Original Article

Cross-Sectional Study of Differences between Intraocular Pressure Measurements using Goldmann, iCare, and Air-Puff Tonometers and their Correlation with Central Corneal Thickness

Sameh Saad Mandour[1], Ahmed Elframawy[2], Mohammad Moataz Murad[3], Sara Abd Elmegeed Nage[1]

[1]Ophthalmology Department, Faculty of Medicine, Menoufia University, Shebin El Kom, Menoufia, Egypt, [2]Faculty of Medicine, Cairo University, Cairo, Egypt, [3]Ophthalmology Department, Research Institute of Ophthalmology, Giza, Egypt

Abstract

Purpose: To investigate the agreement between the Goldmann tonometer (GAT), the air-puff tonometer, and the iCare tonometer in intraocular pressure (IOP) evaluation as well as their association with central corneal thickness (CCT) in normal participants, glaucoma patients, and patients following refractive surgery.

Methods: This is a cross-sectional study conducted on 204 eyes from 102 patients. The study consisted of three equal groups: group I (control group, n = 34), group II (glaucoma patients on medication, n = 34), and group III (refractive surgery patients, n = 34). All patients were subjected to examination (complete ocular examination, refraction, and IOP measurement).

Results: A total of 102 participants were included in the study with both genders distributed equally. The mean ± standard deviation age was 44.12 ± 12.8 years in the control group while it was 46.29 ± 13.24 years in the glaucoma group and 40.68 ± 15.86 years in the refractive surgery group. Overall, there was a high correlation between the three methods. The mean IOP measured by GAT was 14.03 ± 3.43. The mean IOP measured by iCare was 15.16 ± 3.46. The mean IOP measured by air-puff was 16.66 ± 3.6. The iCare showed the most significant agreement with the GAT (intraclass correlation coefficient [ICC] 0.985, $P > 0.05$) and the mean difference in IOP between GAT and iCare was 1.1 (95% limits of agreement, −0.62–+2.85 mmHg). The mean difference in IOP between iCare and air-puff was 1.5 and it was 2.6 between GAT and air-puff. There were no significant differences in IOP measurements between GAT and iCare tonometer or between iCare tonometer and air-puff in all groups ($P > 0.05$). However, there were significant differences in IOP measurements between GAT and air-puff in all groups ($P < 0.001$). The ICC between all studied methods was strong (ICC > 0.92 for all). Regarding CCT, the mean CCT was 517.14 ± 29.82 µm. There were significant positive correlations between increasing CCT and increasing IOP by GAT, iCare, and air-puff tonometer among the three groups ($P < 0.001$).

Conclusions: In conclusion, the iCare tonometer, specifically the iCare PRO RT model, is a reliable and efficient alternative instrument for assessing IOP. The IOP values obtained with the iCare PRO RT were found to be consistent with those obtained using the air-puff and GAT.

Keywords: Air-puff tonometers, Central corneal thickness, Goldmann, iCare, Intraocular pressure

Address for correspondence: Ahmed Elframawy, Faculty of Medicine, Cairo University, Cairo, Egypt.
E-mail: ama7_framawy@yahoo.com
Submitted: 23-Aug-2023; **Revised:** 21-Feb-2024; **Accepted:** 21-Feb-2024; **Published:** 10-Aug-2024

Access this article online

Quick Response Code:

Website: https://journals.lww.com/joco

DOI: 10.4103/joco.joco_180_23

How to cite this article: Mandour SS, Elframawy A, Murad MM, Nage SA. Cross-sectional study of differences between intraocular pressure measurements using Goldmann, iCare, and air-puff tonometers and their correlation with central corneal thickness. J Curr Ophthalmol 2023;35:326-31.

Introduction

Intraocular pressure (IOP) measurement is an integral component of routine ocular examination.[1] It is also an essential tool in managing and following up glaucoma patients. Glaucoma is a common preventable cause of blindness and is a popular cause of visual field defects.[2] Early detection and management of glaucoma are crucial to prevent irreversible damage, especially since the disease prevalence increases with age.[3-6] Many variables, including central corneal thickness (CCT), corneal astigmatism, and biomechanical features of the cornea, might influence IOP measurement accuracy.[7] Goldmann tonometer (GAT) is widely regarded as the main instrument for measuring IOP by ophthalmologists.[8] Many innovative approaches have recently been developed to make IOP measurement quicker and more comfortable.[9] Another applanation instrument is the air-puff tonometer, which utilizes air to flatten the cornea rather than touching it.[10] The iCare Pro rebound tonometer is a novel approach for measuring IOP. A thin probe is propelled against the corneal surface to establish brief contact and return from the cornea. After six rebounds per measurement, the probe's deceleration is measured, translated into an IOP value, and displayed on the device. The iCare tonometer has received much attention in clinical practice because of its comfort and convenience.[11] This study aimed to compare IOP readings in normal participants, glaucomatous patients, and patients following refractive surgery using three distinct tools: the GAT, the air-puff tonometer, and the iCare tonometer. Multiple studies have been conducted on this subject. While some indicated that iCare is reliable and comparable to the gold standard GAT, others did not. Despite its advantages in terms of ease, speed, and patient comfort, iCare is not often used in ophthalmology practice compared to GAT. This research included a comparison between iCare and GAT, as well as the inclusion of the air-puff tonometer in the comparison. The research also included a distinct cohort, namely, those who had undergone refractive surgery. This cohort comprises individuals with reduced corneal thickness. The impact of CCT on IOP measurement is well-established. The purpose of this study is to investigate the agreement between iCare and GAT, and the air-puff tonometer in IOP evaluation as well as their relationship to CCT in normal participants, glaucoma patients, and patients following refractive surgery.

Methods

This is a cross-sectional study with 102 patients (204 eyes) enrolled. The study was conducted at the outpatient clinic of the ophthalmology department at Menuofia University and was approved by the ethics committee (approval ID 8/2022 OPHT 20). Participants signed an informed written permission form for the study and the publication. All measures of the study agree with the tenets of the Declaration of Helsinki. Written informed consent has been obtained from the patients to participate in this study and to publish the results.

The study included glaucomatous patients (on medical treatment for glaucoma with no surgical intervention) and patients who underwent refractive surgery. Ages ranged from 18 to 60 years old, as well as age-matched normal subjects. Each gender represented 50% of the total number of the studied cases. Patients with corneal diseases, eyelid diseases, nystagmus, retinal disorders, and uveitis were excluded from our study. All the included cases were phakic. Study subjects were then divided into three equal groups: a group of normal subjects (as a control group), a group of already-diagnosed glaucomatous patients on medical treatment, and a group of subjects with refractive surgery. All patients had a thorough medical history, examination of both eyes (including a comprehensive ocular examination and refraction with a NIDEK Auto-Refractometer-Keratometer), and IOP measurement. All examinations were done by a single operator in the afternoon clinic between 12 and 2 pm. IOP was measured starting with the air-puff then the iCare, followed by GAT with a 10–15 min break between each measurement.

Tonometry was done for each patient using an air-puff tonometer (Nidek RKT 7700, Nidek Corporation, Japan). Each eye was given three consecutive readings. If the values differed by more than 2 mmHg, the measurement was repeated. We took the average of three measurements and evaluated it.

IOP was measured after 10 min using iCare Pro (iCare Finland Oy, Helsinki, Finland). It was loaded with a single-use or disposable probe oriented 4–8 mm vertically to the central corneal surface. After six measurements, the greatest and lowest results were automatically removed, and the average IOP was determined by the built-in software using the remaining four values.

The purpose of the test and painless measurement were explained to patients. We put one drop of benoxinate hydrochloride 0.4% sterile ophthalmic solution (10 mL) (BENOX) in each eye, and the tip of a fluorescein sodium test strip was attached to the tear layer on the inner side of each lower lid. Contact lenses were removed before fluorescein. The tonometer tip was disinfected. The tension knob was 1 g. The prism head may shake and damage the corneal epithelium if the knob is zero. The widest slit beam used the cobalt filter. The light was 60° from the micros-dimmed room illumination. The patient sat comfortably in an examination chair facing the slit light. The slit light, chair, and chin rest heights were adjusted until the patient was comfortable and ready for measurement. Blinking twice spreads the fluorescein-stained tear film over the cornea. The prism touched the globe when its black circle moved slightly. Blinking and squeezing will occur if the biprism touches the lids or lashes. The central applanation zone and fluorescein-stained tear film were imaged monocularly. Draw two equal semicircles in the screen center using the control stick. The tension knob was cranked until the inner fluorescein rings approached. Ten times the gram measurement calculated IOP in millimeters of mercury.

Statistical analysis

IBM Corp.'s 2017 Statistical Package for Social Science (IBM

SPSS Statistics for Windows 25.0) updated, tagged, tallied, and uploaded data to a PC (IBM Corp., Armonk, NY, USA). Shapiro–Wilks normality test and histograms were used to test the distribution of quantitative variables to select accordingly the type of statistical testing: parametric or nonparametric. Parametric variables were expressed as mean and standard deviation (SD) and were compared using analysis of variance test among the three groups with *post hoc* (Tukey) test to compare each two groups. Categorial variables were expressed as frequency and percentage and were statistically analyzed by Chi-square test. The Bland–Altman method assessed tonometer agreement. Intraclass correlation coefficient (ICC) was tested. Pearson's correlation coefficient determined CCT-IOP relationships. The statistical significance was 0.05. Significant two-tailed *P* values were below 0.05.

Results

Among 116 patients, 102 patients (204 eyes) agreed to participate in the trial, whereas 14 were excluded (five rejected permission and nine did not match the inclusion criteria). Each gender represented 50% of the total number. The mean ± SD age was 44.12 ± 12.8 years in the control group, while it was 46.29 ± 13.24 in the glaucoma group and it was 40.68 ± 15.86 in the refractive surgery group [Supplementary Table 1]. Three equal groups were formed. Group I was a control group (n = 34), group II was glaucoma patients on medication (n = 34), and group III was refractive surgery patients (n = 34).

IOP measurements by three different methods, Goldmann, air-puff, and iCare tonometer, were compared, tabulated, and statically analyzed. GAT is the primary method for IOP measurement; its measurements were the lowest in the three groups compared to the iCare and air-puff. The mean IOP measured by GAT was 14.03 ± 3.43. The mean IOP measured by iCare was 15.16 ± 3.46. The mean IOP measured by air-puff was 16.66 ± 3.6. There were no significant differences in IOP measurements between GAT and iCare tonometer or between iCare tonometer and air-puff in all groups ($P > 0.05$). However, there were significant differences in IOP measurements between GAT and air-puff in all groups ($P < 0.001$) [Table 1].

There was a high correlation between the three methods. iCare showed the most significant statistical agreement with the GAT (ICC 0.985) and the mean difference in IOP between GAT and iCare was 1.1 (95% limits of agreement, −0.62– +2.85 mmHg). The mean difference in IOP between iCare and air-puff was 1.5 and it was 2.6 between GAT and air-puff. ICC of air-puff and GAT equals 0.973 and the iCare and air-puff tonometer ICC was 0.935. The ICC between all studied methods was strong [Table 2].

Regarding CCT, the mean and standard deviation of each group are provided in Table 3. There were significant positive correlations between increasing CCT and increasing IOP by GAT, iCare, and air-puff tonometer among the three groups ($P < 0.001$) [Table 4]. Figures 1-3 show the Bland–Altman plot for comparison among all methods. Correlation of CCT with age and IOP by different methods is available in Table 4.

Discussion

In glaucoma treatment and follow-up, IOP monitoring is essential in ophthalmic practice. CCT, corneal astigmatism, and corneal biomechanics may affect IOP measurement accuracy.[12] In everyday ophthalmic practice, GAT is considered the main approach for measuring IOP. In the present investigation, IOP was evaluated using GAT and compared to measurements

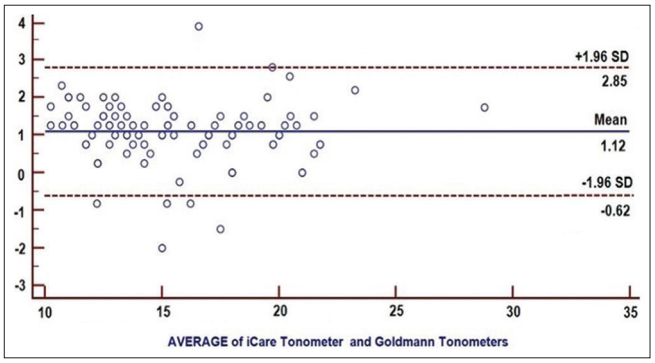

Figure 1: Bland–Altman plot for comparison between iCare tonometer and Goldmann tonometer methods. Blue line, mean difference between methods; dashed lines: 95% limits of agreement

Table 1: Comparison of intraocular pressure by the three different methods

	Goldmann	iCare	Air-Puff	P1	P2	P3	P4
Control							
Mean±SD	13.4±3.0	14.3±2.9	15.8±3.0	<0.001	0.387	0.02	0.572
Range	8–20	9–21	11–23				
Glaucoma							
Mean±SD	15.1±4.5	16.4±4.6	18±4.7	<0.001	0.565	0.02	0.674
Range	9–29	10–30	11–31				
Refractive							
Mean±SD	13.6±2.8	14.8±2.9	16.2±3.1	<0.001	0.687	0.03	0.265
Range	8–20	9–22	12–23				

P1 is a comparison between all methods, P2 is, a comparison between Goldmann and iCare, P3, is a comparison between Goldmann and Air-Puff, and P4, is a comparison between iCare and Air-Puff. Analysis of variance statistical analysis and *post hoc* Tukey test were used. SD: Standard deviation

taken using air-puff and iCare in three separate study groups: control, glaucoma, and refractive surgery. When compared to the iCare and air-puff, GAT readings were the lowest among the three groups. GAT and iCare IOP measurements did not vary substantially across the groups investigated. IOP measurements from iCare and air-puff did not differ significantly across the groups investigated.

In keeping with our results, Chen *et al*.[13] discovered no significant variation in IOP assessed by the three approaches. Kato *et al*.[14] conducted a trial to test the inter-device agreement between the GAT, iCare, and iCare PRO, rebound tonometers, noncontact tonometer (NCT), and tonopen XL tonometer. Sixty healthy older people were recruited. Each of the five tonometers measured the IOP in each subject's right eye. They also said there was no statistically significant change in the mean IOP.

The iCare rebound tonometer has lately gained popularity. However, the highly accurate nature of its IOP measurement remains a source of contention. According to certain research studies, IOP measured by iCare was somewhat greater than GAT.[15,16] Tamçelik *et al*.[17] discovered that iCare Pro overestimated IOP in low IOP and underestimated it in high IOP when compared to GAT.

IOP measurements by GAT and air-puff tonometers vary considerably across all research groups. The mean IOP difference between air-puff and GAT was 2.6, 1.12 between iCare and GAT and 1.5 between iCare and air-puff tonometer. In line with the above results, Basuony *et al*.[18] undertook comparison research to assess the difference between IOP measurements collected by GAT and air-puff to assess the reliability of air-puff as a screening tool. This research included 200 eyes from 100 study participants. The reading difference between the two approaches was computed. The average IOP detected by GAT was 14.48 ± 2.29 mmHg, whereas the air-puff tonometer was 16.34 ± 2.3 mmHg. The average difference in pressure between the two techniques was 1.855 mmHg. In line with our findings, Chen *et al*.[13] found that the IOP assessed by air-puff was considerably higher than iCare. Furthermore, Bang *et al*.[19] claim that the Canon TX-20P, Nidek NT-530P, and Topcon CT-1P all have equal accuracy to the GAT. Kouchaki *et al*.[20] performed a cross-sectional investigation on 46 participants, which contradicted our results. The results showed a significant air-puff-GAT agreement limit. Furthermore, Vincent *et al*.[21] discovered substantial variances in the average values for each tonometer. The NCT measurement was lower than the average GAT reading for both the right and left eyes. The authors determined that the NCT and GAT measure IOP differently. Our findings differ from the air-puff tonometer accuracy studies above for unexplained reasons. However, including varied populations – healthy or glaucomatous – and sample size, age groups, and countries may explain this difference.

In terms of our findings, the interclass correlation between all techniques investigated was strong. Compared to the control and glaucoma groups, the CCT was considerably lower in the refractive surgery group. Using Pearson correlation, Chen *et al*.[13] discovered a substantial association between the three devices in each IOP group. The ICC across the three measuring devices was likewise high. In the current study, CCT was found to have a significant positive correlation with IOP measured

Table 2: Agreement between methods among all studied groups

	Mean differences	95% limits of agreement	ICC
Air-Puff and GAT	2.6	0.3−5	0.973
iCare and GAT	1.12	0.62−2.85	0.985
iCare and Air-Puff tonometer	−1.5	−3.8−0.7	0.935

ICC: Intraclass correlation coefficient, GAT: Goldmann tonometer

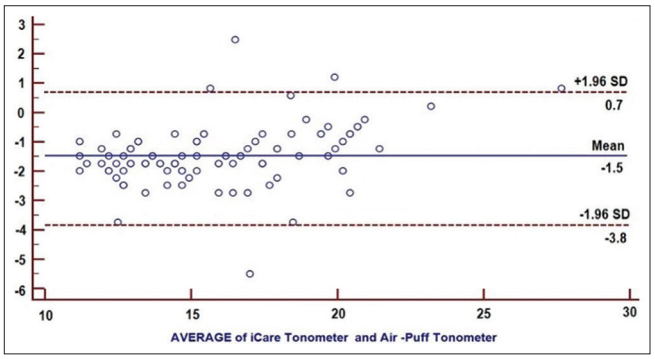

Figure 2: Bland–Altman plot for comparison between iCare tonometer and air-puff tonometer methods. Blue line, mean difference between methods; dashed lines: 95% limits of agreement

Table 3: Comparison of central corneal thickness among all studied groups (*n*=34)

	Control	Glaucoma	Refractive	P1	P2	P3	P4
Right							
Mean±SD	542.8±34.4	541.7±38.0	463.9±16.7	<0.001	0.889	<0.001	<0.001
Range	452–603	482–628	437–490				
Left							
Mean±SD	546.8±34.6	545.6±36.1	463.6±19.1	<0.001	0.869	<0.001	<0.001
Range	471–608	470–641	435–492				

Analysis of variance statistical analysis was used. P1: Comparison between all studied groups, P2: Comparison between glaucoma and control, P3: Comparison between refractive and control, P4: Comparison between glaucoma and refractive, SD: Standard deviation

Table 4: Correlation of central corneal thickness with age and intraocular pressure by the different methods among the three groups

	CCT					
	Control		Glaucoma		Refractive	
	r	*P*	*r*	*P*	*r*	*P*
Age	−0.045	0.715	−0.159	0.196	0.085	0.490
iCare	0.514	<0.001	0.573	<0.001	0.515	<0.001
Air-Puff	0.581	<0.001	0.574	<0.001	0.592	<0.001
Goldmann	0.558	<0.001	0.550	<0.001	0.535	<0.001

r: Correlation coefficient, CCT: Central corneal thickness

by the iCare tonometer, air-puff tonometer, and GAT in each group. Basuony *et al*.[18] and Kato *et al*.[14] observed consistent positive associations between IOP assessed by air-puff, iCare Pro, GAT, and CCT. Similarly, Erdogan *et al*.[22] conducted a prospective study of 188 eyes from 94 healthy participants to compare the IOP with an NCT and GAT. The research tested if there was a change in each approach in line with the CCT. The mean CCT was 538.2 ± 34.4 microns, and it correlated positively with NCT and GAT measurements. Bang *et al*.[19] discovered a strong positive connection between rising CCT and increasing IOP in the Topcon CT-1P and Nidek NT-530P. In line with our results, Kouchaki *et al*.[20] discovered a statistically significant relationship between CCT and air-puff measures. According to a simple regression model, CCT demonstrated a strong connection with IOP evaluated by air-puff or GAT. George *et al*.[23] also did cross-sectional observational research to compare IO*P* values in various IOP ranges. GAT and NCT were used to quantify IOP in 500 eyes (glaucomatous and nonglaucomatous). CCT was measured, and its association with GAT and NCT was examined. It was discovered that IOP readings with GAT and NCT were positively connected with CCT.

The very small sample size constrains our findings, and they may vary elsewhere. Our research did not address corneal biomechanics characteristics that may interact with IOP measurement. Patients with corneal and eyelid disorders were excluded. We had a heterogeneous group of patients in the refractive surgery subgroup; this needs to be addressed in another study with a larger sample size and with reference to the difference in the corneal biomechanics following different refractive surgeries.

In clinical practice, a precise IOP measurement is required for an eye examination. Compared to GAT and air-puff, iCare may be a simple, time-saving, and reliable alternative instrument for IOP measurements. The iCare and air-puff tonometers offer IOP measures that are comparable to and compatible with the gold standard GAT. According to our findings, the iCare, air-puff tonometer, and GAT have excellent consistency.

Financial support and sponsorship

Nil.

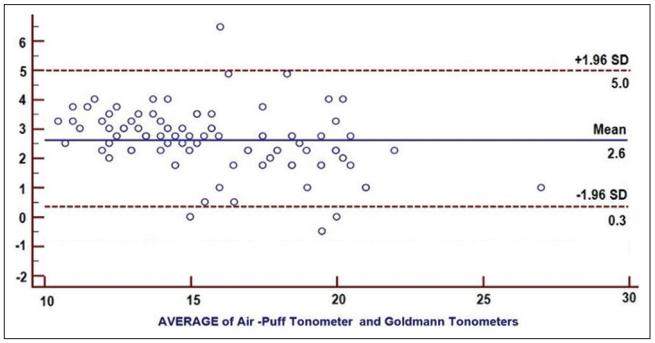

Figure 3: Bland–Altman plot for comparison between air-puff tonometer and Goldmann tonometer methods. Blue line, mean difference between methods; dashed lines: 95% limits of agreement

Conflicts of interest

There are no conflicts of interest.

References

1. Chihara E. Assessment of true intraocular pressure: The gap between theory and practical data. Surv Ophthalmol 2008;53:203-18.
2. Quigley HA. Number of people with glaucoma worldwide. Br J Ophthalmol 1996;80:389-93.
3. Ramrattan RS, Wolfs RC, Panda-Jonas S, Jonas JB, Bakker D, Pols HA, *et al.* Prevalence and causes of visual field loss in the elderly and associations with impairment in daily functioning: The Rotterdam study. Arch Ophthalmol 2001;119:1788-94.
4. Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. Arch Ophthalmol 1983;101:371-5.
5. Friedman DS, Wolfs RC, O'Colmain BJ, Klein BE, Taylor HR, West S, *et al.* Prevalence of open-angle glaucoma among adults in the United States. Arch Ophthalmol 2004;122:532-8.
6. Burnstein Y, Ellish NJ, Magbalon M, Higginbotham EJ. Comparison of frequency doubling perimetry with Humphrey visual field analysis in a glaucoma practice. Am J Ophthalmol 2000;129:328-33.
7. Smedowski A, Weglarz B, Tarnawska D, Kaarniranta K, Wylegala E. Comparison of three intraocular pressure measurement methods including biomechanical properties of the cornea. Invest Ophthalmol Vis Sci 2014;55:666-73.
8. Kim JH, Caprioli J. Intraocular pressure fluctuation: Is it important? J Ophthalmic Vis Res 2018;13:170-4.
9. Cook JA, Botello AP, Elders A, Fathi Ali A, Azuara-Blanco A, Fraser C, *et al.* Systematic review of the agreement of tonometers with Goldmann applanation tonometry. Ophthalmology 2012;119:1552-7.
10. Forbes M, Pico G Jr., Grolman B. A noncontact applanation tonometer. Description and clinical evaluation. Arch Ophthalmol 1974;91:134-40.
11. Moreno-Montañés J, Martínez-de-la-Casa JM, Sabater AL, Morales-Fernandez L, Sáenz C, Garcia-Feijoo J. Clinical evaluation of the new rebound tonometers icare PRO and icare ONE compared with the Goldmann tonometer. J Glaucoma 2015;24:527-32.
12. Abdi P, Farsiani AR, Fallah Tafti MR, Latifi G, Abdi P. Effect of ocular biometric factors on corneal biomechanical properties. Int Ophthalmol 2023;43:1877-88.
13. 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;19:225.
14. 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;38:687-96.

15. Kim KN, Jeoung JW, Park KH, Yang MK, Kim DM. Comparison of the new rebound tonometer with Goldmann applanation tonometer in a clinical setting. Acta Ophthalmol 2013;91:e392-6.
16. Salim S, Du H, Wan J. Comparison of intraocular pressure measurements and assessment of intraobserver and interobserver reproducibility with the portable ICare rebound tonometer and Goldmann applanation tonometer in glaucoma patients. J Glaucoma 2013;22:325-9.
17. 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;54:18-25.
18. Basuony R, Orouk W, Soliman T, Attia T. Comparison of intraocular pressure (iop) measured by non-contact (Air–Puff) tonometer compared with Goldmann applanation tonometer. Benha Med J 2021;39:49-58. [doi: 10.21608/bmfj. 2021.17077.1062].
19. Bang SP, Lee CE, Kim YC. Comparison of intraocular pressure as measured by three different non-contact tonometers and Goldmann applanation tonometer for non-glaucomatous subjects. BMC Ophthalmol 2017;17:199.
20. Kouchaki B, Hashemi H, Yekta A, Khabazkhoob M. Comparison of current tonometry techniques in measurement of intraocular pressure. J Curr Ophthalmol 2017;29:92-7.
21. Vincent SJ, Vincent RA, Shields D, Lee GA. Comparison of intraocular pressure measurement between rebound, non-contact and Goldmann applanation tonometry in treated glaucoma patients. Clin Exp Ophthalmol 2012;40:e163-70.
22. Erdogan H, Akingol Z, Cam O, Sencan S. A comparison of NCT, Goldman application tonometry values with and without fluorescein. Clin Ophthalmol 2018;12:2183-8.
23. George LS, Bhatti A, Batra N, Chopra R. Correlation of intraocular pressure measurements with non contact tonometer and Goldmann applanation tonometry. J Evid Based Med Healthc 2017;4:3430-3.

Supplementary Table 1: Comparison of demographics ($n=34$)

	Control	Glaucoma	Refractive	P1	P2	P3	P4
Sex, *n* (%)							
Male	18 (52.9)	18 (52.9)	15 (44.1)	0.703	1	0.467	0.467
Female	16 (47.1)	16 (47.1)	19 (55.9)				
Age							
Mean±SD	44.12±12.8	46.29±13.24	40.68±15.86	0.255	0.524	0.315	0.102
Range	16–60	16–60	16–60				

P1: Comparison between all studied groups, P2: Comparison between glaucoma and control, P3: Comparison between refractive and control, P4: Comparison between glaucoma and refractive, SD: Standard deviation