ORIGINAL ARTICLE

NORTH BENGAL MEDICAL COLLEGE JOURNAL [2024], VOL., 10, No. 2 : 36-42

Comparison between Goldmann Applanation Tonometry and Non-Contact Tonometry: A Specialized Hospital Based Study

*Salma Parvin,[1] Md Arif Mian,[2] Mafruha Afrin,[3] Samhita Sharma Puja[4]

ARTICLE INFO

Article history:
Received: 03 March 2024
Accepted: 24 June 2024

Online:
www.nbmc.ac.bd

Keywords:
Intraocular pressure, Glaucoma, Tonometry

ABSTRACT

Introduction: *Measurement of intraocular pressure (IOP) is a part of routine eye examination and key component of glaucoma screening and management. Goldmann Applanation Tonometry (GAT) is the gold standard but Non-Contact Tonometry (NCT) offers some advantages. This study aimed to compare IOP measurements by GAT and NCT.* ***Methods:*** *This observational study involved 80 patients (Total 159 eyes) conducted at Bangladesh eye hospital (Malibagh branch), Dhaka, Bangladesh during the period of July, 2023 and December, 2023. IOP was measured via GAT and NCT by a single experienced ophthalmologist.* ***Results:*** *Among the 80 patients, majority of them were belongs to 41-70 years age group with 61.25% of females. Non-Contact Tonometry (NCT) showed 72.50% of left eyes and 73.42% of right eyes with IOP levels between 10-21 mmHg. Goldmann Applanation Tonometry (GAT) results aligned closely. Notably, 8.75% of left eyes and 16.46% of right eyes exhibited no difference between GAT and NCT. A large portion of participants (43.75% for left eyes, 40.51% for right eyes) showed differences of 1-3 mmHg. Larger differences of >3 mmHg was observed in the remaining cases. Overall, 12.58% of all eyes had no difference, while 41.51% had a 1-3 mmHg difference, and the remaining 45.91% had a >3 mmHg difference. There is significant difference between NCT and GAT in mean IOP measurement of both eyes.* ***Conclusion:*** *NCT demonstrates easy way of IOP measurement as it doesn't touch the cornea. It is more convenient to measure for a large number of patients in a short time than GAT. So, NCT is better for IOP screening.*

1. *Associate Professor, Department of Ophthalmology, Green Life Medical College Hospital, Dhaka, Bangladesh*
2. *Professor, Bangladesh Eye Hospital, Dhaka, Bangladesh*
3. *Associate Professor, Department of Ophthalmology, Green Life Medical College Hospital, Dhaka, Bangladesh*
4. *Medical Officer, Department of Ophthalmology, Green Life Medical College Hospital, Dhaka, Bangladesh*

***Corresponding author:** ✉ salma99parvin@gmail.com

INTRODUCTION

Intraocular pressure (IOP) measurement is very important in the diagnosis and management of glaucoma and other ocular conditions. Glaucoma, often referred to as the silent killer of sight. It is one of the leading causes of irreversible blindness globally with high prevalence in Africa and Asia.[1-3] This condition, along with other ocular diseases, necessitates accurate and reliable methods for IOP measurement. The

journey of IOP measurement techniques has evolved significantly over the years from rudimentary methods to sophisticated devices. The quest for precision and ease of use has been paramount. The development of these techniques has been driven by the need for accurate assessment of IOP to better understand and manage ocular conditions effectively.[4,5] Goldmann Applanation Tonometry (GAT) has long been considered the gold standard in IOP measurement. Its working principle, based on the Imbert-Fick law, involves flattening a small area of the cornea to gauge the IOP. This method is revered for its accuracy and reliability, forming the basis of comparison for newer tonometry technologies.[6,7] However, GAT is not without its limitations and challenges. Factors such as corneal thickness and curvature can influence its readings, and the technique requires direct contact with the cornea, which can be uncomfortable for patients and carries a risk of infection.[8,9] In contrast, Non-Contact Tonometry (NCT) represents a technological advancement in this field. NCT, utilizing a rapid air puff to applanate the cornea, offers a non-invasive approach to IOP measurement. This method is particularly advantageous in terms of patient comfort and reduced risk of infection. The ease of use and non-invasiveness of NCT make it an attractive option in clinical settings, especially for screening purposes.[10,11] However, concerns regarding the accuracy of NCT compared to GAT and its dependency on operator skill have been noted in the literature.[5,12] Previous research comparing GAT and NCT has provided mixed findings. Some studies have found a good correlation between the two methods, while others have reported discrepancies in measurements, particularly in certain patient populations or under specific clinical conditions.[13-16] These inconsistencies highlight the need for ongoing research to optimize IOP measurement techniques, ensuring they are adaptable to diverse clinical scenarios and patient needs.

This study was aimed *to* compare IOP measurements by GAT and NCT in a diverse patient population. We hypothesize that while GAT remains the gold standard in accuracy, NCT offers substantial benefits in terms of non-invasiveness and ease to use, making it a viable alternative in certain clinical circumstances.

METHODS

This observational study was conducted at Bangladesh Eye Hospital, Malibagh branch in Dhaka, Bangladesh between July, 2023 to December, 2023. A total of 80 patients enrolled in this study on the basis of inclusion criteria, providing 159 eyes for analysis. One patient only had a left eye. Any non-cooperative patient, patients with history of intraocular surgery, patients with red and painful eyes and patients under 18 years of age were excluded from the study. IOP was measured in both eyes of each participant using first the NIDEK NT-530 Non-Contact Tonometer followed immediately by the Carl Zeiss Meditec Ag SL 115 Classic Goldmann Applanation Tonometer, using the same slit lamp. Measurements were taken by a single experienced ophthalmologist. Ethical clearance regarding the study was obtained from the Institutional Review Board. Statistical analysis was performed using SPSS version 26.0.

RESULTS

The age range varied from 18 to 80 years, with the majority patients were between 41 and 70 years. Among them, 26.25% of patients were aged 41-50 years, 32.5% were aged 51-60 years and 26.25% were 61-70 years age group. The mean age of the patients was 53.11±12.62 years. (Table I).

Table I: Age distribution of the Patients (n-80)

Age in years	Frequency	Percentage	Mean±SD
≤20	3	3.75%	
21-30	3	3.75%	
31-40	2	2.50%	
41-50	21	26.25%	53.11±12.62
51-60	26	32.50%	
61-70	21	26.25%	
71-80	4	5.00%	
Total	**80**	**100%**	

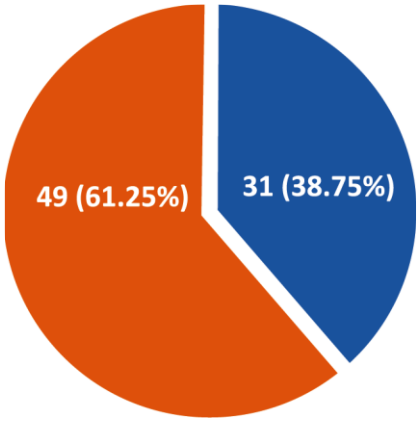

Figure 1: Gender distribution of the Patients (n-80)

Among the patients, 38.75% were male, representing 31 individuals, while 61.25% were female, constituting 49 individuals. (Figure 1)

Table II: Comparison of Intraocular Pressure by NCT test (n-159 eyes)

IOP Categorization	Left eye (n=80)		Right Eye (n=79)	
	frequency	percentage	frequency	percentage
<10 mmHg	1	1.25%	1	1.27%
10-21 mmHg	58	72.50%	58	73.42%
>21 mmHg	21	26.25%	20	25.32%
Mean±SD	18.83±5.358 mmHg		17.96±4.95 mmHg	

*One patient had only left eye

In the left eye group, the majority of participants, comprising 72.50%, exhibited IOP levels falling within the range of 10-21 mmHg, followed by 26.25% with IOP levels exceeding 21 mmHg. A small proportion, 1.25%, had IOP levels below 10 mmHg. Similarly, in the right eye group, the distribution of IOP levels was consistent with the left eye group, with 73.42% falling within the 10-21 mmHg range, 25.32% exhibiting IOP levels exceeding 21 mmHg, and a minimal proportion, 1.27%, with IOP levels below 10 mmHg (Table II).

Table III: Comparison of Intraocular Pressure by GAT test (n-159 eyes)

IOP Categorization	Left eye (n-80)		Right Eye (n-79)	
	frequency	percentage	frequency	percentage
<10 mmHg	4	5.00%	2	2.53%
10-21 mmHg	66	82.50%	72	91.14%
>21 mmHg	9	11.25%	5	6.33%
Mean±SD	15.75±5.036 mmHg		15.15±4.148 mmHg	

*One patient had only one eye and was missing their right eye

In the left eye, the majority of participants, comprising 82.50%, demonstrated IOP levels falling within the range of 10-21 mmHg, followed by 11.25% with IOP levels exceeding 21 mmHg, and 5.00% with IOP levels below 10 mmHg. Similarly, in the right eye group, the distribution of IOP levels was predominantly within the 10-21 mmHg range, constituting 91.14% of participants, followed by 6.33% with IOP levels exceeding 21 mmHg, and 2.53% with IOP levels below 10 mmHg. (Table III).

Table IV: Difference of IOP between GAT and NCT measurements in the left eye (n-80 eyes)

Difference	Frequency	Percentage
No Difference	7	8.75%
Difference of 1-3 mmHg	35	43.75%
Difference of >3 mmHg	38	47.50%
Total	**80**	**100%**

In Table IV, we observe the discrepancy in intraocular pressure (IOP) measurements between Goldmann Applanation Tonometry (GAT) and non-contact tonometry (NCT) specifically for the left eye, with data from 80 eyes analyzed. The breakdown reveals distinct categories of differences in IOP readings between the two methods. Notably, 8.75% of participants showed no discernible difference in IOP measurements between GAT and NCT. About 44% of the participants had a difference of 1-3 mmHg, which was in the acceptable range. However, 47.50% of the participants, the largest proportion of the cases, had difference of >3 mmHg.

Table V: Difference of IOP between GAT and NCT measurements in the right eye (n-79eyes)

Difference	Frequency	Percentage
No Difference	13	16.46%
Difference of 1-3 mmHg	32	40.51%
Difference of >3 mmHg	34	43.03%
Total	**79**	**100%**

In Table V, we observe the comparison of intraocular pressure (IOP) measurements between GAT and NCT specifically for the right eye, based on data obtained from 79 eyes. The table delineates the frequency and percentage distribution of differences in IOP readings between the two methods. Notably, 16.46% of participants exhibited no discernible difference in IOP measurements between GAT and NCT in the right eye. 40.51% of participants demonstrated a difference in IOP measurements ranging from 1 to 3 mmHg between the two techniques, which was within the acceptable range. However, 43.03% of the participants had a difference of >3 mmHg in terms of IOP measurements between GAT and NCT.

Table VI: Difference of IOP between GAT and NCT measurements in total eyes (n-159)

Difference	Frequency	Percentage	*p*-value
No Difference	20	12.58%	
Difference of 1-3 mmHg	66	41.51%	<0.005
Difference of >3 mmHg	73	45.91%	
Total	**159**	**100%**	

Table VI offers a straightforward comparison of intraocular pressure (IOP) measurements between Goldmann Applanation Tonometry (GAT) and Non-Contact Tonometry (NCT) across the total number of eyes in this study, encompassing 159 eyes. The table breaks down the frequency and percentage distribution of differences in IOP readings between the two methods. Notably, 12.58% of eyes showed no discernible difference in IOP measurements between GAT and NCT. A total of 41.51% eyes exhibited a difference in IOP measurements

ranging from 1 to 3 mmHg between the two techniques. Additionally, 45.91% showed a difference of >3 mmHg in IOP measurements between GAT and NCT.

Table VII: Difference of Mean±SD IOP between GAT and NCT measurements in both eyes (n-159)

Eye	GAT Mean±SD	NCT Mean±SD	*p*-value
Right eye (n-79)	17.96±4.95	15.15±4.15	<0.05
Left Eye (n-80)	18.83±5.35	15.75±5.04	<0.05

*Significance measured using ANOVA test

For the right eye (n-79), the mean IOP measured by GAT was 17.96 mmHg with a standard deviation (SD) of 4.95, while NCT recorded a mean of 15.15 mmHg with an SD of 4.15; this difference was statistically significant with a p-value of less than 0.05. Similarly, the left eye (n=80) showed a mean IOP of 18.83 mmHg with an SD of 5.35 for GAT and a mean of 15.75 mmHg with an SD of 5.04 for NCT, also with a statistically significant p-value of less than 0.05.

DISCUSSION

The accurate measurement of intraocular pressure (IOP) is integral part for diagnosing and managing various eye related problems, especially glaucoma. As the only modifiable risk factor, lowering elevated IOP is critical to halting glaucomatous optic nerve degeneration.[17] While Goldmann Applanation Tonometry (GAT) has long served as the clinical gold standard, limitations like required topical anesthesia and contact with the ocular surface present drawbacks.[18,19] Non-Contact Tonometry (NCT) provides an alternative approach that is rapid, painless, and avoids corneal contact.[20] However, questions have persisted around the reliability of NCT measurements versus GAT values.[14,21] Study conducted by Ahmed et al.[22] revealed that GAT is more accurate but NCT is good and easy for screening purpose. Dibaji et al.[23] stated that, IOP measurement by NCT was quick for screening purposes but it should be cross checked by GAT. This study aimed to provide further insights by directly comparing IOP readings obtained via both methods. We found generally good agreement between NCT and GAT across our sample, with a large portion of eyes exhibiting a difference of 3 mmHg or less. This adds to evidence from multiple prior investigations also reporting close concordance between the techniques.[14,16] For example, one meta-analysis found NCT to have high diagnostic accuracy for detecting elevated IOP compared to GAT.[20] However, we observed a higher proportion of >3 mmHg differences than other reports. This may relate to instrumentation factors, as the principles and measurement influences for contact versus non-contact tonometry differ. Patient characteristics like ocular biomechanics and pachymetry profiles that impact each method dissimilarly were also not analyzed but can account for inter-device variability.[21]The mean IOP measurements of both left eye and the right eye were significantly difference between NAT and GAT method. Larger sample sizes would strengthen our ability to generalize conclusions on agreement between GAT and NCT across different populations. Additional covariates warrant investigation to optimize NCT accuracy. While GAT remains the standard, non-contact screening holds promise for efficient glaucoma detection programs critical to managing this leading cause of blindness worldwide. Further refining NCT may establish it as a reliable replacement in select contexts. This study adds to evidence that, NCT demonstrates validity as a screening option versus the gold standard GAT method. However, continued research is still needed to fully define its clinical applicability. Please let me know if any part of the discussion would benefit from further elaboration or expansion.

CONCLUSION

This study reinforces NCT for potential clinical applicability as a rapid, non-invasive option for IOP measurement. Further refinement of NCT technology and standardization of procedures may be needed.

Acknowledgements: Authors are grateful to all staffs of Bangladesh Eye Hospital, Malibagh, Dhaka, for their cordial support during this study.

Conflicts of interest: None.

REFERENCES

1. Li HG, Chen YH, Lin F, Li SY, Liu QH, Yin CG, et al. Agreement of intraocular pressure measurement with Corvis ST, non-contact tonometer, and Goldmann applanation tonometer in children with ocular hypertension and related factors. Int J Ophthalmol. 2023; 16(10): 1601–1607.
2. Wang P, Song Y, Lin F, Wang Z, Gao X, Cheng W, et al. Comparison of Non-contact Tonometry and Goldmann Applanation Tonometry Measurements in Non-pathologic High Myopia. Front Med. 2022; 9(819715): 1-9.
3. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global Prevalence of Glaucoma and Projections of Glaucoma Burden through 2040. Ophthalmology. 2014; 121(11): 2081–2090.
4. Chuprov AD, Pidodniy EA, Trubnikov VA. Comparative analysis of Maklakov and automated ocular tonometry methods of intraocular pressure measurement. National J glaucoma. 2023; 22(4): 27–32.
5. Murtagh P, O'Brien C. Corneal Hysteresis, Intraocular Pressure and Progression of Glaucoma: Time for a "Hyst-Oric" Change in Clinical Practice? J Clin Med. 2022; 11(10): 1-13.
6. Shiratori N, Nishio Y, Takeda A, Sugimoto S, Takazawa K, Otsuka N, et al. Twenty-Four-Hour Intraocular Pressure Control with Omidenepag Isopropyl 0.002% in Patients with Glaucoma and Ocular Hypertension. Clin Ophthalmol. 2021; 15: 3997–4003.
7. Maklad O, Theofilis V, Elsheikh A. Role of impinging jets in the biomechanical correction of the intraocular pressure (IOP) measurement. ICFD13. 2018 Dec 21: 1-8.
8. Vincent S, Vincent R, Shields D, Lee G. Comparison of intraocular pressure measurement between rebound, non-contact and Goldmann applanation tonometry in treated glaucoma patients. Clin Exp Ophthalmol. 2011; 40: e163-170.
9. Shaheen S, Ali M, Ali A, Sharif H, Afghani T. Comparison of Intraocular Pressure Measurement by Goldmann Applanation Tonometer and Non-Contact Airpuff Tonometer. PJO. 2022; 38(3): 175-180.
10. Gaber FGA, El- Raggal TM, Metwally MG, Abdelmonsef Ebeid A. Comparison of Intraocular Pressure before and after Laser in Situ Keratomileusis Measured with Applana-tion Tonometry, Non Contact Tonometry and Rebound Tonometry. QJM: Int J Med. 2021; 114(Supplement_1): hcab109.011.
11. Trakanwitthayarak S. Comparison of Intraocular Pressure Measurement between Non-Contact and Goldmann Applanation Tonometry among Glaucoma Patients in Ratchaburi Hospital. Jed Assoc Thai. 2020; 103(8): 819–823.
12. Petchyim S. An Agreement of Two Tonometers: Goldmann Applanation and Non-Contact Scheimflug Technology in Healthy, Ocular Hypertension and Open-angle Glaucoma Patients. Siriraj Med J. 2019; 71(3): 201–206.
13. Kyei S, Gboglu CP, Kwarteng MA, Assiamah F. Comparative Assessment of The Goldmann Applanation and Noncontact Tonometers in Intraocular Pressure Measurements in a Sample of Glaucoma Patients in the Cape Coast Metropolis, Ghana. Niger Med J. 2020; 61(6): 323–327.
14. Erdogan H, Akingol Z, Cam O, Sencan S. A comparison of NCT, Goldman application tonometry values with and without fluorescein. Clin Ophthalmol. 2018; 12: 2183–2188.
15. Stock RA, Ströher C, Sampaio RR, Mergener RA, Bonamigo EL. A Comparative Study Between the Goldmann Applanation Tonometer and the Non-Contact Air-Puff Tonometer (Huvitz HNT 7000) in Normal Eyes. Clin Ophthalmol. 2021; 15: 445–451.

16. Kouchaki B, Hashemi H, Yekta A, Khabazkhoob M. Comparison of current tonometry techniques in measurement of intraocular pressure. J Curr Ophthalmol. 2017; 29(2): 92–97.
17. Sharif NA. Glaucomatous optic neuropathy treatment options: the promise of novel therapeutics, techniques and tools to help preserve vision. Neural Regen Res. 2018; 13(7): 1145–1150.
18. Zeppieri M, Gurnani B. Applanation Tonometry. In: Stat Pearls. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Feb 12]. Available from: http://www.ncbi.nlm.nih.gov /books/ NBK 58 2132/
19. Pagoulatos DD, Kapsala ZG, Makri OE, Georgalas IG, Georgakopoulos CD. Comparison of intraocular pressure using Goldmann applanation tonometry versus noncontact tonometry in eyes with high-viscosity silicone oilier J Ophthalmol. 2020; 30(3): 494–499.
20. Mowatt G, Burr JM, Cook JA, Siddiqui MAR, Ramsay C, Fraser C, et al. Screening Tests for Detecting Open-Angle Glaucoma: Systematic Review and Meta-analysis. Invest Ophthalmic Vis Sci. 2008; 49(12): 5373–5385.
21. Vinciguerra R, Rehman S, Vallabh NA, Batterbury M, Czanner G, Choudhary A, et al. Corneal biomechanics and biomechanically corrected intraocular pressure in primary open-angle glaucoma, ocular hypertension and controls. Br J Ophthalmol. 2020; 104(1): 121–126.
22. Ahmed J, Khan MR, Azhar MN, Arain TM, Qazi ZA. Accuracy of IOP measured by noncontact monometer compared with Goldmann Applanation Tonometer. Pak J Ophthalmic. 2014; 30(1): 20-23.
23. Dibaji M, Sheikh RM. Study o accuracy of Intraocular Pressure measured by non contact (air puff) Tonometer confirmed by Goldmann Applanation Tonometer. Pak J Med Health Sci. 2016; 10(3): 972-974.