management and follow up of patients' decisions; both in the Ocular Hypertensives, Glaucoma suspects and Glaucoma patients [4-6]. Goldman applanation tonometry (GAT) is still considered the gold standard for assessing IOP in clinical practice. However, in eyes with thick corneas, GAT IOP measurements tend to be overestimated, whereas underestimation may occur in eyes with thin corneas [7,8]. The GAT obtains the IOP indirectly based on the Imbert-Fick principle, which states that the pressure within a sphere is approximately equal to the external force needed to flatten a portion of the sphere divided by the area of the sphere that is flattened [9,10]. Great variability in corneal thickness affects the IOP. Relatively minor changes in Central Corneal Thickness (CCT) will produce a clinically significant change in mean IOP. To overcome GAT limitations, other tonometers have been proposed, such as the Ocular Response Analyzer (ORA, Reichert, Inc., Depew, NY). The ORA incorporates measurements of corneal biomechanics in calculations of a "corneal-compensated" IOP (IOPcc). The ICare Rebound Tonometer (RBT, Tiolat, Oy, Helsinki, Finland) is a handheld, lightweight, contact tonometer that has the advantage of being portable and not requiring topical anesthetic.

Some studies have shown that IOPcc measurements seem to be less influenced by central corneal thickness (CCT) compared with GAT [7,11]. Some other tonometric methods such as rebound tonometry, also has been suggested to be less affected by corneal thickness [12,13]. However, the issue of the extent to which the CCT affects actual IOP measurement remains a considerable debate in the literature. There have been many studies in the literature comparing IOP measurements obtained by different forms of tonometry and their relationship with corneal properties [12,14]. However, the ultimate value of IOP measurements resides in their ability to predict clinically relevant outcomes in glaucoma, such as risk for visual field progression. Therefore, although IOP comparisons among instruments may provide information about their comparability and agreement, the best method to assess and compare their utility is to investigate how well their measurements are associated with clinically relevant outcomes in the disease, such as rates of visual field progression.

CCT's impact on IOP necessitates inclusion of pachymetry (measuring CCT) and incorporating its effect in the IOP measurement. For the purpose of screening for glaucoma, the Non-contact Air Puff tonometer is a veritable tool due to the advantage of being portable, non-invasive and not requiring topical anesthetic. The purpose of this study was therefore to investigate the relationship between IOP measurements obtained by the Non-contact Air Puff tonometer with and without CCT correction factor.

2. MATERIALS AND METHODS

One hundred and thirty-two (132) adults were screened for glaucoma during the 2019 World Glaucoma week in Port Harcourt. They had their Intraocular pressure assessed with Air Puff (Non-contact) Keeler Tonometer(Pulsair intelliPuff Keeler tonometer), after which they underwent pachymetry (Sonomed Escalon PacScan Plus) to determine corneal thickness and using a correction factor [1] their IOP were adjusted according to corneal thickness and the corrected IOP was determined.

All data were cross checked for accuracy, entered into a proforma and were analyzed using commercially available statistical data management software- Statistical Package for Social Sciences (IBM-SPSS) version 25. Distribution was described as mean and standard deviation. Continuous variables were reported with tables and graphs. Analysis of Variance (ANOVA) was used to determine the statistical significance of the differences between proportions. The level of significance was taken to be $p<0.05$.

3. RESULTS

A total number of 132 participants were involved in the screening, 61.4% were female while 38.6% were male.

Fig. 2 shows the age distribution of the study population. The highest number of participants was in the 5th decade.

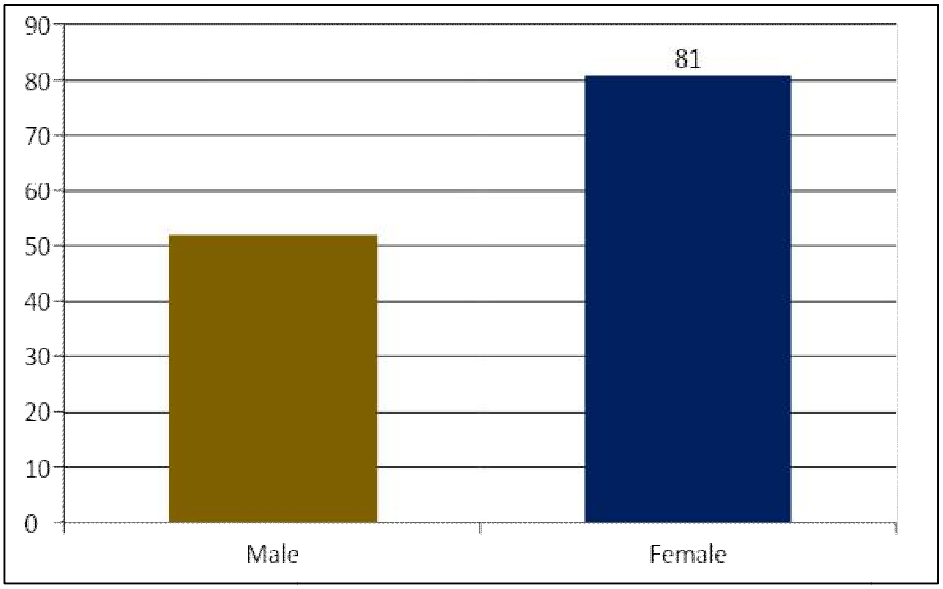

Fig. 1. Sex distribution of participants

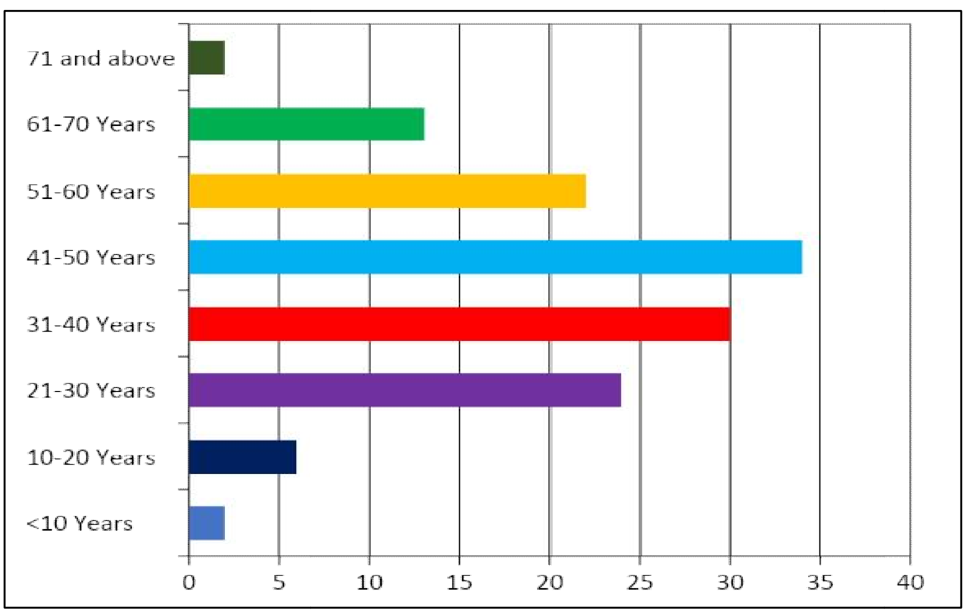

Fig. 2. Age distribution of participants

Table 1. Pattern of distribution of IOP in the study population

	N	Mean	Std. deviation	Std. error	95% confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
IOPR	132	14.5303	3.44297	.29967	13.9375	15.1231	12.00	32.00
IOPL	132	14.7500	3.63901	.31673	14.1234	15.3766	12.00	35.00
CoIOPR	132	16.3712	3.91982	.34118	15.6963	17.0461	10.00	34.00
CoIOPL	132	16.7273	4.59022	.39953	15.9369	17.5176	10.00	39.00
Total	528	15.5947	4.02866	.17532	15.2503	15.9391	10.00	39.00

**IOPR (IOP right eye), IOPL (IOP left eye), CoIOPR (corrected IOP Right eye), CoIOPL (corrected IOP left eye)*

Table 2. Summary of analysis of variance (ANOVA) on the mean difference between IOPR and CoIOPR and IOPL and CoIOPL

	Sum of squares	df	Mean square	F	Sig.
Between groups	492.644	3	164.215	10.675	.000
Within groups	8060.621	524	15.383		
Total	8553.265	527			

Table 2 shows that there is statistical significant difference between the uncorrected IOPs and corrected IOPs $F1, 528 = 10.675$, $p<0.05$.

Table 3 shows that IOPR & CoIOPR and IOPL & CoIOPL are the sources of significant variation.

4. DISCUSSION

Glaucoma is characterized by optic neuropathy associated with progressive retinal ganglion cell loss and visual field defect [15]. The current reliable treatment for glaucoma presently is reduction of intraocular pressure and the Goldmann applanation tonometer (GAT) developed by Goldmann and Schmidt is still considered the gold standard in tonometry [16]. Evaluation of corneal biomedical properties and measurements of the corrected IOP are thought to be useful in diagnosis of glaucoma [17]. Yaoeda et al in their study found that the IOP adjusted by CCT or corneal biomechanical properties depends on the measurement instrument itself rather than the adjustment methods [18]. P-A Tonnu et al found a change in measured IOP with a 10 µm increase in central corneal thickness (CCT). They concluded that IOP measurement was affected by CCT and the effect of CCT on Non-contact Tonometer is significantly greater than on the Goldman applanation tonometer (GAT) [19]. Central Corneal thickness (CCT) affects the accuracy of IOP measurements as a thicker cornea requires more force to applanate and a thinner one less force [20]. This is similar to our study where we checked IOP using non- contact tonometry

Table 3. Scheffe multiple comparisons on the sources of difference

(I) IOP	(J) IOP	Mean difference (I-J)	Std. Error	Sig.	95% confidence interval	
					Lower bound	Upper bound
IOPR	IOPL	-.21970	.48278	.976	-1.5737	1.1343
	CoIOPR	-1.84091*	.48278	.002	-3.1949	-.4869
	CoIOPL	-2.19697*	.48278	.000	-3.5510	-.8430
IOPL	IOPR	.21970	.48278	.976	-1.1343	1.5737
	CoIOPR	-1.62121*	.48278	.011	-2.9752	-.2672
	CoIOPL	-1.97727*	.48278	.001	-3.3313	-.6233
CoIOPR	IOPR	1.84091*	.48278	.002	.4869	3.1949
	IOPL	1.62121*	.48278	.011	.2672	2.9752
	CoIOPL	-.35606	.48278	.909	-1.7101	.9979
CoIOPL	IOPR	2.19697*	.48278	.000	.8430	3.5510
	IOPL	1.97727*	.48278	.001	.6233	3.3313
	CoIOPR	.35606	.48278	.909	-.9979	1.7101

**. The mean difference is significant at the 0.05 level* before and after correction and found a statistically significant difference between both readings. There is divided opinion about the clinical significance of the effect of CCT on IOP measurements. Singh et al. [21] reported the effect was minimal and not relevant for most patients while Bhan et al. [22] reported that correction for corneal effects may be needed in some patients.

NCT has been adjudged to be a good means of obtaining IOP readings in large groups of patients owing to its ease of use however in patients with CCT significantly different from population mean the IOP readings need to be adjusted [1,23]. In our study the mean uncorrected IOP RE and LE was 14.53 mmHg and 14.75 mmHg respectively while Corrected IOP RE and LE was 16.37 mmHg and 16.72 mmHg respectively. These differences were statistically significant ($p<0.05$).This study also compares favorably with a study by Sood et al. [22] where IOP measurements showed a positive correlation with central corneal thickness.

A few studies in our region have compared different tonometer readings with the effect of CCT. Babalola OE et al. [23] found that NCT readings were significantly affected by CCT and pachymetric corrections were necessary, Oladigbolu K et al. [24] however did not find any significant correlation between CCT and IOP and the reason may be due to the fact that the tonometer used in their study was the hand held Perkins tonometer. A comparative clinic based observational study done in South West Nigeria comparing IOP from Tono-Pen to GAT; the Tono-Pen gave a higher value for IOP than the uncorrected and corrected GAT values [25].

CCT ranges in Sub-Saharan African countries including Nigeria are yet to be extensively evaluated though a few studies have been done [26-28]. In our study the average CCT was 530.2 µm (95% CI, 521.5 – 538.7). And this compares favorably with the of Oladigbolu et al. in Zaria, Nigeria [24]. A study by Nkanga DG et al. [29] found that CCT adjusted values for IOP ranged from -7 to +7and proposed that routine CCT measurements should form part of Glaucoma assessment especially in patients of African ancestry and Normal Tension Glaucoma patients where thinner corneas may masquerade as lower IOP with GAT.

Several studies also corroborate the effect of central corneal thickness on IOP and advocate for pachymetry [30-32].

5. CONCLUSION

Variations in CCT significantly affect IOP readings and IOP readings in our study had a positive correlation with CCT. We therefore recommend that IOP measurement should be associated with a pachymetry correction to avoid inaccurate readings.

CONSENT AND ETHICAL APPROVAL

Ethical clearance was obtained from the Ethical Committee of University of Port Harcourt Teaching Hospital. Informed written consent and assent were obtained from each patient before enrolment into the study in accordance with Helsinki Declaration involving human subjects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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