

# Intraocular Pressure Comparison between Icare Tonometer with Goldmann Applanation Tonometer and their Correlation with Central Corneal Thickness (CCT) in Glaucoma Suspects In a Tertiary Hospital

Kamala Thapa, Sachit Dhakal, Sagar Rajkarnikar, Ram Shrestha, Nabaratna Bista, Pragya Manjari Rana

Department of Ophthalmology, Nepalese Army Institute of Health Sciences, Shree Birendra Hospital, Chhauni, Kathmandu, Nepal.

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## Correspondence

Kamala Thapa,  
Department of Ophthalmology,  
Shree Birendra Hospital, Chhauni,  
Nepalese Army Institute of Health Sciences,  
Syanobharyang, Kathmandu, Nepal.  
Email: drkamalathapa@gmail.com

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**Introduction:** Glaucoma is a group of optic neuropathies characterized by progressive degeneration of retinal ganglion cells where intraocular pressure (IOP) is the cardinal modifiable risk factor. This study is done to compare intraocular pressure (IOP) measurements obtained by ICare tonometer and Goldmann applanation tonometer (GAT) in glaucoma suspects and to investigate the influence of central corneal thickness (CCT) on IOP measurements.

**Methods:** 220 eyes of 110 patients diagnosed with glaucoma suspect attending glaucoma clinic of Shree Birendra Hospital underwent ultrasonic CCT followed by IOP measurement by ICare and GAT. The results were calculated and compared and the effect of CCT was co-related by linear regression analysis. Intraclass correlation analysis were performed to see the agreement between IOP measurement by ICare and GAT. Statistical test was done using SPSS V. 20.0 software.

**Results:** The mean IOP with ICare and GAT were 16.25 and 16.04 mmHg respectively which was not statistically significant ( $p=0.06$ ). The mean CCT was 547.49 $\mu$ m. The average IOP increased by 0.35 and 0.36mmHg for every 10-unit increase in CCT by ICare and GAT respectively. Intraclass correlation coefficient (ICC) between two modalities of IOP measurement was 0.89 (95% CI=0.86-0.92),  $p<0.001$  which was statistically significant.

**Conclusion:** IOP readings with ICare and GAT were comparable. IOP measurement was affected by CCT thus pachymetry should be taken into consideration.

**Keywords:** *intraocular pressure, ICare tonometer, Goldmann applanation tonometer, central corneal thickness.*

## Introduction

Glaucoma is a group of optic neuropathies characterized by progressive degeneration of retinal ganglion cells<sup>1</sup> where intraocular pressure (IOP) is the cardinal modifiable risk factor, and the disease usually stops progressing if the IOP is lowered by 30% to 50%.<sup>2</sup> It is the second leading cause of irreversible blindness after cataract.<sup>3</sup> Globally the prevalence of glaucoma is 3.54% in a population of 40-50 years.<sup>4</sup> It is estimated that there will be 79.6 million people globally with glaucoma in 2020<sup>5</sup> and 111.8 million in 2040.<sup>4</sup> The reduction of intraocular pressure delays and halts the progression of glaucoma.<sup>6</sup>

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Accurate measurement of IOP is essential in diagnosis and management of glaucoma patients. Goldman applanation tonometry (GAT) is a routine procedure performed in glaucoma clinic. Since it is convenient and gives more accurate measurement, it is considered the gold standard<sup>7</sup> for IOP measurement and is based on Imbert–Fick law<sup>8</sup>. Measurement by GAT is dependent on factors like corneal thickness; corneal curvature, structure and axial length.<sup>9</sup> The influence of Central Corneal thickness (CCT), need of local anesthetic drops and the slit lamp are the major disadvantages of the GAT.

Rebound Tonometer is a portable tonometer which uses a moving probe which is propelled towards the cornea. The speed at which the probe bounces back to the tonometer varies according to the ocular pressure and is used for the calculation of IOP.<sup>10</sup> ICare Tonometry has an advantage over GAT as it is handy, quick, easy to perform and doesn't use local anesthetic drops. IOP can be taken in patients with comfortable sitting posture where the rapid measurement of IOP is possible in uncooperative patients especially in pediatric population.

Proper CCT measurement helps in precise IOP interpretation by GAT. CCT measurement of 520um is considered as a reference value in calibration of GAT<sup>11</sup> that causes an overestimation of IOP in thicker corneas and underestimation of IOP in thin corneas.<sup>12</sup>

## Methods

A cross-sectional study was done taking 220 eyes of 110 glaucoma suspect (64 males and 46 females) in glaucoma clinic of Shree Birendra Hospital from August 2023–January 2024. Ethical approval was obtained from Institutional review committee (IRC) of Nepalese Army Institute of Health science (NAIHS). Written, informed consent was taken from all subjects before the procedures.

Paediatric patient <19 years, patients on antiglaucoma medication, ocular infection, corneal abnormalities or scarring and patient with history of refractive surgery were excluded. All included patients underwent an ophthalmologic examination including visual acuity, slitlamp examination, gonioscopy and posterior segment examination. Fundus examination was done after full dilatation of the pupil using 1% tropicamide using 90 D lens. The CCT was measured with central ultrasonic pachymetry (Nidek, US 4000-ecoscan). The pachymeter probe was placed on the center of the cornea and the mean of 3 readings was calculated for each eye.

The Icare<sup>®</sup> HOME, Finland software (Icare, model -TA02, model -11cm×8cm×3cm, weight -150g, measurement range up to 40mmHg) was preprogrammed for six measurements. An average of the best four readings, discarding the highest and lowest, was displayed as the final (6th) IOP. An unacceptable reading where the SD of the measurements is greater than normal was displayed

with an error sign. All measurements with error was discarded. Measurements were performed according to the manufacturer's guidelines. All patients were examined in sitting position and patient was asked to look straight ahead to a distant point. To take IOP measurements, the device was positioned near the patient's eye with the forehead being used as a base support, and the tip of the probe was maintained at a distance of approximately 4 to 8 mm from the cornea. All measurements of GAT and ICare was taken by the single experienced ophthalmologist. A minimum gap of 20mins was kept between the two procedures after CCT measurement.

GAT (Haag Streit) was performed after ICare tonometry on a slit lamp with a tonometer calibrated according to the manufacturer's guidelines. Before each reading, the measuring drum was reset to 10 mmHg. The tonometer head was disinfected according to the hospital infection control guidelines. IOP was measured after instillation of a drop of preservative-free lignocaine (4%) and fluorescein sodium (0.25%) solution.

Data entry, cleaning, coding etc were done in Microsoft EXCEL. Statistical analysis was done with SPSS software for windows version 20.0. Mean standard, minimum maximum values were calculated as descriptive statistics. Difference of IOP by both measured were analyzed using Wilcoxon signed rank test since the difference was not normally distributed. Simple linear regression analysis was performed to quantify the Intra Ocular pressure (both ICare and GAT) from CCT. Bland Altman plot was prepared to see any systematic difference in IOP taken by both ICare and GAT. Similarly, Intraclass correlation coefficient (ICC) was used to assess the correlation between ICare and GAT. A p value < 0.05 was considered statistically significant.

## Results

Total of 220 eyes of 110 patients, (64 males and 46 females) were included, with a mean age of 41.74 years (range 18-80) and SD of 16.95. The minimum age was 19 and maximum age was 80 years. Most of the patient (23.64%) was of age between 21 -30 years.<sup>9</sup>

The mean CCT was 547.49um and the mean IOP by ICare and GAT was 16.25(3.56) and 16.04 (3.21) mmHg respectively. Mean (SD) difference in IOP between ICare and GAT method was 0.21 (1.6) which was not statistically significant, p=0.06.

ICC between IOP (ICare) IOP (GAT) was 0.89 (95% CI = 0.86-0.92), p<0.001 which shows very strong agreement (89% agreement) between IOP (I care) with IOP (GAT), which is statistically significant p<0.001. Scatter plot comparing the GAT and the ICare tonometry readings also showed very strong correlation (r=0.9, p<0.001) between the 2 methods (fig 1). The average IOP increased by 0.35 and 0.36 mmHg for every 10-unit increase in CCT by ICare and GAT respectively (table 2).

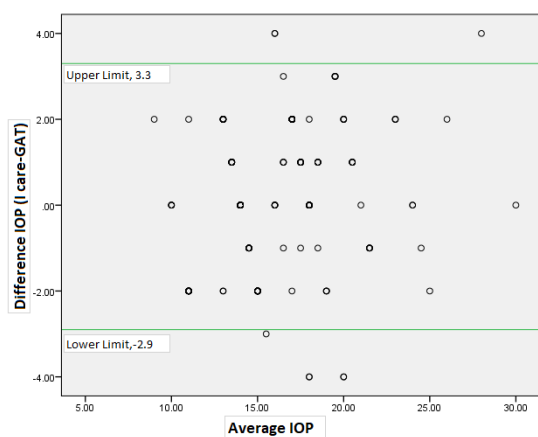
**Table 1:** Baseline descriptive, mean IOP and CCT of the study population

Variables	Mean (SD)	Range (Min to Max)
CCT	547.49 (34.75)	(462 to 645)
IOP (Icare)	16.25 (3.56)	(10 to 30)
IOP(GAT)	16.04 (3.21)	(8 to 30)

Note: Diff (Icare-GAT) had mean (SD) 0.21 (1.60),  $p=0.06$

**Table 2:** Estimation of IOP with per 10-unit change in CCT using simple linear regression

IOP	Coefficient (95% CI) + constant	R <sup>2</sup>	Correlation (r)	p value
Icare	0.35 (0.23 - 0.45) + 3.31	0.13	0.36	<0.001
GAT	0.36 (0.23 - 0.5) + 3.23	0.11	0.34	<0.001

**Figure 1:** Bland Altman plot

ICC = 0.89 (95% CI = 0.86-0.92,  $p < 0.001$ )

## Discussion

Precise IOP measurement plays an important role in glaucoma management. The requirement of slit lamp, use of topical anesthesia and fluorescein staining along with the risk of cross infection and epithelial erosions due to direct contact with the prism are the major problems of GAT that led to the emergence of newer, precise, practical and convenient methods of IOP measurement.

ICare tonometer is a small hand-held device that uses disposable probes of diameter 0.9mm. It can be used easily at home and has become a blessing to the patients because of its simplicity, accuracy, reliability and portability. It is easy to learn, time saving device where self-measurement of IOP is possible. ICare is also popular in pediatric population and is well tolerated as it avoids the risk of multiple examination

under general anesthesia.

### ICare versus GAT

Several studies have been conducted to compare the accuracy of ICare and GAT. A study<sup>13</sup> evaluated clinical usefulness of ICare PRO with GAT and found IOP ICare PRO overestimated IOP than GAT reading. The study found a good correlation between the IOP measurement by GAT and that by Icare PRO.

Comparison of 60 normal subjects with ICare and GAT showed ICare RT overestimated the GAT IOP measurements<sup>14</sup> which was similar to study done in 100 patients.<sup>15</sup> Study by Salim et al.<sup>16</sup> showed a mean difference of IOP measurements by RBT and GAT of 2.45 mm Hg. Other studies<sup>17,18</sup> also demonstrated the overestimation of IOP by RT than GAT. Another study reported rebound tonometer (RBT) measurement was on average  $0.21 \pm 1.7$  mmHg higher than GAT.<sup>19</sup> Our study also showed similar result where mean difference in IOP by ICare and GAT was  $0.21 \pm 1.6$  mmHg. A good correlation was found in a study between ICare and GAT even at extremes of IOP.<sup>20</sup> Brusini et al.<sup>21</sup> studied 178 open angle glaucoma patients and found good agreement between GAT and ICare. The mean IOP and the mean corrected IOP with GAT were  $19.4 \pm 5.4$  mm Hg, and  $18.5 \pm 5.7$  mm Hg, respectively. The mean ICare IOP reading was  $18.4 \pm 5.2$  mm Hg. In our study, the mean IOP by ICare and GAT was 16.25 and 16.04 mmHg respectively.

### CCT Versus ICare and GAT

IOP measurement is influenced by CCT, biomechanical properties of cornea, racial variation.<sup>22</sup> There is no normogram to compensate GAT for the corneal thickness<sup>12,23</sup> and most tonometers are affected by CCT.<sup>24</sup>

Some studies reported positive correlation between IOP measured with GAT and CCT<sup>25,26</sup> and some found positive correlation between RT measurements and CCT.<sup>15,21</sup> In our study we found readings with ICare and GAT increased with 0.35 and 0.36 mmHg for every 10-unit increase in CCT respectively. Brusini et al.<sup>21</sup> found an increase of 0.7 mmHg of Icare pro for every 10um change in CCT whereas another study<sup>27</sup> demonstrated 0.097 mmHg deviation for every 10um change in CCT.

Likewise, another study showed deviation in mean IOP measurement by 0.27 mmHg with NCT and 0.19 mmHg with GAT for every 10um change in CCT.<sup>28</sup> ICare overestimated GAT reading by 1 mmHg for every 100-um increment in CCT.<sup>20</sup> Study by Martinez et al.<sup>18</sup> showed similar result of ICare and GAT with effect on CCT. Similar positive correlation was seen by Guler et al.<sup>29</sup> and Kato et al.<sup>30</sup> which were comparable to different other studies<sup>16,19</sup>

## Conclusion

ICare showed good correlation in IOP reading with that obtained by GAT. It offers comfort and becomes more practical especially in children and in cases with difficulty head positioning in slit lamp. It is a well-tolerated, safe, highly reproducible useful device which yields faster and reliable results in glaucoma screening, inpatient examination and emergency setting and can be taken as an effective alternative to GAT for clinical purpose.

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