Is iCare rebound tonometry as accurate as Goldmann applanation tonometry in the measurement of intraocular pressure?

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ABSTRACT

Background: Intraocular pressure (IOP) measurement is an important examination in ophthalmic practice, especially in the diagnosis of optic nerve disease.

Aim: To compare intraocular pressure measurements obtained using the Goldmann applanation (GAT) tonometer with the iCare rebound tonometer (RBT) and evaluate the suitability of the iCare tonometer for routine clinical use.

Methods: A total of 410 eyes of 205 patients were studied. Using GAT measurements, patients were classified into three groups: Group A (7–15 mmHg), Group B (16–22 mmHg) and Group C (≥23 mmHg). The RBT measurements were compared with the GAT measurements using Student's paired t-test and Pearson's correlation. Statistical significance was set at $p<0.05$, while a difference of ±3 mmHg between the two instruments was considered clinically significant.

Results: There were 140 (34.2%) eyes in Group A, 206 (50.2%) eyes in Group B and 64 (15.6%) eyes in Group C. Overall, the mean difference in IOP values between GAT and RBT was 2.505±0.99 mmHg ($p=0.096$), while for Group C only, there was a statistically significant difference in the mean values of IOP obtained by GAT versus RBT (2.20±3.5 mmHg, $p<0.01$). There was a statistically significant correlation ($r=0.84$) between GAT and RBT measurements.

Conclusion: iCare significantly underestimated IOP at high IOP levels compared with GAT. Nevertheless, differences in the overall mean IOP values obtained by GAT and RBT were statistically insignificant. This suggests that the two instruments may be used interchangeably, but with caution in glaucoma patients when elevated IOP values are anticipated.

Keywords: Goldmann applanation, iCare rebound tonometer, intraocular pressure.

INTRODUCTION

Accurate intraocular pressure (IOP) measurement is an important aspect of examination in the ophthalmic clinic, as it is a crucial component in the diagnosis and management of several ocular conditions, especially glaucoma. IOP was first measured in 1865, when Von Graefe developed the first tonometry instrument [1]. Since then, many devices have been developed to measure IOP, including the Maklakoff tonometer, the Goldmann tonometer, the Perkins tonometer, rebound tonometers (RTs) and noncontact tonometers. Goldmann applanation tonometry (GAT) is still considered the gold standard for IOP measurement.[1-3] There are about 5 different models of iCare tonometers: the iCare TAOi, iCare Pro, iCare ic100, iCare ic200, and the iCare Home; however, each seems to have its own characteristics and IOP value tendency. The iCare tonometer ic100 (TA011) device is portable, easy-to-use and does not require the use of topical anesthesia. It measures the IOP by striking the central cornea with a probe and gives an average of 6 measurements displayed as the IOP value. The GAT (KAT SL Vnyals 131), on the other hand, is mounted on a slit lamp microscope (Topcon SLD301), requires the use of topical anesthesia and its accuracy is dependent on examiner expertise. The objective of this study was to compare

intraocular pressure (IOP) measurements obtained using the Goldmann applanation (GAT) tonometer with the intraocular pressure measurements obtained using the iCare rebound tonometer ic100 (RBT).

METHODS

Approval was obtained from the Ethics and Research Committee of Federal Teaching Hospital Birnin Kebbi, and informed consent was obtained from each patient before inclusion into the study. The study was conducted at the Ophthalmology Department, Federal Teaching Hospital, Birnin Kebbi, between August and September 2023. All consecutive patients who attended routine clinical appointments during the study period were eligible for inclusion. Exclusion criteria were failure to consent, corneal pathologies, active ocular infection and recent intraocular surgery. Relevant demographic data such as age, sex, occupation and tribe were recorded. The iCare tonometer was used first to measure the patient's IOP, then GAT was used to measure IOP after instilling a drop of amethocaine hydrochloride 0.5% and 5% fluorescein. In order to minimize patients' discomfort, only one measurement was obtained with each tonometer (GAT and iCare) in each eye by the same examiner. Data was analyzed using IBM SPSS version 27. Using the measurements obtained with GAT, patients were classified into three groups: Group A if IOP was 7 – 15 mmHg; Group B if IOP was 16 – 22 mmHg and Group C if IOP was $\geq$23 mmHg. The mean values for both instruments were compared using paired samples T-test. Pearson's correlation coefficient was used to explore the correlation between the IOP measurements using the 2 tonometers. Any p-value less than 0.05 was considered statistically significant. A difference in IOP of ± 3 mmHg between the two instruments was considered clinically significant.[4,9,11]

RESULTS

A total of 410 eyes of 205 patients aged between 9 and 76 years, with a mean age of 34.36 ± 1.397 years, were examined. A hundred and eleven (54.3%) subjects were female. The male-to-female ratio was 1:1.2. Table 1 shows the age and sex distribution of the patients.

The intra-ocular pressure measurements with RBT ranged between 8 and 35 mmHg, with a mean of 12.18 ± 4.62 mmHg in the right eyes. While the range of measurements obtained with GAT in the right eyes was 6 to 37 mmHg, with a mean of 14.68 ± 4.81 mmHg (Table 2). There were 140 (34.2%) eyes in Group A, 206 (50.2%) eyes in Group B and 64 (15.6%) eyes in Group C. The measurement difference between GAT and RBT in 258 eyes (62.9%) was $\leq$ ±2 mmHg, while

Table 1: Age and sex distribution of the patients

Age in years	Sex		
	male	female	Total
1 - 10	0	1	1
11 - 20	0	1	1
21 - 30	6	10	16
31 - 40	8	25	33
41 - 50	20	36	56
51 - 60	30	20	50
61 - 70	18	18	36
> 70	12	0	12
TOTAL	**94**	**111**	**205**

Table 2: Intraocular pressure measurements using both tonometers

Variables	N	Minimum (mmHg)	Maximum (mmHg)	Mean (mmHg)	Standard deviation (mmHg)
iCare IOP RE	205	8	35	12.18	4.624
iCare IOP LE	205	8	41	12.13	4.919
GAT IOP RE	205	6	37	14.68	4.810
GAT IOP LE	205	8	44	14.50	5.028

IOP- intraocular pressure, RE- right eye, LE- left eye, GAT-Goldmann applanation tonometer

the difference was > ±3 mmHg in 152 eyes (37.1%). For Groups A and B, the mean measurement difference between GAT and RBT was -0.12±2.77 mmHg and 0.04±2.86 mmHg, respectively. These differences were not statistically significant. However, for the eyes in Group C, the RBT measurements were significantly lower than those obtained with GAT (-1.66±3.87 mmHg). This difference was statistically significant (t=-2.84, p=0.007).

The overall mean difference in IOP values between iCare and GAT was -2.51±0.99 mmHg (p=0.096); however, the iCare significantly underestimated IOP at values ≥ 23 mmHg compared with GAT (GAT minus iCare = 2.20 ± 3.5 mmHg, P<0.01). Table 3 shows the comparison of the mean differences in IOP values when the analysis was performed for right and left eyes separately.

Table 3: Paired samples test

	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
iCare IOP LE - GAT IOP LE	-2.365	1.337	0.131	-2.625	-2.105	-18.042	205	0.0964
iCare IOP RE - GAT IOP RE	-2.505	0.906	0.099	-2.702	-2.308	-25.270	205	0.0978

DISCUSSION

Only a few studies have compared the iCare ic100 tonometer with the GAT. We set out to address this gap by comparing IOP measurements obtained by this model of the iCare tonometer with the gold standard, GAT.[3,4-13] Our study found the iCare ic100 generally undermeasures IOP compared to GAT, with a mean difference of 2.51±0.99 mmHg between the iCare and GAT. This mean difference in IOP is considerably larger than the mean difference of 0.44±4.4 mmHg reported by Wong *et al*[3] in their study of 74 eyes. It is also larger than the mean difference of 1.5±2.8 mmHg reported by Nakakura *et al*[5] in a small study of 45 eyes. Ashano *et al*[6] in their study in Southwest Nigeria reported a statistically significant difference in the mean values of IOP obtained by the GAT and RBT similar to the observation in our study although the type of iCare used in their study was not stated and also their sample size (132 eyes) was smaller than this study. However, they considered corneal thickness in their study. Our findings showed that the iCare underestimated the IOP measurement more so at the higher IOP ranges (i.e ≥23 mmHg). This finding is similar to the study by Wong *et al*[3] who reported that the largest mean differences in IOP measurement were among eyes with ocular hypertension. Similarly, in a study of 672 eyes using an earlier version of iCare (TA01i) Gao *et al*[4] reported that the only subgroup with a statistically significant difference in IOP was the group of eyes that had IOP ≥23 mmHg. Within the IOP subgroups, the mean difference was 2 mmHg and above (for IOPs ≥23 mmHg).[10-14] Exceptions to this were evident in patients with IOP 15 mmHg and below, where the mean difference was less than 2 mmHg.

CONCLUSION

iCare significantly underestimated IOP at high IOP levels compared with GAT. Nevertheless, differences in the mean IOP values obtained by GAT and RBT were statistically insignificant. This suggests that they can be interchanged but with caution for routine use in a glaucoma clinic, especially when IOP values are likely to be higher than 22 mmHg.

Limitation: Our study is limited by the fact that it was hospital-based, which limits the generalizability of the results.

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