Original Article

Accuracy of I-care Rebound Tonometer and Its Comparison with Goldman Applanation Tonometer

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ABSTRACT

Purpose: To determine accuracy of I-Care rebound tonometer (IRT) in terms of agreement with Goldman Applanation Tonometer (GAT) and effect of Central corneal thickness (CCT) on its accuracy.

Study Design: Comparative cross sectional study.

Place and Duration of Study: Ophthalmology Department of Ittefaq Hospital Lahore from September 2022 to May 2023.

Methods: Participants of the study were recruited through non-probability convenient sampling. With I-care PRO® rebound tonometer (IRT), two consecutive sets of measurements with 6 measurements for each set were made, and the averaged values were used for the statistical analyses. After 5 minutes GAT measurement was taken for intraocular pressure (IOP). CCT was measured by ultrasound pachymetry from mean of 2 measurements noted. Data was analyzed by Bland-Altman plots for determining agreement of GAT-IOP and IRT-IOP. Pearson correlation coefficient determined the correlation of GAT-IOP and IRT-IOP with CCT.

Results: Out of 200 participants there were 76(38%) males and 124(62%) females. Mean age of participants was 27.84±6.1 years. Mean IOP with IRT was 16.24±2.02 (range 12.1 – 20.3 mmHg). Mean IOP with GAT was 14.40±1.98 (range 11.00 – 19 mmHg). Mean IOP with adjusted CCT using GAT was 14.40±1.64 (range 11 – 18 mmHg). Mean CCT was 544.81±42.04 (range 615 – 471um). Mean IOP-GAT & IOP-IRT with adjusted CCT showed normal distribution. Mean difference of IOP-GAT and IOP-IRT with t test was 1.83±1.12 (p=.079).

Conclusion: There is a strong agreement between IOP-GAT and IOP-IRT. CCT had a strong impact on IOP measurements with both tonometers. However, CCT affected IOP reading of GAT more than IRT.

Key Words: Intraocular pressure, Goldman Applanation tonometer, Rebound tonometer, I-Care tonometer.

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INTRODUCTION

An error-free measurement of IOP is cardinal in the management of various ophthalmic conditions. Continuous monitoring of IOP is an essential requirement in almost all ocular conditions e.g., glaucoma, uveitis, pre- or post-surgical procedures, ocular trauma, steroid responders, ocular hypertension etc. In routine ophthalmic practice GAT is considered the gold standard for measuring IOP worldwide. However, it has some limitations such as its reliance on CCT and corneal scarring can give false high or low IOP measurements. Corneal astigmatism and biomechanical properties of cornea are reported to have impact on IOP measurement as well.[1]

Furthermore, due to its contact nature there is an increase chance of cross infections as well. It requires topical anesthetic eye drops, which can cause

discomfort. Getting IOP measurements is also difficult in patients with deep sunken eyes, and/or children.[2]

With the advancement of technology different types of contact and non-contact tonometers were introduced over the last few decades to address the issues related to GAT. The Icare PRO® rebound tonometer (IRT) (iCare, Helsinki, Finland) is one of the non-contact devices that was being introduced and now globally used. It has an advantage over GAT that it does not require topical anesthetics and fluorescein dye and easy to use. In IRT technique, there is rebound of a fine plastic probe after swift contact and springs back from the cornea which measures IOP. The deceleration of the probe is calculated into the IOP and a mean of six readings (rebounds per measurement) is displayed on the device screen in different three colors.[3]

Previous studies found that IOP measurement methods including iCare and GAT are affected by CCT.[4]However, corneal thickness is reported to have less impact on the measurements with IRT.[2] Furthermore, Nakakura, S. et al, reported comparable IOP measurement outcomes between iCare PRO and IC200 and GAT in a study on 145 glaucomatous eyes.[5] Chen, M., et alevaluated the comparison of IOP readings by non-contact air puff tonometer (NCT), iCare pro rebound tonometer (iCare), and GAT and found that iCare measurements are significantly comparable with GAT statistically as compared to air puff tonometer.[6] Although literature validate the reliability of IOP measurements with Icare PRO® rebound tonometer, however the results of studies comparing GAT and IRT remain debatable due to the heterogeneity of the study population and the difference in the IOP range measured in variable ophthalmic conditions. In different clinical settings different devices are used that raises the concerns if the results of these tonometers are interchangeable. What about the inter-device compatibility in different IOP groups and which method is more significantly affected by CCT? This study was designed to determine accuracy of IRT in terms of agreement with GAT and to see the effect of CCT on its accuracy.

METHODS

A comparative cross-sectional study was conducted at the Ophthalmology Department of Ittefaq Hospital Lahore from September 2022 to May 2023 after approval by the Institutional Review Board (TUF/IRB/205/23). Non-probability convenient sampling technique was used. After informed consent the self-designed proforma was filled out. Participants with age range between 18-40 years were included in the study, other inclusion criteria were: patients with confirmed or suspected glaucoma (POAG), best-corrected visual acuity (BCVA) of 6 /9 or better, and CCT more than 450um. Subjects were excluded if they had any corneal pathology; pterygium, corneal edema, scarring, corneal graft etc. Participants wearing contact lens on the day of examination, or diagnosed with secondary causes of glaucoma, history of ocular trauma or active systemic diseases (e.g., Diabetes, HTN), pregnancy or patient on ocular or systemic steroids, or patients suffering from any physical or mental disability that interfere with the use of Tonometer were also excluded.

With Icare PRO® rebound tonometer (IRT), two consecutive sets of measurements with 6 measurements for each set were made, and the averaged values were used for the statistical analyses. Approximately 5 minutes after these measurements, a GAT measurement was taken. In all participants, the CCT was measured by ultrasound pachymetry (SP-100; TOMEY, Tokyo, Japan), and was determined from the mean of 2 measurements noted.

Data was analyzed using IBM SPSS version 25. Normality of the data was assessed by using Shapiro-Wilk test. P>0.05 suggested that the data had a normal distribution. The mean of IOP with IRT, GAT, CCT and GAT with adjusted CCT was determined. T test was applied for difference of IOP of IRT and GAT. The Pearson correlation test was used to correlate the value of IOP (in mmHg) measured by GAT and IRT and to establish the relationship between the CCT and the intraocular pressure of GAT and IRT. The data was further analyzed by Bland-Altman plots to determine the IOP difference between IRT and GAT at the 95% CI. A difference in IOP of ≤2mmHg between the two instruments was considered clinically significant. Correlation of IOP measurements and CCT using GAT was evaluated through a standard scale for IOP correction factor according to CCT.[7]

RESULTS

Out of 200 participants, there were 76(38%) males and 124(62%) females. Mean age of participants was 27.84±6.1 years (range 18 to 40 years). Using descriptive statistics, the mean IOP with IRT was 16.24 ± 2.02 (range 12.1 – 20.3 mmHg) and with GAT

Table 1: *Mean IOP with IRT and GAT and Mean CCT and IOP-GAT with adjusted CCT.*

	IOP-GAT[a] (mmHg)± SD	IOP-IRT[b] (mmHg)±SD	CCT[c] (um) ± SD	IOP-GAT[b](mmHg) with Adjusted CCT (um) ±SD
Mean	14.40±1.98	16.23±2.01	544.81±42.03	14.4±1.644
Variance	3.931	4.068	1767.009	2.702
Minimum	11.00	12.1	471.00	11
Maximum	19.00	20.3	615.00	18

[a]GAT-Goldman ApplanationTonometer,[b]IRT-IcarePRO®Rebound Tonometer, [c]CCT- central corneal thickness.

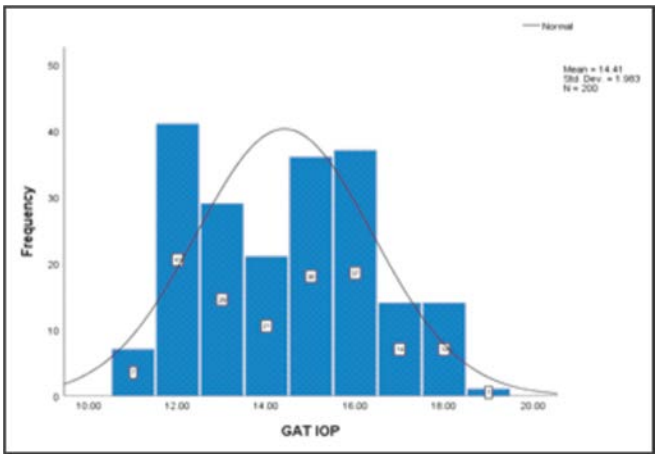

Figure 1: Mean of IOP-GAT with adjusted CCT showing the normal distribution.

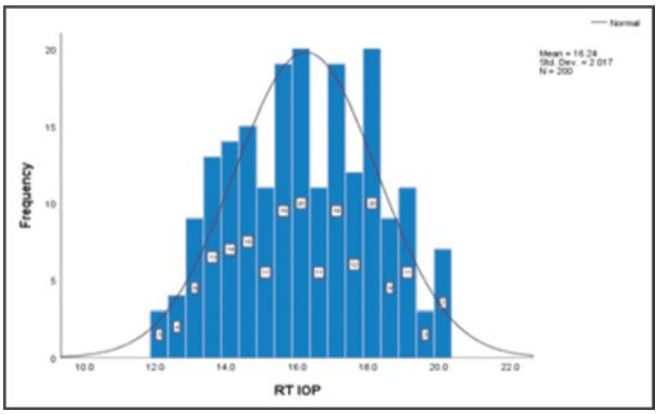

Figure 2: Mean of IOP-IRT with adjusted CCT showing the normal distribution.

was 14.4±1.982 mm Hg (range 11 – 19mmHg). Mean IOP with adjusted CCT using GAT was 14.40±1.64 mmHg (range 11 – 18mmHg). Mean CCT was 544.81±42.04 um (range471 – 615um) Table1. Mean IOP-GAT and IOP-IRT with adjusted CCT showing the normal distribution is shown in Figures 1 and 2.The mean difference of IOP-GAT and IOP-IRT with t test was 1.83 ±1.12 mm Hg (p=0.079).

The Bland–Altman analysis presented the distribution of IOP differences of GAT and IRT. The average of both tonometers was taken on x-axis and difference of both tonometers was taken on Y-axis. Mean 1.83±1.96 at 95% confidence interval (CI) showed a strong agreement between IOP-GAT and IOP-IRT. The middle line showed the mean of 1.83, upper and lower limit of agreement with 1.83±1.96 (Figure 3).

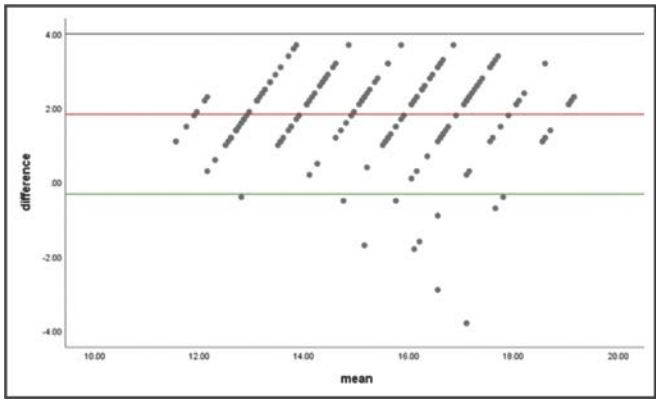

Figure 3: Bland–Altman plot between IOP-GAT and IOP-IRT.

Pearson correlation coefficient showed strong positive linear and statistically significant correlation between GAT and CCT (r= .871, r^2 = 0.759, p<0.001). This correlation determined that increase in CCT was associated with rise of IOP which also affected the IOP-GAT measurements. Pearson correlation coefficient between IRT and CCT was positive moderate linear but statistically significant (r= .709, r^2 = 0.502, p<0.001). This correlation showed that increase in CCT associated with rise of IOP was less affected in case of IRT when compared with GAT.

DISCUSSION

In the current hospital-based study, IOP was measured using Icare PRO tonometer (IRT) and Goldmann Applanation Tonometer (GAT), in 200 eyes of 200

patients in sitting position to determine the difference of IOP measurements between GAT and IRT. We also determined the impact of CCT on IOP measurements using both devices. Literature has shown effects of CCT on IOP.[8,9,10]

In this study mean IOP-IRT was 16.24±2.01 mmHg and the mean IOP-GAT was 14.4±1.98 mmHg. The IOP measurements were within normal range of 10 to 21 mmHg with normal distribution of data ($P<0.05$). The mean difference of IOP (IRT-GAT) which was 1.8±1.12 mmHg demonstrated that IOP values taken with the IRT were overestimated as compared to GAT (as the clinically relevant mean deviation of the measured values between the two instruments set in current study criteria was IOP differences of $\leq$ 2 mmHg. However, it should be considered that IOP-GAT values were adjusted for CCT to get true IOP in comparison to those taken by the IRT. Moreover, the Bland-Atman plots also showed linear direct agreement of the measurement. When this plot was drawn for IOP-GAT with adjusted CCT, there was a significance deviation from linear relationship. Our findings are in accordance with the previous reports which also found IOP deviation on higher side with IRT as compared to IOP-GAT.[11,12] In contrast, Tamcelik et al, reported an underestimation of the IOP-IRT measurements as compared to IOP-GAT.[4]Meta-analysis of six studies on the concordance of IRT and GAT reported mean difference of 1.15 mmHg.[13]

The impact of CCT on IOP between the two methods has been analyzed in several studies. Brusini et al, noticed that every 10-um change in CCT draws a 0.7 mmHg deviation in Icare tonometer measurements. Similarly, it was also found that with GAT, the changes in IOP readings were 1.1 mmHg/100um of CCT and with IRT 8mmHg/100um of CCT.[14,15]Stoor K et al, (with Icare model TA01i and GAT)found that the difference between the IOP readings scaled up when CCT was increased.[16]

The present study also determines a strong positive direct relationship of GAT and CCT ($r= .871$, $r^2= 0.759$, $p<0.01$) and positive moderate linear relationship between IRT and CCT ($r= .709$, $r^2 = 0.502$, $p<0.01$) with Pearson correlation coefficient test. Although both results are statistically significant but association of rise in IOP with increased CCT has less impact on the IOP-IRT measurements as compared to IOP-GAT measurements. The Pearson correlation coefficient test applied for IOP-GAT with adjusted CCT and IOP-IRT draws a negative weak correlation of IOP-GAT with adjusted CCT and IOP-IRT. ($r = -0.227$; $r^2 = 0.051$; $p = 0.001$). Thus, accentuating the need to consider IOP-GAT measurements with adjusted CCT.

Hence, our study showed that CCT has impact on the measurements with both IRT and GAT. The Deceleration of the iCare probe is claimed to be proportional to IOP in early rebound tonometer models. Therefore, the probe deceleration could also be altered by corneal parameters i.e., the thicker or rigid cornea. The shorter duration of impact, thus could be a cause or IRT to overestimate IOP.[17]

Multiple studies compared GAT with different Icare models in healthy as well as glaucoma patients. The reports have variable outcomes and in different ethnicity. For example; Peraz et al, measured IOP readings by IC200 RT and compared with hand-held GAT.[18] They reported tendency towards overestimation of IOP with IC200 but the differences in IOP measurements between IC200 and GAT were not statistically significant in patients with glaucoma and in healthy volunteers. CCT and IOP measurements demonstrated a statistically significant correlation with IC200 ($r = 0.32$; $p = 0.003$) and GAT ($r = 0.23$; $p = 0.031$).[18] The mean IOP values between the two tonometers were 15.91 and 20.10 mm Hg. It should be noted that excellent agreement was found for the IC200 and GAT tonometers in both healthy and glaucoma patients. The IC200 showed a tendency to overestimate IOP. But in patients with glaucoma, CCT had no effect on IOP readings.

Badakere et al, also compared IOP in adult eyes using IcareIC200 and GAT. They reached to the conclusion that iC200 could be an effective alternative for GAT within IOP range of 7.4 to 50 mmHg due to the small level of agreement between the tonometers at an IOP of less than 21 mmHg.[19]

Similarly, in our study we concluded a strong agreement of IOP reading between GAT and IRT with 95% limits of agreement and the results supported that the two instruments can be interchangeable when there were limitations of GAT especially in screening of the community e.g., bedridden patients.[20]

Even in children with and without primary congenital glaucoma where it is difficult to use GAT for monitoring because of need of topical anesthesia and fluorescein, IRT can be a reliable device to get IOP readings.[21,22]

Limitations of this study are that we did not evaluate corneal biomechanical parameters, which can affect IOP measurements. This study did not include high pressure ranges. High IOP can also affect the readings of many tonometers. However, IRT because of its ease of use can be appropriate for home tonometry. It has the capacity to record and save measurement results, which may then be reviewed there or sent to a computer. Its ease of use makes it a suitable tonometer for screening.

CONCLUSION

Routine IOP monitoring using IRT is feasible in medical settings. It is handheld, portable and does not need any anesthesia and fluorescein like GAT. It can be used in children and patients with poor cooperation. As the IRT has a smaller impact on fluctuations in corneal thickness so it can be used in the presence of corneal pathology.

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Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(TUF/IRB/205/23).**

REFRENCES

1. **Yaoeda K, Fukushima A, Shirakashi M, Fukuchi T.** Comparison of intraocular pressure adjusted by central corneal thickness or corneal biomechanical properties as measured in glaucomatous eyes using noncontact tonometers and the Goldmann applanation tonometer. Clin Ophthalmol. 2016;**10:**829-834. Doi: 10.2147/OPTH.S106836.
2. **Subramaniam AG, Allen P, Toh T**. Comparison of the Icare ic100 Rebound Tonometer and the Goldmann Applanation Tonometer in 1,000 Eyes. Ophthalmic Res. 2021;**64(2):**321-326. Doi: 10.1159/000511455
3. **Kato Y, Nakakura S, Matsuo N, Yoshitomi K, Handa M, Tabuchi H, et al.** Agreement among Goldmann applanation tonometer, iCare, and Icare PRO rebound tonometers; non-contact tonometer; and Tonopen XL in healthy elderly subjects. Int Ophthalmol. 2018;**38(2):**687-696. Doi: 10.1007/s10792-017-0518-2
4. **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. Doi: 10.1159/000381781.
5. **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 (Lond). 2021;**8(1):**25. Doi: 10.1186/s40662-021-00249-z.
6. **Chen M, Zhang L, Xu J, Chen X, Gu Y, Ren Y, et al.** Comparability of three intraocular pressure measurement: iCare pro rebound, non-contact and Goldmann applanation tonometry in different IOP group. BMC Ophthalmol. 2019;**19(1):**225. Doi: 10.1186/s12886-019-1236-5.
7. **Wang H, Zhang Y, Ding J, Wang N.** Changes in the circadian rhythm in patients with primary glaucoma. PLoS One. 2013;**8(4):**e62841. Doi: 10.1371/journal.pone.0062841.
8. **Schuster AK, Erb C, Hoffmann EM, Dietlein T, Pfeiffer N.** The Diagnosis and Treatment of Glaucoma. Dtsch Arztebl Int. 2020;**117(13):**225-234. Doi: 10.3238/arztebl.2020.0225.
9. **Poostchi A, Mitchell R, Nicholas S, Purdie G, Wells A.** The iCare rebound tonometer: comparisons with Goldmann tonometry, and influence of central corneal thickness. Clin Exp Ophthalmol. 2009;**37(7):**687-691. Doi: 10.1111/j.1442-9071.2009.02109.x.
10. **Bader J, Zeppieri M, Havens SJ.** Tonometry. 2023 May 22. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 29630277.
11. **Kim KN, Jeoung JW, Park KH, Lee DS, Kim DM.** Effect of lateral decubitus position on intraocular pressure in glaucoma patients with asymmetric visual field loss. Ophthalmology. 2013;**120(4):**731-735. Doi: 10.1016/j.ophtha.2012.09.021
12. **Nakamura M, Darhad U, Tatsumi Y, Fujioka M, Kusuhara A, Maeda H, et al.** Agreement of rebound tonometer in measuring intraocular pressure with three types of applanation tonometers. Am J Ophthalmol. 2006;142(2):332-334. Doi: 10.1016/j.ajo.2006.02.035.
13. **Rödter TH, Knippschild S, Baulig C, Krummenauer F.** Meta-analysis of the concordance of Icare® PRO-based rebound and Goldmann applanation tonometry in glaucoma patients. Eur J Ophthalmol. 2020;**30(2):**245-252. Doi: 10.1177/1120672119866067.

14. **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. Doi: 10.1097/01.ijg.0000212208.87523.66.
15. **Sahin A, Niyaz L, Yildirim N.** Comparison of the rebound tonometer with the Goldmann applanation tonometer in glaucoma patients. ClinExp Ophthalmol.2007;**35(4):**335-339. Doi: 10.1111/j.1442-9071.2007.01451.x.
16. **Stoor K, Karvonen E, Ohtonen P, Liinamaa MJ, Saarela V.** Icare versus Goldmann in a randomised middle-aged population: The influence of central corneal thickness and refractive errors. Eur J Ophthalmol. 2021;**31(3):**1231-1239. Doi: 10.1177/1120672120921380.
17. **Kontiola AI.** A new induction-based impact method for measuring intraocular pressure. Acta Ophthalmol Scand. 2000;**78(2):**142-145. Doi: 10.1034/j.1600-0420.2000.078002142.x.
18. **Perez-Garcia P, Morales-Fernandez L, Saenz-Frances F, Mendez-Hernandez CD, Garcia-Feijoo J, Santos-Bueso E, et al.** Comparison of intraocular pressure measured using the new icare 200™ rebound tonometer and the Perkins™ applanation tonometer in healthy subjects and in patients with primary congenital glaucoma. Arch Soc Esp Oftalmol (Engl Ed). 2021;**96(4):**175-180. English, Spanish. Doi: 10.1016/j.oftal.2020.06.007.
19. **Badakere SV, Chary R, Choudhari NS, Rao HL, Garudadri C, Senthil S.** Agreement of Intraocular Pressure Measurement of Icare ic200 with Goldmann Applanation Tonometer in Adult Eyes with Normal Cornea. Ophthalmol Glaucoma. 2021;**4(3):**238-243. Doi: 10.1016/j.ogla.2021.04.002.
20. **Ting SL, Lim LT, Ooi CY, Rahman MM.** Comparison of Icare Rebound Tonometer and Perkins Applanation Tonometer in Community Eye Screening. Asia Pac J Ophthalmol (Phila). 2019;**8(3):**229-232. Doi: 10.22608/APO.2018433.
21. **Esmael A, Ismail YM, Elhusseiny AM, Fayed AE, Elhilali HM.** Agreement profiles for rebound and applanation tonometry in normal and glaucomatous children. Eur J Ophthalmol. 2019;**29(4):**379-385. Doi: 10.1177/1120672118795060.
22. **Barclay J, Moore A.** Is iCare as accurate as Goldmann or Perkins applanation tonometry at measuring intraocular pressure in the setting of suspected or diagnosed congenital glaucoma? A systematic review. Australian Orthoptic J.2022;**54:**19–28. Doi: 10.3316/informit.869390137907010

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Memoona Arshad; Assistant Professor: *Data Analysis, Manuscript Preparation, Manuscript Review.*

Nimra Gull; Lecturer: *Design, Data Analysis, Statistical Analysis.*

Shabana Chaudhry; Associate Professor: *Manuscript Preparation, Manuscript Editing, Manuscript Review.*

Muhammad Zubair Nazar; Optometrist: *Data Acquisition, Manuscript Review.*