·Clinical Research·

Intraocular pressure measurement over soft contact lens by rebound tonometer: a comparative study

Senay Asik Nacaroglu[1], Emine Seker Un[1], Mehmet Giray Ersoz[1], Yelda Tasci[2]

[1]Department of Ophthalmology, Tepecik Traning and Research Hospital, Izmir 35240, Turkey
[2]Department of Ophthalmology, Akdagmadeni State Hospital, Yozgat 66300, Turkey
Correspondence to: Senay Asik Nacaroglu. Turan Gunes cd. Denizatikent sitesi, A2 blok No:57 Zeytinburnu, Istanbul, Turkey. asksenay@yahoo.com
Received: 2014-07-19 Accepted: 2014-08-29

Abstract

• AIM: To evaluate the intraocular pressure (IOP) measurements by Icare rebound tonometer over a contact lens in comparison with Goldmann applanation tonometry (GAT).

• METHODS: Fifty patients using contact lens were included in this study. One of the eyes of the patients was selected randomly and their IOP were measured by rebound tonometer with and without contact lens (RTCL, RT respectively) and by GAT, as well as their central corneal thickness (CCT) by optical pachymeter. The results of both methods were compared by correlation analysis, general linear method repeated measure and Bland-Altman analysis.

• RESULTS: Mean IOP values measured by RTCL, RT and GAT were 15.68±3.7, 14.50±3.4 and 14.16±2.8 ($P<0.001$), respectively. Mean IOP by RTCL was significantly higher than the measurements implemented by RT and GAT ($P<0.001$), while there was no difference between the measurements by GAT and RT ($P=0.629$). There was a good level of positive correlation between GAT and RTCL as well as RT ($r=0.786$ $P<0.001$, $r=0.833$ $P<0.001$, respectively). We have observed that CCT increase did not show any correlation with the differences of the measurements between RTCL and RT ($P=0.329$), RTCL and GAT ($P=0.07$) as well as RT and GAT ($P=0.189$) in linear regression model.

• CONCLUSION: The average of the measurements over contact lens by rebound tonometer was found to be higher than what was measured by GAT. Although this difference is statistically significant, it may be clinically negligible in the normal population.

• KEYWORDS: contact lens; intraocular pressure; rebound tonometer

DOI:10.3980/j.issn.2222-3959.2015.03.18

Nacaroglu SA, Un ES, Ersoz MG, Tasci Y. Intraocular pressure measurement over soft contact lens by rebound tonometer: a comparative study. *Int J Ophthalmol* 2015;8(3):540-543

INTRODUCTION

Among tonometers for IOP measurement, Goldmann applanation tonometry (GAT) is the gold standard[1]. Accuracy of GAT measurement depends on many factors such as corneal thickness, corneal biomechanics and corneal curvature [2]. Furthermore, this device is dependent on slit lamp and can not implement measurements over a contact lens because it requires florescein dye. However, Icare tonometer that implements measurements based on rebound principle, is a lightweight, portable and quick measuring device. Besides, it does not require topical anaesthesia and can measure over a contact lens [3]. Previous studies have shown that there is a good level of correlation between Icare tonometer and GAT [4,5]. The aim of this study is to assess the accuracy of intraocular pressure (IOP) measurements using Icare rebound tonometer with and without refractive contact lenses (RTCL, RT respectively), to compare with the measurements by GAT, and to evaluate the effect of central corneal thickness (CCT) on these measurements.

SUBJECTS AND METHODS

Randomly selected 50 eyes of 50 patients were included in this study, who were wearing spherical silicon hydrogel refractive (senofilcon A) contact lenses and followed up at the Cornea and Contact Lens Unit of the Ophthalmology Clinic of Izmir Tepecik Education and Research Hospital between January 2012 and June 2012. All contact lenses fit had an 8.40 mm base curve, 14.0 mm total diameter, 0.72 MPa modulus, 38% water content and had different central contact lens thicknesses (*e.g.* 0.07 mm for -3.00 D). Each case was subjected to an ophthalmological examination before being included in the study. All patients underwent measurement of best corrected visual acuity (Snellen charts), visual field examination (30-2, Humphrey Field Analyzer; Dublin, CA, USA), optical corneal pachymeter (Topcon® SP-2000P, Japan), examination of the anterior and posterior segments of the eye. The cases having any ocular pathology, any refractive error with spherical equivalent beyond the interval of +2.00 D and -4.00 D, any corneal astigmatism above 1.00 D, any corneal scar, glaucoma suspect, glaucoma history in the family, and ocular surgery history, were excluded.

After approval was obtained from the ethical board of our hospital, written informed consent was also obtained from all patients. The study was executed in accordance with the ethical standards specified in the Declaration of Helsinki (2008).

IOP measurements were performed by three resident doctors, unaware of each other. The first IOP measurement was implemented over contact lens by Icare® TA01i (Finland). By this device which gives the average of four values, excluding the maximum and minimum IOP, three consecutive measurements were made, and the average was taken. After contact lens was removed, and CCT was measured by Topcon® SP-2000P (Japan) optical pachymeter three times, and were averaged, IOP value without lens was obtained by average of three measurements by Icare done by another resident doctor without using anesthetic drop. After topical anesthetic and fluorescein eye stain instillation, IOP was measured three times by GAT by another resident doctor and their averages were recorded. All measurements were completed within 15min.

Statistical analysis was performed by using Statistical Package for Social Science (SPSS 19.0 for Windows; SPSS Inc., Chicago, USA). The results of two devices, as well as repeated measurements, were compared by general linear model repeated measure. Post hoc tests were done by Bonferoni correction. Correlation analysis was done by Pearson's correlation coefficient test. Bland-Altman analysis was used to demonstrate the compatibility of both devices. The relation between CCT and IOP measured by Icare was evaluated by using regression analysis. P<0.05 value was accepted as significant.

RESULTS

Thirty-six (72%) of the cases were women, 14 (28%) were men, and their mean age was 26.52±6.12y (18-41). Mean CCT was 540±33.5 μm. Mean best corrected visual acuity was 0.89±0.14 with Snellen chart (Table 1).

The mean IOP measurement by RTCL was 15.68±3.75 mm Hg (range 8-24), while mean IOP measurement by RT was 14.50±3.41 mm Hg (range 7-21) and mean IOP measurement by GAT was 14.16 ±2.88 mm Hg (range 9-20). IOP measurement by RTCL was found to be significantly higher than measurements by both RT and GAT (P<0.001). The difference of measurements, however, between RT and GAT was not significant (P=0.629; Table 2).

The comparison of two devices by Bland-Altman analysis is shown in Figure 1. Measurements by RTCL tended to be higher with respect to measurements by GAT. The average of the difference of measurement of IOP by RT and IOP by GAT was 0.34 mm Hg and the standard deviation was 1.89 mm Hg; the limits of agreement were -3.48 mm Hg and +4.08 mm Hg.

The average of the difference between IOP measurement by RTCL and IOP measurement by GAT was 1.52 mm Hg and the standard deviation was 2.32 mm Hg; the limit of agreement was between -3.02 and +6.16 mm Hg (Figure 2).

The difference between the IOP measurements by RT and GAT was ≤2 mm Hg in 88% of the cases, and it was ≤3 mm Hg in 94% of the cases. The difference between the IOP measurements by RTCL and GAT was ≤2 mm Hg in 72% of the cases, it was ≤3 mm Hg in 80% of the cases.

The difference between RTCL and RT measurements was ≤2 mm Hg in 80% of the cases and ≤3 mm Hg in 92% of the cases.

There was a good level of positive correlation between the measurements of GAT and RTCL as well as RT (r=0.786, P<0.001, r=0.833, P<0.001, respectively). There was however a very good level of positive correlation between RTCL and RT measurements (r=0.903, P<0.001). We have observed that CCT increase in linear regression model did not show any correlation with the differences

Table 1 Patients demographics (n=50)

Variables	$\bar{x} \pm s$
Gender (F/M)	36/14
Mean age (a)	26.52±6.12
CCT (μm)	540±33.5
Spherical equivalent (D)	-1.62±1.63
BCVA (Snellen)	0.89±0.14

CCT: Central corneal thickness; BCVA: Best corrected visual acuity; SD: Standart deviation.

Table 2 Comparison and correlation of mean IOP measurements that were measured by RTCL, RT and GAT

IOP	$\bar{x} \pm s$	P	r	P
RTCL-RT	15.68±3.75 - 14.50±3.41	<0.001	0.903	<0.001
RTCL-GAT	15.68±3.75 - 14.16±2.88	<0.001	0.786	<0.001
RT-GAT	14.50±3.41 - 14.16±2.88	0.629	0.833	<0.001

IOP: Intraocular pressure; RTCL: Rebound tonometry with contact lens; RT: Rebound tonometry without contact lens; GAT: Goldmann applanation tonometry.

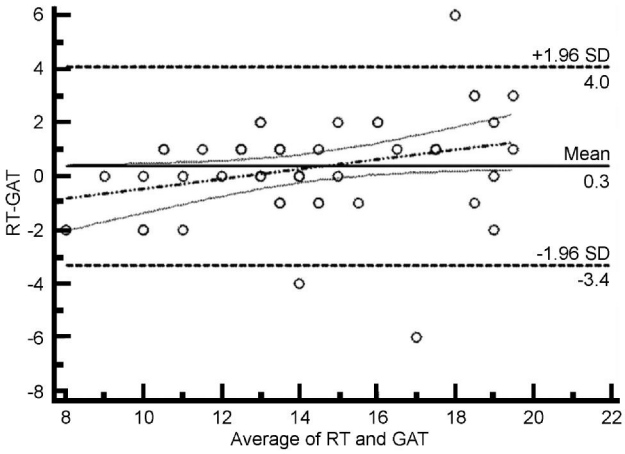

Figure 1 Bland-Altman analysis comparing IOP values measured by rebound tonometry without contact lens (RT) and GAT X axis shows IOP means measured by RT and GAT, Y axis shows IOP differences measured by RT and GAT. Bold line shows the average, dashed slope shows regression curve and dim lines show 95% confidence interval.

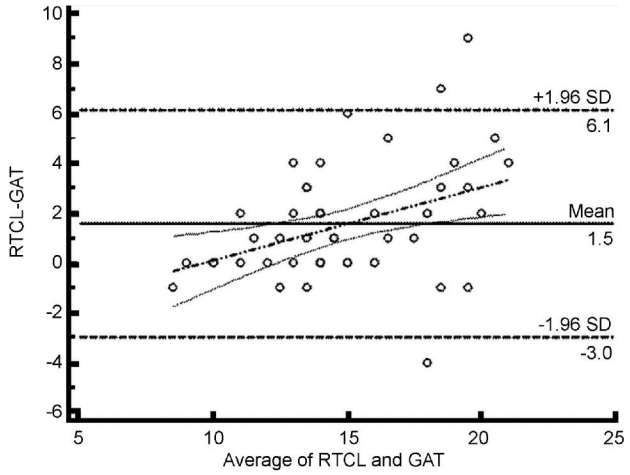

Figure 2 Bland –Altman analysis comparing IOP values measured by RTCL and GAT X axis shows IOP means measured by RTCL and GAT, Y axis shows IOP differences measured by RTCL and GAT. Bold line shows the average, dashed slope shows regression curve, and dim lines show 95% confidence interval.

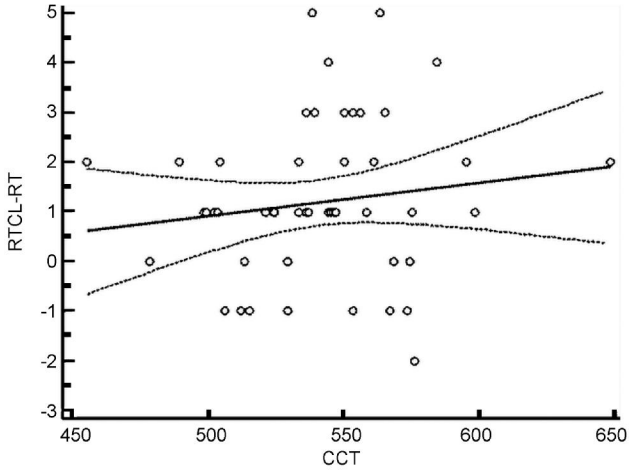

Figure 3 Dot graph showing the relation between the difference of IOP measurements of RTCL and rebound tonometry without contact lens (RT) and CCT (P=0.329).

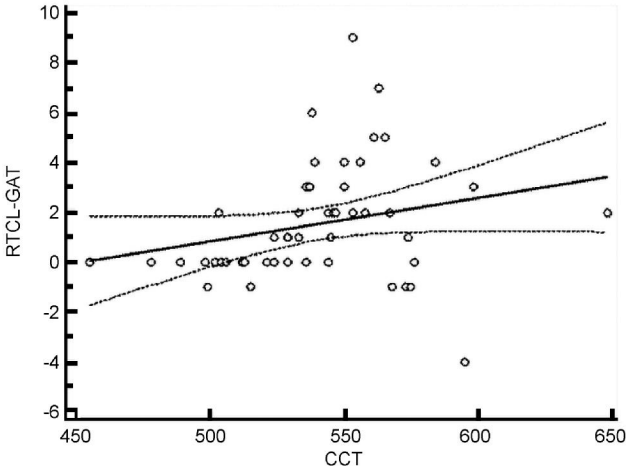

Figure 4 Dot graph showing the relation between the difference of IOP measurements of RTCL and GAT and CCT (P=0.07).

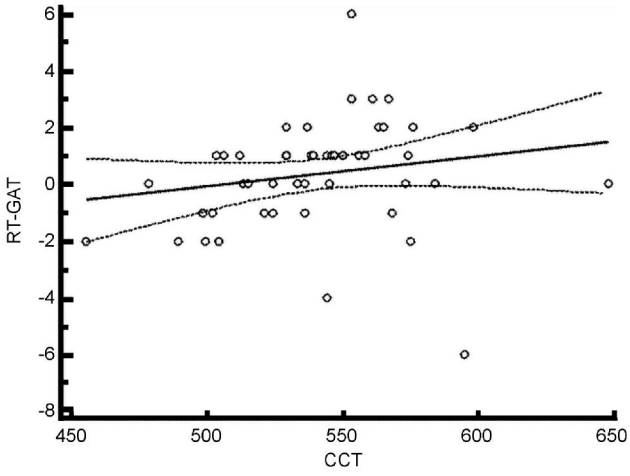

Figure 5 Dot graph showing the relation between the difference of IOP measurements of RT and GAT and CCT (P=0.189).

between RTCL and RT measurements (P=0.329), RTCL and GAT measurements (P=0.07) as well as RT and GAT measurements (P=0.189; Figures 3, 4, 5).

DISCUSSION

Icare tonometer is a modern tonometer that measures the IOP by rebound method. It provides quick measurement without requiring slit lamp, and it is a portable and lightweight device[6,7]. Furthermore, it has advantages such as providing a comfortable measurement without any need for local anaesthesia. It is enabling IOP measurement over contact lens and self-measurement by the patients[8,9].

The initial studies of the Icare tonometer compared with GAT reported a good correlation, with a slight overestimation of the measurements [10-12]. Although there are many studies comparing Icare tonometer with GAT, there is a limited number of studies comparing IOP measurement by Icare over contact lens and without contact lens and GAT. In a study Zeri *et al* [13] have found that IOP values measured over contact lens by rebound tonometer were lower than the ones directly measured over cornea. Anton *et al* [14] in a study that they compared noncontact tonometer and rebound tonometer in patients wearing contact lenses, the measurements over the lens by Icare were found to be significantly higher. In this study, we have found that RTCL measurements were significantly higher than RT and GAT measurements, in concordance with the results of the study published by Anton *et al*[14].

Fernandes *et al* [4] have compared Icare and GAT in a study, and reported that the average of the difference of measurements by two devices was 1.34 mm Hg (95% confidence interval -2.6 and 5.3 mm Hg) and the measurements by Icare have the tendency of giving higher results. Yet again in several studies in the literature comparing Icare with GAT, these ratios vary between 0.4 and 1.9 mm Hg[15-17]. In our study, in a similar way, the average of the differences between the measurements of RT and GAT is

0.34±1.89 mm Hg (limit of agreement -3.48 and 4.08 mm Hg). These results are lower than the averages in the literature. In a study by Khan and Graham [18], they showed that the IOP measurements right after the removal of contact lens happen to be 0.8 mm Hg lower. Inconsistent with the literature our mean IOP was lower, since the measurements were done immediately after lens removal. Rao *et al* [19], in their study, have found a significant correlation (r =0.8, P <0.001) between the measurements of rebound tonometer and GAT, besides they have evaluated how much rebound tonometer measurement deviate from GAT measurement by variation in CCT, and observed that the measurements of glaucoma patients were affected by CCT increase. They have reported, however, that such an effect did not occur in normal cases. In this study we have found that there was a good degree of correlation between RTCL, RT and GAT. Jóhannesson *et al* [20] have demonstrated a negative correlation between CCT and the difference of IOP measured by applanation and Icare tonometry. However, in our study, neither the difference between RTCL and GAT nor the difference between RT and GAT, was related with CCT variation. That is to say, as CCT increased, the measurements by rebound tonometer with or without lens, did not show any significant deviation from GAT measurements. However, there are some limitations of our study. First of all, the patients who were included in the study were from a healthy population, and IOP readings were almost in normal range. Thereby assessing Icare performance across the extreme values of IOP as well in patients with glaucoma was insufficient. All measurements were implemented over silicone hydrogel contact lenses, different kind of contact lenses especially which have lower modulus may cause lower IOP readings with rebound tonometer. Another limitation is the number of patients, further studies are needed with a higher population to compare RT and GAT.

In conclusion, although the IOP measurements implemented by RT were found to be higher than the measurements by GAT, this difference was found to be statistically insignificant. However, the measurements over contact lens by rebound tonometer were found to be significantly higher than both measurements without lens and measurements by applanation. This difference is at a negligible level in clinical practice for healthy individuals. However, more detailed studies are needed as for glaucoma patients using contact lens and the patients with ocular hypertension where this difference might be significant.

ACKNOWLEDGEMENTS

Conflincts of Interest: Nacaroglu SA, None; **Un ES**, None; **Ersoz MG**, None; **Tasci Y**, None.

REFERENCES

1 Dielemands I, Vingerling JR, Hofman A, Grobbee DE, de Jong PT. Reliability of intraocular pressure measurement with the Goldmann applanation tonometer in epidemiological studies. *Graefes Arch Clin Exp Ophthalmol* 1994;232(3):141-144

2 Whitecare MM, Stein R. Source of error with use of Goldman-type tonometers. *Surv Ophthalmol* 1993;38(1):1-30

3 Kontiola AI. A new induction-based impact method for measuring intraocular pressure. *Acta Ophthalmol Scand* 2000;78(2):142-145

4 Fernandes P, Diaz-Rey JA, Queiros A, Gonzalez-Meijome JM, Jorge J. Comparison of the ICare rebound tonometer with the Goldmann tonometer in a normal population. *Ophthalmic Physiol Opt* 2005;25(5):436-440

5 Martinez-de-la-Casa JM, Jimenez-Santos M, Saenz-Frances F, Matilla-Rodero M, Mendez-Hernandez C, Herrero-Vanrell R, Garcia-Feijoo J. Performance of the rebound, noncontact and Goldmann applanation tonometers in routine clinical practice. *Acta Ophthalmol* 2011;89 (7): 676-680

6 Abraham LM, Epasinghe NC, Selva D, Casson R. Comparison of the ICare rebound tonometer with the Goldmann applanation tonometer by experienced and inexperienced tonometrists. *Eye (Lond)* 2008;22 (4): 503-506

7 Marini M, Da Pozzo S, Accardo A, Canziani T. Comparing applanation tonometry and rebound tonometry in glaucomatous and ocular hypertensive eyes. *Eur J Ophthalmol* 2011;21(3):258-263

8 Halkiadakis I, Stratos A, Stergiopoulos G, Patsea E, Skouriotis S Mitropoulos P, Papaconstantinou D, Georgopoulos G. Evaluation of the Icare-ONE rebound tonometer as a self- measuring intraocular pressure device in normal subjects. *Graefes Arch Clin Exp Ophthalmol* 2012;250 (8):1207-1211

9 Flemmons MS, Hsiao YC, Dzau J, Asrani S, Jones S, Freedman SF. Home tonometry for management of pediatric glaucoma. *Am J Ophthalmol* 2011; 152(3):470-478

10 Martinez-de-la-Casa JM, Garcia-Feijoo J, Vico E, Fernandez-Vidal A, Benitez del Castillo JM, Wasfi M, Garcia-Sanchez J. Effect of corneal thickness on dynamic contour, rebound, and Goldmann tonometry. *Ophthalmology* 2006;113(12):2156-2162

11 Jorge JM, Gonzalez-Meijome JM, Queiros A, Fernandes P, Parafita MA. Correlations between corneal biomechanical properties measured with the ocular response analyzer and ICare rebound tonometry. *J Glaucoma* 2008; 17(6):442-448

12 Moreno-Montañés J, García N, Fernández-Hortelano A, García-Layana A. Rebound tonometer compared with goldmann tonometer in normal and pathologic corneas. *Cornea* 2007;26(4):427-430

13 Zeri F, Calcatelli P, Donini B, Lupelli L, Zarilli L, Swann PG. The effect of hydrogel and silicone hydrogel contact lenses on the measurement of intraocular pressure with rebound tonometry. *Cont Lens Anterior Eye* 2011;34(6):260-265

14 Anton A, Neuburger M, Böhringer D, Jordan JF. Comparative measurement of intraocular pressure by Icare tonometry and Airpuff tonometry in healthy subjects and patients wearing therapeutic soft contact lenses. *Graefes Arch Clin Exp Ophthalmol* 2013;251(7):1791-1795

15 Martinez-de-la-Casa JM, Garcia-Feijoo J, Castillo A, Garcia-Sanchez J. Reproducibility and clinical evaluation of rebound tonometry. *Invest Ophthalmol Vis Sci* 2005;46(12):4578-4580

16 Pakrou N, Gray T, Mills R, Landers J, Craig J. Clinical comparison of the Icare tonometer and Goldmann applanation tonometry. *J Glaucoma* 2008;17(1):43-47

17 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(5):e392-396

18 Khan JA, Graham CE. Effect of contact lens removal or displacement on intraocular pressure. *Arch Ophthalmol* 1991;109(6):825-828

19 Rao A, Kumar M, Prakash B, Varshney G. Relationship of central corneal thickness and intraocular pressure by icare rebound tonometer. *J Glaucoma* 2012;23(6):380-384

20 Jóhannesson G, Hallberg P, Eklund A, Linden C. Pascal, ICare and Goldmann applanation tonometry-a comparative study. *Acta Ophthalmol* 2008;86(6):614-621