Open Access

Original Article

Comparison of Intraocular Pressure Measurement by iCare Tonometer and Goldman Applanation Tonometer

Asem Hameed, Beenish Saleem, Mahwish Akhtar*, Waseem Yousaf, Taimoor Ashraf Khan, Abdul Qadir**

Department of Ophthalmology, Combined Military Hospital, Quetta/National University of Medical Sciences (NUMS) Pakistan, *Department of Community Medicine, Fazaia Medical College, Islamabad Pakistan, **Department of Ophthalmology, Combined Military Hospital, Peshawar/National University of Medical Sciences (NUMS) Pakistan

ABSTRACT

Objective: To compare the Intraocular Pressure measured by the Goldmann Applanation tonometer with by iCare ic100 tonometer in normal human eye to determine the accuracy and reliability of both methods.

Study Design: Comparative cross-sectional study.

Place and Duration of Study: Ophthalmology Department, Combined Military Hospital, Quetta Pakistan, from Oct 2022 to Apr 2023.

Methodology: Approval was secured prior to enrolling every individual, protecting their privacy throughout the process. All instruments adhered to the manufacturer's guidelines for calibration. A single ophthalmologist assessed the intraocular pressure of all participants. In our study we included 400 eyes (200 right and 200 left) among 200 patients. Initially, study eyes were inspected using a slit lamp. Subsequently, iCare tonometer and Goldman applanation tonometer were employed to gauge the intraocular pressure.

Results: Out of 200, 87 patients (43.5%) were male and 113(56.5%) were females. Median age of the patients was 51.00(45-58) years range from 22-77 years. Mean IOP measured by iCare was 19.01±7.86 mmHg and by Goldman applanation tonomter was 20.14±8.15 mmHg. The correlation coefficient value between the readings of two instruments was r=0.866 with significant p value ($p< 0.001$).

Conclusion: The iCare ic100 consistently provides high intraocular pressure measurements (2-3mmHg) compared to the Goldmann Applanation tonometer across various sub Groups.

Keywords: Goldmann Applanation tonometer, iCare ic 100 tonometer, Intraocular pressure, Ocular tonometry.

How to Cite This Article: *Hameed A, Saleem B, Akhtar M, Yousaf W, Khan TA, Qadir A. Comparison of Intraocular Pressure Measurement by iCare Tonometer and Goldman Applanation Tonometer. Pak Armed Forces Med J 2024; 74(5): 1379-1383. DOI: https://doi.org/10.51253/pafmj.v74i5.11090*

INTRODUCTION

Intraocular pressure (IOP) is a measurement that should be taken as part of an ophthalmic examination, especially in those patients who have ocular hypertension, glaucoma or patients who have risk factors for developing glaucoma.[1] IOP measurements involve assessing the cornea, which is influenced by its curvature, thickness and biomechanics.[2] The Maklakoff Applanation tonometer, developed in 1865 by Albrecht von Graefe, was the first instrument to measure IOP during that time.[3]

Tonometers that are used in clinical settings nowadays give an estimation and measurement of IOP. Tonometers can be Applanation, rebound, indentation, transpalpebral, or contour.[4] Goldmann Applanation tonometry (GAT) is a gold standard for clinical application.[5] GAT is a small metal device with a measurement range from 0-80 mmHg. To calculate IOP, GAT employs the Imbert-Fick law.[6] To guarantee accurate results, the tonometer should be calibrated on a regular basis with a control weight bar.[7] Despite of being the clinical gold standard, GAT has its limitations including the pre-requisite of corneal anesthesia, requirement of patient cooperation, variability of readings with corneal topographic changes and effect of corneal thickness on intraocular pressure readings.[8]

Measurement of IOP using iCare tonometer is a new technique. The iCare tonometer is a compact handheld equipment that measures IOP using an induction/impact principle.[9] As the instrument is held 3-10 mm from the unanaesthetized eye, a solenoid magnetized probe in the device is driven towards the eye, strikes, and then bounces from the cornea.[10]

Due to paucity of date on the comparison between this two tonometers in our local setup, our study objective was to compare the intraocular pressure measurement by iCare 100 compared with Goldman Aplanation tonometer in normal human eyes.

Correspondence: Dr Taimoor Ashraf Khan, Department of Ophthalmology, Combined Military Hospital, Peshawar Pakistan

Received: 20 Oct 2023; revision received: 01 Jun 2024; accepted: 04 Jun 2024

METHODOLOGY

This Comparative Cross-Sectional study was performed at Combined Military Hospital Quetta, Pakistan for six months, from October 2022 to April 2023 after taking approval from Institutional Review Board (vide reference number CMH/Qta IRB 039)

Inclusion Ciriteria: Normal healthy individuals of either gender, aged 18 years and above, who presented to the OPD of Ophthalmology department were included in this study.

Exclusion Criteria: Patients who had ocular pathologies such as central corneal opacities, nystagmus, corneal astigmatism, ocular infection, ocular trauma, dry eyes, and cornea with contact lenses, and post-operative patients were excluded from this study.

The sample size was calculated by using the WHO sample size calculator by using correlation coefficient r=0.816 for GAT and r=0.916 for iCare.[11] Our sample size came to 200 individuals, or 400 eyes. Sampling was done using a non-probability consecutive sampling.

Prior to enlisting patients, we acquired written, informed consent after ensuring their confidentiality. All devices were adjusted as per the manufacturer's guidelines. The same ophthalmologist measured the intraocular pressure of every patient. The eyes were initially examined using a slit lamp. After that, the iCare Tonometer (ic100) followed by the Goldman Applanation Tonometer was employed to perform intraocular pressure (IOP) assessments while the patient was seated. The iCare device utilizes a disposable probe, ensuring a single-use application. The probe is precisely positioned 4-8 mm perpendicular to the cornea's center. In this procedure, six measurements are taken for each patient. The software disregards the highest and lowest values, utilizing only the four most accurate readings for IOP determination. Subsequently, a 30-minute interval is observed following the iCare method to minimize fluctuations in IOP readings before proceeding with the GAT method. During the utilization of the GAT technique, a small quantity of proparacaine hydrochloride (0.5%) combined with fluorescein (0.25%) was instilled into both eyes. Next, the Goldmann Applanation device, connected to a slit-lamp biomicroscope, was utilized to obtain three measurements from each eye. In our study, if the range of intraocular pressure (IOP) fell within 2mm-Hg, additional testing was unnecessary, and the average of the aforementioned three measurements was considered conclusive.

Subsequently, a pachymeter utilizing ultrasonic waves and possessing a solid tip was employed to gauge the thickness of the central cornea (CCT). In order to determine this, we obtained the mean value from nine rapid measurements subsequent to administering a single drop of proparacaine hydrochloride (0.5%). Lastly, the IOL-Master was utilized to measure the axial length (AL). IOP of GAT measurement was used to divide all the subjects into three Groups: Group with low IOP (eyes with less than 10 mm Hg IOP); Group with normal IOP (eyes with 10–21 mmHg IOP); and Group with high IOP (eyes with more than 30 mmHg IOP).

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 26. Descriptive analysis included frequencies and percentages, mean and standard deviation. In the case of non-normally distributed data, median and interquartile range were presented. To measure the IOP (Intraocular Pressure) using ICare and GAT, independent t-test was employed. The correlation coefficient was calculated, considering a *p*-value ≤0.05 as statistically significant.

RESULTS

In our study, we included 400 eyes (200 right and 200 left) among 200 patients. Out of 200 patients, 87 patients (43.5%) were male and 113(56.5%) were females. Median age of the patients was 51.00(58.00-45.00) years range from 22-77 years. Mean of Central Corneal Thickness (CCT) and Axial Length (AL) was 567.88±34.45 µm and 24.26±1.01 mm respectively. The details of demographic and clinical characteristics are shown in Table-I.

Table-I: Demographic and Clinical Characteristics of the Study Participants (n=200)

Parameters	Catagories	Values
Gender	Male	87(43.5%)
	Female	113(56.5%)
Age in years	Median (IQR)	51.00(58.00-45.00)
	Range	22-77
CCT (µm)	Mean±SD	567.88±34.45
AL (mm)	Mean±SD	24.26±1.01

**CCT: Central Corneal Thickness, AL: Axial Length*

Mean IOP measured by iCare was 19.01±7.86 mmHg and by GAT was 20.14±8.15 mmHg. The mean difference of 1.12 was significant with *p*-value=0.046 shown in Table-II.

Table-II: Comparison of IOP Measurement by iCare 100 and Goldman Applanation Tonometer

Parameter	Instruments		*p*-value
	Goldman Applanation Tonometer (n=400)	iCare (n=400)	
IOP (mmHg)	20.14±8.15	19.01±7.86	0.046

In low IOP Group, mean value of IOP measurement by iCare and GAT was similar with no statistically significant difference (*p*-value=0.059), while normal IOP and high IOP Groups had statistically significant difference in IOP measurement by iCare and GAT as *p*-value< 0.05 shown in Table-III.

Table-III: Measurement of IOP by iCare 100 and Goldman Applanation Tonometer in Three Groups

Groups	Goldman Applanation Tonometer (n=400)	iCare (n=400)	*p*-value
Low IOP(n=44)	8.38±0.96	7.95±0.96	0.059
Normal IOP (n=207)	16.56±3.89	15.22±3.72	< 0.001
High IOP (n=172)	28.60±5.13	27.38±4.37	0.027

Furthermore, both left and right eyes also showed statistically significant difference in IOP measurement by iCare and GAT as *p*-value <0.05 shown in Table-IV.

Table-IV: Measurement of IOP by iCare 100 and Goldman Applanation Tonometer with Respect to Laterality of Eyes

Position of Eye	Goldman Applanation Tonometer (n=400)	iCare (n=400)	*p*-value
Left	20.07±7.87	18.95±7.89	<0.001
Right	19.81±7.98	18.90±7.88	0.001

The correlation coefficient value between iCare and GAT with respect IOP measurement was r=0.866 with significant *p*-value <0.001 shown in Figure.

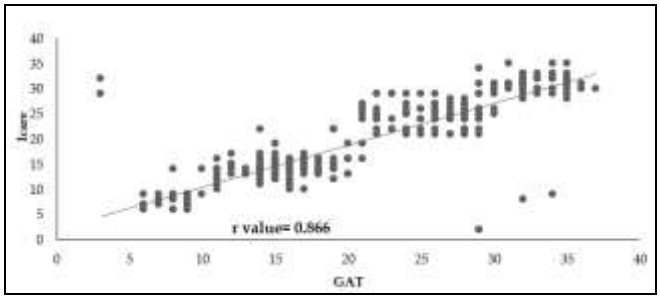

Figure: Correlation between iCare 100 and GAT by Measurement of IOP (mmHg) (n=400)

DISCUSSION

Our results confirmed strong correlations between the IOP measurements obtained from iCare ic100 and GAT within three distinct Groups. GAT has consistently been considered the benchmark for assessing IOP.[12] Despite its benefits, GAT has certain drawbacks. Firstly, it requires an expert hand to perform and also needs patient's cooperation. Secondly, instillation of topical anesthetic drug and fluorescein staining are mandatory for the measurement process. Lastly, there is a potential risk of infection associated with the contact of the prism tip.[13]

The basic idea behind GAT measurement is to flatten a specific region of the central cornea. As a result, corneal biomechanics and the thickness of the central cornea inherently influence GAT measurements.[14] Ehlers *et al.*[15] discovered that for accurate IOP measurements with GAT, a corneal thickness of 520 µm is necessary. In our investigation, the average measurement of the thickness of the central cornea was 567.88±34.45, aligning closely with the findings of Ehler's research.

iCare is a compact, portable gadget containing a disposable magnetized tool. It doesn't necessitate local anesthesia or fluorescein dye for measuring IOP. It is simpler for operators to use and causes less discomfort to patients, making it a viable alternative to GAT.[16] In our study on 200 patients, mean IOP measured by iCare was 19.01±7.86 mmHg and by GAT was 20.14±8.15 mmHg. Similar to our study, Subramaniam *et al*. demonstrated that mean IOP measured by iCare was 12.1±4.6 mmHg and 16.2±5.3 mmHg measured by GAT.[17] Tamcelik *et al*. discovered that iCare Pro had a tendency to overestimate intraocular pressure (IOP) when the IOP was low and underestimate it when the IOP was high, as compared to the Goldmann Applanation tonometry (GAT).[18] However, our study revealed that there was no significant variation in the average IOP measurements obtained by iCare Pro and GAT across the three different IOP Groups. Martinez-de-la-Casa *et al*. conducted a study in which they found a strong correlation (r=0.865) between the intraocular pressure (IOP) readings obtained using the iCare tonometer and the Goldmann Applanation tonometer (GAT).[19] In our own study, we also observed a strong comparable correlation coefficient (r=0.866) between iCare and GAT measurements. Consistent with Martinez-de-la-Casa's findings, we found that the IOP readings obtained by the iCare

were consistently 2-3mmHg higher than those obtained by the Goldman Applanation tonometer in all three Groups studied.

Based on our observations, to achieve more precise readings (with reduced error bars) or readings that align better with the GAT, we found it crucial to pay extra attention to the following factors: ensuring that the tonometer probe was held perpendicular to the cornea, taking the 6 measurements rapidly, and minimizing any movements of both the operator and the patients' eyes during the process.

LIMITATIONS OF STUDY

Our study had several limitations that should be acknowledged. Firstly, the sample size of subjects in the low and high IOP Groups was relatively small, which may have limited the power of subGroup analysis. Secondly, we did not assess corneal biomechanics parameters, which could potentially influence IOP measurements. In future studies, it would be beneficial to include a larger sample size with or without astigmatism and to evaluate corneal biomechanics to enhance the comprehensiveness of our research.

ACKNOWLEDGEMENT

We would like to acknowledge all those who participated directly or indirectly in the study.

CONCLUSIONS

The ICare 100 consistently provides higher IOP measurements (2-3mmHg) compared to the Goldmann Applanation tonometer (GAT) across various subGroups. However, caution should be exercised, particularly for IOP values that are high (≥22 mmHg), as the ICare tonometer may not accurately reflect true IOP in such cases.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AH & BS: Conception, study design, drafting the manuscript, approval of the final version to be published.

MA & WY: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

TAK & AQ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Brusini P, Salvetat ML, Zeppieri M. How to measure intraocular pressure: an updated review of various tonometers. J Clin Med 2021; 10(17): 3860. https://doi.org/10.3390/jcm10173860
2. Olyntho Junior MA, Augusto LB, Gracitelli CP, Tatham AJ. The effect of corneal thickness, densitometry and curvature on intraocular pressure measurements obtained by applanation, rebound and dynamic contour tonometry. Vision 2020; 4(4): 45. https://doi.org/10.3390/vision4040045
3. Ramesh PV, Ramesh SV, Sainath D. Commentary: Decoding the intraocular pressure conundrum surrounding the core of COR. Indian J Ophthalmol 2023; 71(3): 879-880. https://doi.org/10.4103/ijo.IJO_7_23_7
4. Da Silva F, Lira M. Intraocular pressure measurement: A review. Surv Ophthalmol 2022; 67(5): 1319-1331. https://doi.org/10.1016/j.survophthal.2022.03.001
5. Hojati A, Yerrabelli RS, Amin AS, Smith AD, Brozek J. A simulator for Goldmann Applanation Tonometry: a novel approach to training. Res Sq 2023. https://doi.org/10.21203/rs.3.rs-2503331/v1
6. Garcia-Feijoo J, Martinez-de-la-Casa JM, Morales-Fernandez L, Frances FS, Santos-Bueso E, Garcia-Saenz S, et al. New technologies for measuring intraocular pressure. Prog Brain Res 2015; 221: 67-79. https://doi.org/10.1016/bs.pbr.2015.06.003
7. Moses RA. The Goldmann applanation tonometer. Am J Ophthalmol 1958; 46(6): 865-869. https://doi.org/10.1016/0002-9394(58)90998-X
8. Ahmed RM, Nawwar MT, Ourouk WM, Higazy MT. Comparison of Rebound Tonometry and Goldmann Applanation Tonometry in Measuring Intraocular Pressure in Healthy Subjects. Benha J Appl Sci 2022; 7(4): 113-117.
9. Saarela V, Karvonen E, Stoor K, Hägg P, Luodonpää M, Kuoppala J, et al. The Northern Finland birth cohort eye study: design and baseline characteristics. BMC Ophthalmol 2013; 13: 1-7. https://doi.org/10.1186/1471-2415-13-51
10. Nakakura S, Asaoka R, Terao E, Nagata Y, Fukuma Y, Oogi S, et al. Evaluation of rebound tonometer iCare IC200 as compared with ICare PRO and Goldmann applanation tonometer in patients with glaucoma. Eye Vis 2021; 8: 1-9. https://doi.org/10.1186/s40662-021-00249-z
11. Wong B, Parikh D, Angert M, Gorski M, Shih C. Comparison of disposable Goldmann applanation tonometer and ICare ic100 to standards of care Goldmann nondisposable applanation tonometer and Tono-pen XL for Measuring Intraocular Pressure. Invest. Ophthalmol. Vis. Sci 2017; 58(8): 5318.
12. Garcia-Feijoo J, Martinez-de-la-Casa JM, Morales-Fernandez L, Frances FS, Santos-Bueso E, Garcia-Saenz S, et al. New technologies for measuring intraocular pressure. Prog Brain Res 2015; 221: 67-79. https://doi.org/10.1016/bs.pbr.2015.06.003
13. Brusini P, Salvetat ML, Zeppieri M, Tosoni C, Parisi L. Comparison of ICare tonometer with Goldmann applanation tonometer in glaucoma patients. J Glaucoma 2006; 15(3): 213-217. https://doi.org/10.1097/01.ijg.0000212208.87523.66
14. Clement CI, Parker DG, Goldberg I. Suppl 1: M2: Intra-Ocular Pressure Measurement in a Patient with a Thin, Thick or Abnormal Cornea. Open Ophthalmol J 2016; 10: 35. https://doi.org/10.2174%2F1874364101610010035
15. Bechmann M, Thiel MJ, Roesen B, Ullrich S, Ulbig MW, Ludwig K, et al. Central corneal thickness determined with optical coherence tomography in various types of glaucoma. Br J Ophthalmol 2000; 84(11): 1233-1237. http://dx.doi.org/10.1136/bjo.84.11.1233

16. Pakrou N, Gray T, Mills R, Landers J, Craig J. Clinical comparison of the ICare tonometer and Goldmann applanation tonometry. J Glaucoma 2008; 17(1): 43-47. https://doi.org/10.1097/IJG.0b013e318133fb32
17. Subramaniam AG, Allen P, Toh TY. Comparison of the ICare ic100 rebound tonometer and the Goldmann Applanation Tonometer in 1,000 Eyes. Ophthalmic Res 2021; 64(2): 321-326. https://doi.org/10.1159/000511455
18. Tamçelik N, Atalay E, Cicik E, Özkök A. Comparability of ICare pro rebound tonometer with Goldmann applanation and noncontact tonometer in a wide range of intraocular pressure and central corneal thickness. Ophthalmic Res 2015; 54(1): 18-25. https://doi.org/10.1159/000381781
19. Martinez-de-la-Casa JM, Garcia-Feijoo J, Castillo A, Garcia-Sanchez J. Reproducibility and clinical evaluation of rebound tonometry. Invest Ophthalmol Vis Sci 2005; 46(12): 4578-4580. https://doi.org/10.1167/iovs.05-0586