

A Study of Intraocular Pressure with I Care Tonometer & Applanation Tonometer

Dr Karthika Mohankumar¹ Dr. Rashmi Jain², Dr Vidya Hegde, Dr Anupama B,
Dr. Rashmi S

¹(Ophthalmology, Yenepoya Medical College, India)

²(Ophthalmology, Yenepoya Medical College, India)

Abstract:

Purpose: To compare the Intra Ocular Pressure (IOP) measurements obtained by Applanation Tonometer (AT) & Rebound Tonometer (RT).

Methods: The Central Corneal Thickness (CCT) corrected IOP of 100 eyes were measured using first with RT (I Care) followed by AT (GAT). Results were compared statistically using Bland –Altman plot & Deming's regression analysis.

Results: Scatter plot analysis showed that for the same value of IOP measurement with I care , corresponding IOP measurement with GAT do not show much variation except for the extreme values of IOP. Bland – Altman plot analysis showed that there is no systematic difference between the measurements with both instruments in the normal range, but show systematic differences for too high & too low values. Deming's regression analysis confirmed a reasonable agreement between both instruments.

Conclusion: There is a positive correlation in our study & the IOP measured with both applanation & rebound tonometer does not vary much except for the extreme values.

Keywords: Applanation tonometer, Rebound tonometer, Intraocular pressure

I. Introduction

Tonometry is a method of measuring the intraocular pressure (IOP) with the help of instruments called tonometer. Applanation Tonometer (AT) work based on the Imbert Fick law, $P = W/A$. For an ideal, dry, thin walled sphere, the pressure inside the sphere (P) is equal to the force required to flatten its surface (W) divided by the area of flattening (A). It consists of a double prism mounted on a standard slit lamp, the prism applanates the cornea in an area of 3.06 mm diameter. Applanation tonometry is considered the gold standard method of IOP measurement. In AT, local anaesthetic agent is used to anaesthetise the cornea & then IOP is recorded. ^[1,2] Rebound tonometer (I care) does not cause any indentation or applanation and no anaesthesia is required. The rebound tonometer (RT) propels a magnetized probe (1mm in diameter) toward the cornea and detects deceleration of the probe as a result of eye contact. The speed of deceleration is recorded and calculated by the device. The deceleration and motion of the probe depends on the hardness or tension of the surface on which it is striking. It is portable and easy to use. Therefore, the IOP recorded by RT in the normal range is 2 to 3mm higher than that by AT and the difference is directly proportional to the IOP. If IOP is higher than the normal range (10 to 21mm Hg), the difference in measured IOP by RT in comparison with AT may be up to 8 to 10mm Hg. Thus, this recording by RT may be more accurate. ^[3]

In this study rebound tonometer (I care) and Applanation tonometer are used to measure the intraocular pressure and the measurements are compared to know the variation in readings with both the instruments. The patient & examiner comfort is also evaluated based on a questionnaire study.

II. Materials And Methods

The study was conducted in accordance with the ethical norms as laid down in the Declaration of Helsinki. Approval of the Yenepoya University Ethics Committee was taken prior to starting the study. Participants were enrolled from patients attending the Ophthalmology department. Informed written consent was taken from the subjects before enrolling them for the study. The participants were explained the details of the study, examination procedure and the time required for the same. The study adhered to the ICMR guidelines for ethical conduct of biomedical research on human participants. It was a hospital based, cross sectional, comparative study. The patients having corneal pathology (e.g., corneal epithelial defects, corneal stromal scarring, and corneal edema) were excluded from the study. Eligible, middle aged (40-60 years) participants irrespective of gender, with or without glaucoma were included in the study.

IOP was recorded first using Icare. Patient is comfortably seated facing the examiner & asked to maintain a straight gaze. Topical anesthesia is not required for measuring IOP with Icare. Icare tonometer is placed in front of the examining eye (right eye followed by left eye), after wiping the tip of probe with alcohol

swab (70% Isopropanol) & adjusting the forehead distance. The tip of the probe is kept 2mm away from the cornea & readings are taken. An average of 5 readings is taken as the final value.

This was followed by recording IOP, using Goldman Applanation Tonometry (Model: Appasamy Associate AIA-12). One drop of 0.5% proparacaine is placed in each eye & the tip of moistened fluorescein strip is touched to the tear layer on the inner surface of each lower eyelid. The patient is asked to close the eyes, for uniform spread of fluorescein. IOP is measured in the right eye until three successive readings were within 1mmHg. IOP is then measured in the left eye. The readings measured in grams were multiplied by 10 to give the IOP in millimeters of mercury.

The correction for the central corneal thickness (CCT) is applied using the standard correction chart. CCT was measured using Ultrasound Pachymetry (Sonomed 200PT) after instilling 3-4 drops of 0.5% proparacaine hydrochloride ophthalmic solution. An average of five readings was taken as final value and after correcting for central corneal thickness.

The IOP measured using GAT & RT was compared. The patient & the examiner were provided with a questionnaire which evaluates the comfort level of both. The comfort level was given scores as listed below ^[10]:

- 1) The Icare much more comfortable (score 1)
- 2) The Icare more comfortable (score 2)
- 3) No difference between the 2 methods (score 3)
- 4) The Goldmann tonometer more comfortable (score 4)
- 5) The Goldmann tonometer much more comfortable (score 5)

The ease of doing the procedure & of doing the sterilization of both Goldmann applanation tonometry & I care (rebound tonometer) were also assessed. The comfort of patient & examiner for doing the procedure also assessed based on a questionnaire.

III. Results

The study included 100 eyes and the age of participants ranged from 44- 53 years, with mean age of 49 years. The gender wise distribution of the participants is depicted in Graph 1. Of the 100 eyes, 71 were non glaucomatous & 29 had glaucomatous changes.

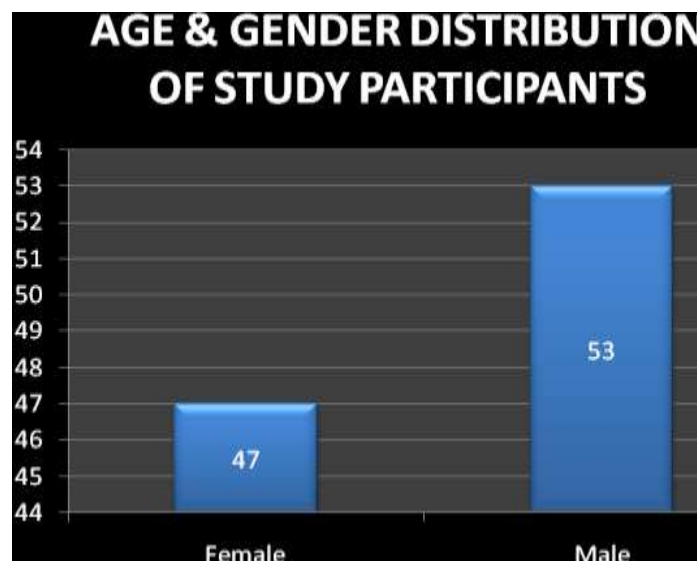


Figure 1: Age and gender distribution of study participants

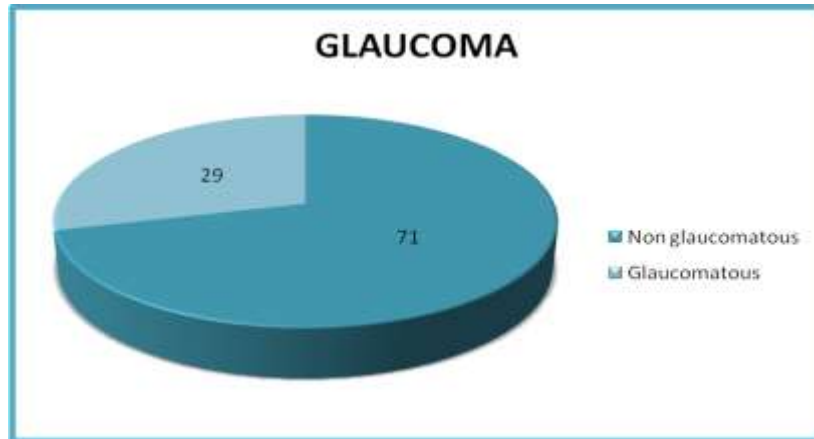


Figure 2: Number of Glaucomatous & non glaucomatous eyes in the study

Of the 100 eyes, 48 right eye & 52 left eye was included, which is shown in figure 3

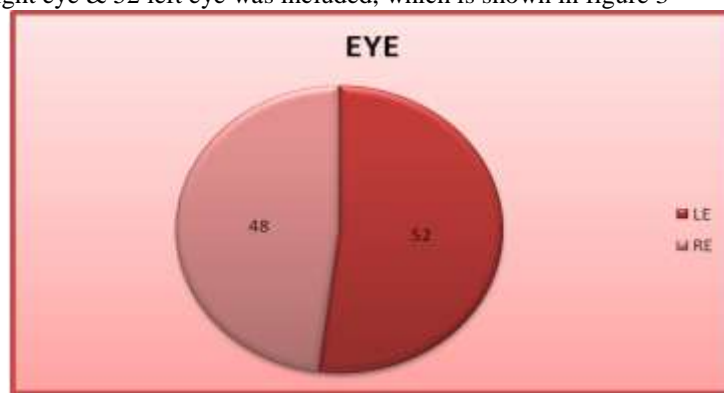


Figure 3: Eyes examined

The Bland Altman plot analysis of IOP by GAT & I Care was carried out using MedCalc ver.15.6.1 and is depicted in figure 4. X Axis shows Mean of CCT corrected IOP with GAT & I care and Y Axis shows difference of CCT corrected IOP with GAT & I care. In Bland-Altman plot the confidence interval lies between 0.48 & 1.42. The zero line of equality falls within the confidence interval which indicates that there is no much systematic difference between the measurements taken with both tonometers. The diagram also shows that most of the measurements fall within the mean of measured values. The two values which show upward bias & three values which show downward bias are extreme values of IOP. Thus it can be concluded that there is significant agreement between IOP measurements with Goldmann Applanation tonometry & Rebound tonometry, except for extreme high & low IOP measurements.

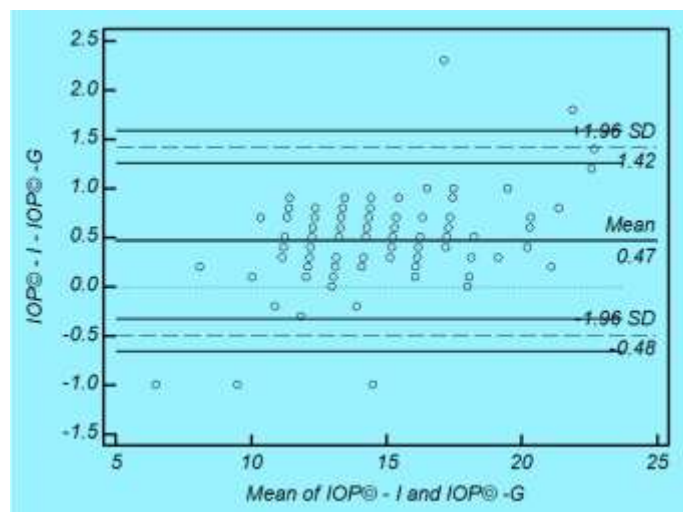


Figure 4 Bland Altman plot analysis of IOP by GAT & I Care

In the scatter plot (Figure5), the dotted line is the line of agreement. Since the values measured with both instruments are almost equal, all pairs of measurements are lying on the dotted line. Few extreme values are falling outside the line which shows that in extreme IOP variation the values obtained by both the instruments vary significantly.

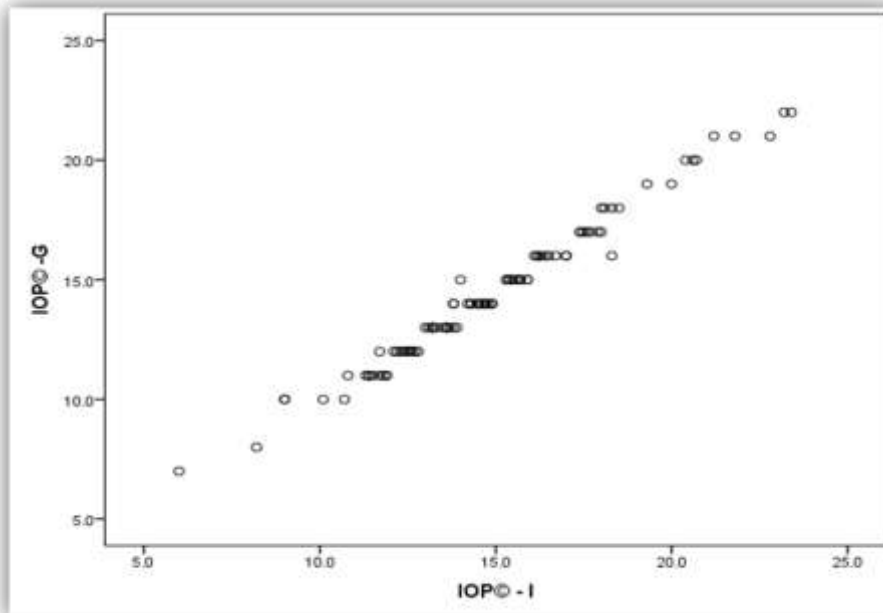


Figure 5: The scatter plot of IOP readings with GAT & I Care

Figure 6 is depicting Deming regression graph. It shows that there is agreement between the values measured with Goldmann applanation tonometry & rebound tonometry. The intercept value is 0.5302 with confidence interval including 0 (0.006368 to 1.0539). This value measures that the systematic difference between the two methods is equal to 0. I.e. we accept the hypothesis that intercept is 0. The slope coefficient is 0.9329 with confidence interval including 1 (0.6874 to 1.0988). This indicates that the proportional difference between the 2 methods is equal to 1(i.e, $Y=X$). We accept the hypothesis that slope is equal to 1. Hence from Deming regression and plots we can conclude that there is reasonable agreement between the 2 measurements. The regression equation can be validated using an independent set of observations.

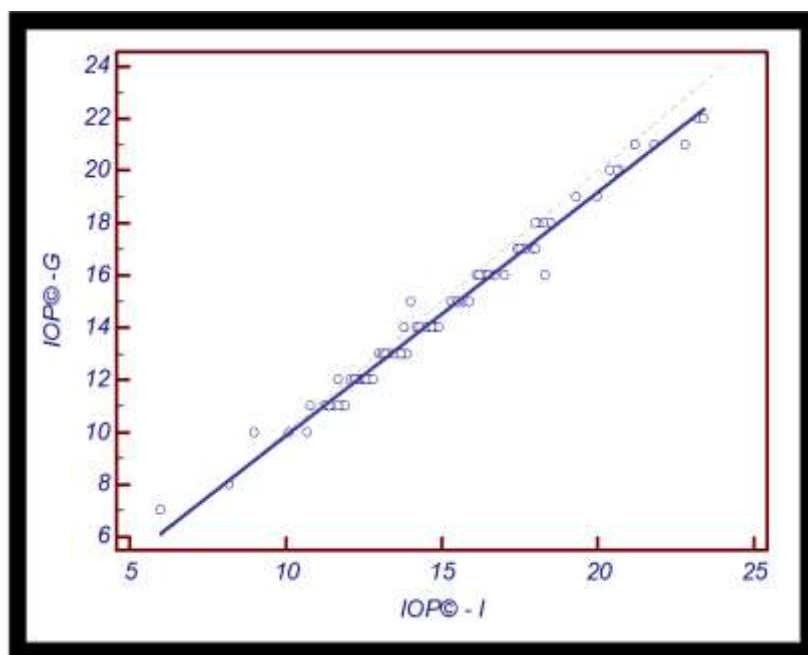


Figure 6: Deming's regression graph of agreement between the measurements with GAT & I care

IV. Discussion

Accurate and consistent measurement of intraocular pressure (IOP) remains a key factor in the diagnosis and management of glaucoma. Despite numerous portable devices available, the majority of ophthalmologists rely solely on the Goldmann applanation tonometry (GAT) as it is the gold standard method of obtaining IOP. However, accurate use of this instrument requires significant training, and inaccuracies are common in the hands of inexperienced examiners. Furthermore, GAT requires a slit lamp microscope, and the use of topical anesthetic with fluorescein dye. Topical anesthetic is unpleasant for the majority of patients due to stinging and reflex closure of eye makes accurate measurements difficult to obtain in a subset of patients. Given the increasing time restraints placed upon many ophthalmologists, IOP measuring devices, which are accurate, portable, and can be easily used by various operators with minimal interoperator variability, are appealing. In situations where rapid assessment or screening is desirable, such as in remote community settings, the use of the GAT is impractical. Furthermore, in circumstances (such as within the emergency department) in which identification of either very low or high pressures can have significant management implications, accessibility to a simple reliable instrument is valuable.

The Icare tonometer is a hand-held portable tonometer, which relies on the induction rebound or impact principle. It is able to rapidly obtain IOP measurements without the need for topical anaesthesia. Rebound or impact tonometry is based on making a moving object collide with an eye while monitoring the motion parameters of the colliding object. At low IOP, the deceleration of the probe is less than that observed at high IOP. Consequently, the higher the IOP, the shorter the duration of the impact. IOP is calculated from the measurement of impact duration and/or maximum deceleration. Use of the device is simple and can be rapidly taught. It may have a role in the setting of community screening, or in situations where GAT is difficult or not practical provided it can be shown to be accurate.

In a study which compares the IOP measurements obtained by the Icare tonometer with those acquired using the gold standard, GAT; IOP values with Icare tonometer is in close agreement with the GAT, in the majority of patients. Furthermore, the Icare was consistently able to identify cases in which the IOP was well outside what is considered normal. However, it does appear that the Icare overestimates the GAT in the lower IOP ranges and underestimates in the higher ranges. Despite this, these discrepancies are small and may not be clinically significant, especially if the instrument is used for screening purposes. The 95% limits of agreement for the Icare versus GAT were approximately between 5.0 and 6.0mm Hg. Thus they concluded that, the Icare seems to record accurate readings in most situations when compared with GAT ^[3].

A study to assess the accuracy of a rebound tonometer (RT) in patients with glaucoma, comparing the measurements with those obtained by a noncontact tonometer (NCT) and a Goldmann applanation tonometer (GAT); IOP readings obtained by an I-care tonometer have shown reasonable concordance with GAT. The study concluded that it may be considered as an appropriate method for clinical use in normal subjects and glaucoma patients ^[4].

In a study to evaluate the relationship between central corneal thickness (CCT) and intraocular pressure (IOP) measured by Icare rebound tonometry (RT) in normal and glaucomatous patients; difference of IOP obtained by RT and GAT increases with increasing CCT. They found a 0.8mm Hg (~1mm Hg) increase in deviation of RT from GAT in glaucomatous patients with thicker corneas > 530 μ m while it did not affect the IOP readings in normal and in glaucomatous eyes with thin cornea. They noticed that the difference between GAT and RT widened by 0.8mm for every 10 μ m increase in CCT. Thus they concluded that central corneal thickness has an importance on IOP readings by Icare RT ^[5].

In a comparative study of intraocular pressure (IOP) measurements obtained by rebound tonometry, Applanation tonometry [Goldmann (GAT) and Perkins (PAT)], and dynamic contour tonometry (DCT) in the upright and the supine positions it has been shown that measurements obtained with the RT, either in the upright or in the supine position, show good correlation and agreement with those provided by applanation and dynamic contour tonometry. In conclusion, IOP measurements taken in the upright position with the Icare tonometer correlate well with those provided by GAT. The Icare in the upright position showed a mean tendency to underestimate IOP in comparison with the DCT reading of 1.8mm Hg. IOP values taken in the supine position were approximately 2mm Hg higher than values taken in the seated position most likely due to hydrostatic pressure. In the supine position, the Icare correlates well with the PAT. The influence of CCT on IOP determination is based on the assumption that thicker corneas are not as deformable as thinner corneas and will therefore record artificially high IOPs ^[6].

In yet another study to analyze the correlation of rebound tonometer (RT) and Goldmann applanation tonometer (GAT), assess the intraobserver and interobserver reproducibility of these tonometer, and investigate the influence of central corneal thickness (CCT) on intraocular pressure (IOP) measurements recorded with both tonometer in glaucoma patients under treatment, it has been shown that both tonometer demonstrated a close level of agreement. CCT influences IOP measurements obtained with both tonometers, with higher IOP readings with thicker corneas. In addition to the influence of CCT on IOP measurements obtained with RT, this

tonometer has been shown to be affected by other biomechanical properties of the cornea, including corneal hysteresis and corneal resistance factor. Intraobserver and interobserver variability have been well reported for GAT in both healthy subjects and glaucoma patients. High reproducibility of RT has been demonstrated in both healthy adults and children. But intraobserver and interobserver reproducibility of RT has not been reported in glaucoma patients. The results indicate high reproducibility in glaucoma patients with both tonometers, as shown by high intraobserver correlation^[7].

A study conducted to investigate whether the ICare rebound tonometer can provide accurate measurements of intraocular pressure (IOP) in the hands of an inexperienced user compared with ICare measurements and Goldmann tonometry by a trained technician, it was found that the patient's measurement using the ICare compared well with that of the trained technician using the ICare (88% correlation). A high degree of corroboration (81%) between the IOP measurements taken by the patient using the ICare and the technician using GAT was also found^[8].

In a prospective observational study to evaluate the effectiveness of using a noncontact tonometer (NCT) versus a rebound tonometer (ICare) when measuring the intraocular pressure (IOP) in healthy children it has been noticed that IOP measurements performed using ICare are better tolerated in the pediatric population, as compared with measurements using NCT, especially in children below the age of 6 years. Tonometry procedures are difficult in children because there is lack of cooperation in these young children and they also do not want to be administered topical anesthetic drugs. In children 9-years-old and older NCT was used to record the IOP readings and came to be accurate. Therefore, the NCT methodology seems not to be applicable in children younger than 9 years of age. In contrast, IOP measurements performed when using ICare were found to be highly reproducible in schoolchildren aged 7 to 15 years^[9].

The study which evaluated the tolerability of the ICare rebound tonometer (RT) and to establish reference values of the intraocular pressure (IOP) in healthy infants, it was found that hand-held RBT is easy to use, as it does not require topical anaesthesia and it is very well tolerated by cooperative infants^[10].

In a prospective study to compare intraocular pressure (IOP) measurements obtained using the rebound tonometer (RT) and the handheld Goldmann applanation tonometer (Perkins) in children with congenital glaucoma, the results came as the RBT overestimates the IOP compared with the Perkins tonometer in patients with congenital glaucoma. Differences in readings between the 2 tonometer become larger as the CCT increases. In conclusion, despite the good correlation between RT measurements and those obtained using the Applanation tonometer, we should expect greater differences in pediatric than in adult patients. Such differences may be conditioned both by the range of pressures examined (i.e., the higher the IOP the greater the difference between the readings provided by the 2 instruments) and by CCT (i.e., the thicker the cornea the greater the difference) such that the 2 tonometer should not be interchangeably used when monitoring this type of patient^[11].

In a study to find out the effect of central corneal thickness (CCT) and radius of the corneal curvature on intraocular pressure (IOP) measurements using rebound tonometer (RT) and Tono-Pen in healthy schoolchildren, it has been concluded that the measured IOP increased 2.3 and 3.5mm Hg for every 100- μ m increase in CCT for the Tono-Pen and RT, respectively. IOP readings by the Tono-Pen and the RBT are affected by CCT to differing degrees in school children, like in adults^[12].

A comparative study in which the intraocular pressure (IOP) measurements are obtained by the Icare and the hand-held Goldmann Applanation tonometer (also called Perkins) in aphakic children after congenital cataract surgery, the results pointed to a conclusion that most of the young patients accepted the Icare tonometer under unsedated conditions. The Icare tonometer for IOP measurements is easy to use, does not require the application of topical anesthetic, and is very well tolerated by young patients. This significant advantage indicated that the Icare tonometer was overall better tolerated in pediatric aphakia population, although it could overestimate the IOPs compared with the measurements obtained from the Perkins tonometer. Differences in readings between the two tonometers become bigger as the CCT increase^[13].

A study which compared the intraocular pressure (IOP) readings taken with the new ICare tonometer and with the Goldmann applanation tonometer (GAT) and to evaluate the influence of central corneal thickness (CCT) on the IOP measurements, they came to the conclusion that The ICare tonometer can be useful in a routine clinical setting. The IOP readings are quite in accordance with those obtained by GAT. The measurements seemed to be influenced by CCT variations, and thus pachymetry should always be taken into consideration. While evaluating the influence of CCT on the IOP measurements obtained with the new ICare tonometer; it has been shown that the ICare measurements were influenced by CCT, being overestimated in eyes with thick corneas and underestimated in eyes with thin corneas^[14].

A study conducted to establish the intraobserver and interobserver reliability of the rebound tonometer (RT) in healthy schoolchildren and to test patient tolerance in an unanesthetized eye, they concluded that measurement of IOP with the RT is a highly reproducible method in school children showing high intraobserver and interobserver correlation and it seems to be very comfortable when performing IOP measurements in school children without an anesthetic. The impact on the eye is so gentle that in a majority of the cases it does not even

cause an eye blinking reflex. Thus, it should be a method for IOP measurement in schoolchildren that is rapid, reliable, operator independent, and has low variability [15].

V. Conclusion

There is an agreement between both the instruments in normal range of IOP, but in there is a statistical disagreement between both the instruments in extreme values of IOP. Comfort of the both the patient & examiner using both the instruments showed that rebound tonometer (I care) is much comfortable to use in most of the patients, but some patients prefer GAT over I care. In such patients we have found that while measuring the IOP they close their eyes when the probe was moved. But when GAT is done after anaesthetising the cornea, the reflex closure of eyes is less. Sterilization of instruments were also assessed which shows that in both the instruments there is no much difference. Both the instruments can be sterilized with 70% isopropyl alcohol swabs that are available. Thus we concluded that I care (rebound tonometer) can be used as alternative to GAT in most of the cases of normal range of IOP, but GAT still remains the Gold standard for IOP measurements in all ranges of IOP measurements.

References

- [1]. Stamper RL, Lieberman MF, Drake MV. Clinical diagnosis of glaucoma. In Stamper RL editors. Becker-Shaffer's diagnosis and therapy of glaucoma. 8th ed. Elsevier 2009; 160-65.
- [2]. Allingham RR, Damji KF, Freedman S, Moroi SE, Rhee DJ. Intraocular pressure and tonometry. In Allingham RR editors. Shields text book of glaucoma. 6th ed. Lippincott Williams & Wilkins 2011; 29-35.
- [3]. Suman S, Agrawal A, Pal V K, Pratap V B. Rebound Tonometer: Ideal Tonometer for Measurement of Accurate Intraocular Pressure. *Journal of Glaucoma* 2014; 23(9):633-637.
- [4]. Rao A, Kumar M, Prakash B, Varshney G. Relationship of Central Corneal Thickness and Intraocular Pressure by Icare Rebound Tonometer. *J Glaucoma* 2014; 23: 380-384.
- [5]. Jablonski K.S, Rosentreter A, Gaki S, Lappas A, Dietlein T.S. Clinical Use of a New Position-independent Rebound Tonometer. *J Glaucoma* 2013; 22: 763-767.
- [6]. 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: 325-329.
- [7]. Asrani S, Chatterjee A, Wallace D. K, Turla C. S, Stinnett S. Evaluation of the ICare Rebound Tonometer as a Home Intraocular Pressure Monitoring Device. *J Glaucoma* 2011; 20: 74-79.
- [8]. Kageyama M, Hirooka K, Baba T, Shiraga F. Comparison of ICare Rebound Tonometer With Noncontact Tonometer in Healthy Children. *J Glaucoma* 2011; 20: 63-66.
- [9]. Lundvall A, Svedberg H, Chen E. Application of the ICare Rebound Tonometer in Healthy Infants. *J Glaucoma* 2011; 20: 7-9.
- [10]. Casa M, Jose M, Feijoo J.G, Frances F. S, Vizzeri G, Vidal A F, Hernandez C.M, Sanchez J.G. Comparison of Rebound Tonometer and Goldmann Handheld Applanation Tonometer in Congenital Glaucoma. *J Glaucoma* 2009; 18: 49-52.
- [11]. Sahin A, Basmak H, Yildirim N, The Influence of Central Corneal Thickness and Corneal Curvature on Intraocular Pressure Measured by Tono-Pen and Rebound Tonometer in Children. *J Glaucoma* 2008; 17: 57-61
- [12]. Pakrou N, Gray T, Mills R, Landers J, Craig J. Clinical Comparison of the Icare Tonometer and Goldmann Applanation Tonometry. *J Glaucoma* 2008; 17: 43-47.
- [13]. Li Y, Tang L, Xiao M, Jia S, Liu P, Zhou Y, Chen H, Zeng J. Comparison of the Icare Tonometer and the Hand-held Goldmann Applanation Tonometer in Pediatric Aphakia. *J Glaucoma* 2013; 22: 550-554.
- [14]. Brusini P, Salvetat M.L, Zeppieri M, Tosoni C, Parisi L. Comparison of ICare Tonometer with Goldmann Applanation Tonometer in Glaucoma Patients. *J Glaucoma* 2006; 15: 213-217.
- [15]. Sahin A, Basmak H, Niyaz L, Yildirim N. Reproducibility and Tolerability of the ICare Rebound Tonometer in School Children. *J Glaucoma* 2007; 16: 185-188.