

Original Article

Evaluating the Diagnostic Accuracy of the iCare Rebound Tonometer Compared to the Goldmann Applanation Tonometer

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Abstract

Purpose: To compare the diagnostic accuracy of the iCare rebound tonometer and the Goldmann Applanation Tonometer (GAT).

Patients and Methods: A comparative assessment of intraocular pressure (IOP) was conducted on patients visiting the vision clinic at Torfeh Eye Hospital, Tehran, Iran, from May 2022 to August 2022. The IOP of both eyes of each patient was initially measured by one individual using the iCare tonometer device. Then, the patients were referred to the ophthalmology department, where the IOP of both eyes was measured using the GAT by an ophthalmologist who was unaware of the IOP results obtained with the iCare tonometer.

Results: The mean age of the patients entering the study was 49 ± 17 years. The mean IOP measured with the GAT was 14.47 ± 5.92 mmHg with a range of 6 mmHg to 75 mmHg. With the iCare tonometer, it was 14.44 ± 6.42 mmHg, with a range of 6.1 mmHg to 80.7 mmHg, indicating no statistically significant difference between the two devices. There was a very strong correlation ($r: 0.864$; 95% confidence interval 0.732-0.983; $P < 0.001$) between the measurements by GAT and the iCare device. The correlation strength did not show a substantial difference between male ($r: 0.885$) and female ($r: 0.816$) patients. The correlation was strong among patients with low IOP ($r: 0.631$), normal IOP ($r: 0.797$), and high IOP ($r: 0.781$) eyes.

Conclusion: iCare tonometer IOP readings have acceptable correlation with GAT readings and can be considered a reliable alternative to GAT for measuring IOP by primary health providers.

Keywords: Glaucoma; Tonometer; Blindness, Screening; iCare; Intra Ocular Pressure .

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Introduction

Glaucoma can lead to blindness due to irreversible damage to the optic nerve. In Iran, the prevalence of glaucoma has been reported as 1.92 % in the age group of 40-60 years and 0.9 % in the age group of 40-44 years, increasing to 3.55 % in the age group of 60-64 years ¹. The percentage of patients who become blind due to glaucoma has been reported to range from 5 % to 33 % ². However, blindness and irreversible vision loss caused by glaucoma can be prevented with timely diagnosis and treatment ².

It is estimated that 4 % to 7 % of people over 40 years of age in the United States have high intraocular pressure (IOP) without detectable glaucoma damage in standard tests ³. In a retrospective cohort study, the cumulative incidence of blindness due to glaucoma was 0.17 % in the screened population compared to 0.32 % in the unscreened population ⁴. These results suggest that population screening may reduce bilateral vision loss and blindness due to glaucoma by about 50 % ³.

Accurate measurement of IOP in ophthalmology examinations is necessary for the diagnosis and management of glaucoma ⁵. Primary care workers can be trained to screen for glaucoma ⁶. Currently, the screening rate for asymptomatic glaucoma by primary care physicians is unclear, and asymptomatic glaucoma often goes undiagnosed ⁷.

The gold standard for measuring IOP in eye examinations is Goldmann Applanation Tonometry (GAT), which is widely used in ophthalmology clinics ⁸. A new alternative to the GAT for measuring IOP is the iCare rebound tonometer ⁹. The iCare tonometer is a portable handheld device that simplifies intraocular pressure measurement, requiring minimal training. This device even has a model for patients to use themselves ¹⁰. Unlike

the GAT, the iCare tonometer does not require local anesthesia and is easier to use ¹¹.

The main purpose of this study was to compare the IOP measurement results obtained from the GAT and the iCare rebound tonometer and to investigate the correlation between these two devices. The results of the study can help us to determine if the iCare device can be used as a reliable alternative to GAT for measuring IOP by primary health providers.

Patients and Methods

In this study, a comparative assessment of intraocular pressure (IOP) was conducted on patients visiting the vision clinic at Torfeh Eye Hospital, Tehran, Iran, from May 2022 to August 2022. The IOP of both eyes of each patient was initially measured by one individual using the iCare tonometer device. Subsequently, the patients were referred to the ophthalmology department, where the IOP of both eyes was measured using GAT by an ophthalmologist who was unaware of the IOP results obtained with the iCare tonometer.

The age of the patients, underlying diseases, and the diagnosis of eye conditions did not affect the study process. All patients provided written consent before participating in the study, which was approved by the ethics committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Statistical analysis of the IOP results obtained from the iCare tonometer and the GAT was performed to determine if there is a statistically significant difference between the two devices and whether their results are in agreement and correlated with each other. We also divided eyes into patients with low IOP ($IOP < 10$), normal IOP ($10 \leq IOP \leq 21$) and high ($IOP > 21$) and calculated the correlation for each group.

Statistical Analysis

Descriptive measures such as mean, standard deviation, median, and range were used to describe the data. The mean IOP measured by each tonometer was compared. The Pearson correlation coefficient was used to explore the correlation between the IOP measurements of the two instruments. The Pearson correlation coefficient was interpreted as $r = 0 - 0.2$ very weak or no correlation, $r = 0.2 - 0.4$ weak correlation, $r = 0.4 - 0.6$ moderate correlation, $r = 0.6 - 0.8$ strong correlation, and $r = 0.8 - 1.0$ very strong correlation. The 95 % limits of agreement between the two methods of tonometry were calculated by the Bland–Altman method. All statistical analyses were conducted using SPSS software Version 25 (Armonk, NY: IBM Corp). A p-value of less than 0.05 was considered indicative of statistical significance.

Results

In this study the intraocular pressure of 412 eyes from 206 patients including 105 females and 101 males was measured. The mean age of patients was 49 ± 17 years. There was no statistically significant difference between the mean IOP measured by GAT and iCare device. The mean IOP measured with the GAT was 14.47 ± 5.92 mmHg with a range of 6 mmHg to 75 mmHg, and with the iCare tonometer, it was 14.44 ± 6.42 mmHg with a range of 6.1 mmHg to 80.7 mmHg. There was a very strong correlation ($r: 0.864$; 95 % confidence interwall 0.732 - 0.983; $P < 0.001$) between the measurements by GAT and iCare device (Table 1). The correlation strength did not show a substantial difference among male ($r: 0.885$; 95 % confidence interwall 0.715 - 0.965) and female patients ($r: 0.816$; 95 % confidence interwall

0.754 - 0.863). The correlation was strong among patients with low IOP ($r: 0.631$; 95 % confidence interwall 0.017-0.858; $P < 0.001$), normal IOP ($r: 0.797$; 95 % confidence interwall 0.752-0.839; $P < 0.001$), and high IOP ($r: 0.781$; 95 % confidence interwall 0.052-0.971; $P < 0.001$) eyes.

Discussion

Tonometry, or IOP measurement, is a fundamental process in routine eye examinations⁹. Accurate and precise measurement of intraocular pressure (IOP) is essential for the diagnosis and treatment of glaucoma, serving as the sole effective method to prevent irreversible blindness¹². The gold standard for measuring IOP is the GAT⁵. The procedure for measuring IOP with the GAT is challenging, requiring specialized equipment such as a slit lamp device, the presence of an ophthalmologist, and local anesthesia⁵. Consequently, access to this measurement is limited to ophthalmology clinics where an ophthalmologist is available.

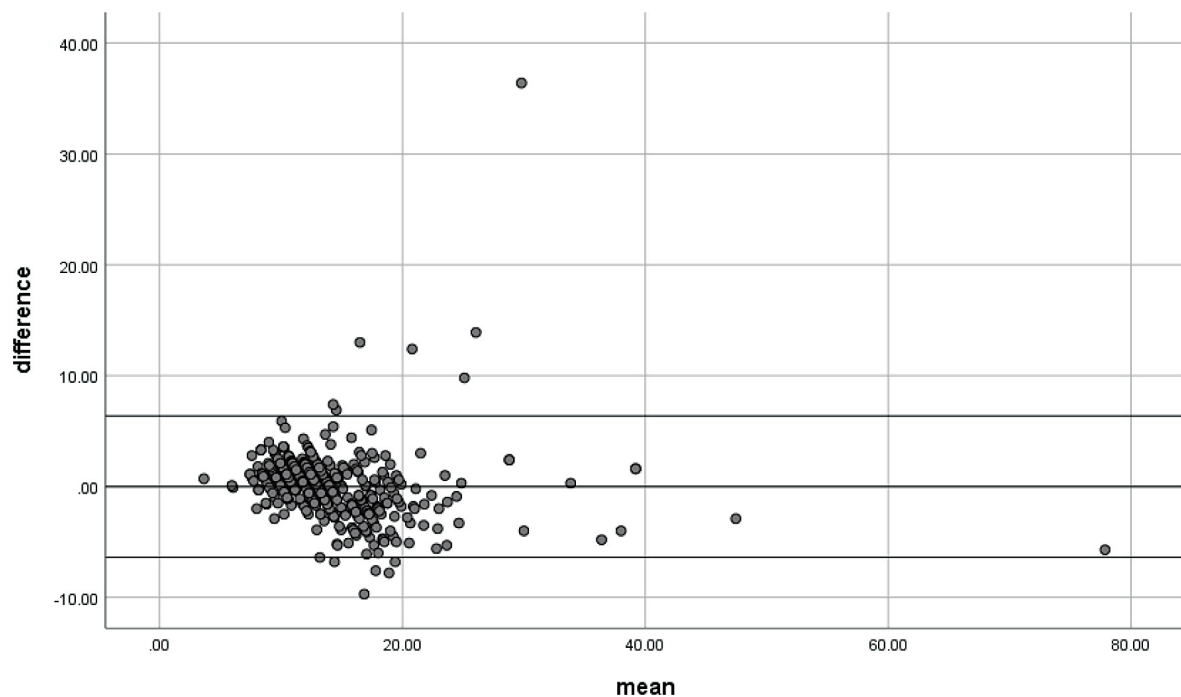
Given that accurate and precise measurement of IOP is a crucial factor in diagnosing and preventing irreversible blindness caused by glaucoma, it is both rational and reasonable to explore alternative methods to the GAT⁸. Based on previous studies, it seems that the iCare tonometer could serve as a suitable alternative to the GAT⁵.

The results of our study indicated a mean IOP reading of 14.47 ± 5.92 mmHg when using the GAT, and 14.44 ± 6.42 mmHg with the iCare tonometer ($P = 0.982$). Similar to our finding Vandewalle et al.,¹³ reported a mean IOP reading of 15.1 ± 4.8 mmHg when using GAT and 15.7 ± 5.7 mmHg when using iCare device indicating no statistically significant difference between the mean readings. Also, Brusini et al.,¹⁴ reported a mean IOP reading

Table 1: The mean and correlation of IOP readings by Goldmann Applanation Tonometry and iCare tonometer

Variable	IOP Reading mmHg Mean $\pm$ SD		Number of Eyes	Pearson Correlation Coefficient (r)	95% Confidence Interval for Correlation		* P Value (Correlation)
	Goldmann Applanation Tonometry	iCare			Lower	Upper	
IOP Total	14.47 $\pm$ 5.92	14.44 $\pm$ 6.42	412	0.864	0.732	0.983	< 0.001
IOP Male	15.099 $\pm$ 7.81	14.663 $\pm$ 8.02	202	0.885	0.715	0.965	< 0.001
IOP Female	13.876 $\pm$ 3.10	14.301 $\pm$ 4.36	210	0.816	0.754	0.863	< 0.001
IOP < 10	8.26 $\pm$ 1.17	8.23 $\pm$ 1.65	30	0.631	0.017	0.858	< 0.001
10 $\leq$ IOP $\leq$ 21	13.86 $\pm$ 2.74	14.05 $\pm$ 4.04	359	0.797	0.752	0.839	< 0.001
IOP > 21	32.17 $\pm$ 12.07	29.20 $\pm$ 14.75	23	0.781	0.052	0.971	< 0.001

* Pearson Correlation

**Figure 1:** Bland Altman plot depicting the agreement of IOP readings by Goldmann Applanation Tonometry and iCare tonometer

of 18.5 ± 5.7 mmHg when using GAT and 18.4 ± 5.2 mmHg when using iCare device indicating no statistically significant difference between the mean readings.

In the present study the results of IOP measurements by the GAT and the iCare tonometer showed a strong correlation ($r: 0.864$). Similar to our results a strong correlation between these two devices has been previously reported by Gao et al.,⁹ ($r=0.806$), Kim et al.,¹⁵ ($r = 0.699$), Stoor et al.,¹⁶ ($r = 0.735$).

Based on the results of the present study and prior research, it is suggested that the iCare tonometer could serve as a suitable alternative for accurate IOP measurement. Furthermore, given that measuring IOP is the primary diagnostic criterion for glaucoma, and considering that the diagnostic accuracy of the iCare tonometer is similar to that of the Goldmann tonometer, it can be employed for screening high-risk individuals in vision clinics, healthcare centers, and rural areas where access to an ophthalmologist and slit lamp is limited. In the event of elevated IOP measured by the iCare tonometer, referral to an ophthalmologist can be initiated. Therefore, through the utilization of this device, general practitioners, optometrists, and healthcare professionals can play a significant role in the diagnosis and screening of glaucoma.

Conclusion

iCare tonometer IOP readings have acceptable correlation with GAT readings and this device can be considered a reliable alternative to GAT for measuring IOP by primary health providers.

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Footnotes and Financial Disclosures

Conflict of interest:

The authors have no conflict of interest with the subject matter of the present manuscript.