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Original Article

Comparison of Goldmann Applanation Tonometry and Icare Rebound Tonometry in Eyes of Varied Corneal Thickness

Isil Pasaoglu,[1] Cigdem Altan,[1] Onur Olcucu,[2] Nese Alagoz,[1] Banu Satana,[1] Berna Basarir,[1] Funda Onmez,[1] Muhittin Taskapili[1]

[1]Department of Glaucoma, University of Health Sciences Beyoglu Eye Training and Research Hospital, Istanbul, Turkey
[2]Department of Ophthalmology, Kırklareli State Hospital, Kırklareli, Turkey

Abstract

Objectives: The aim of the present study was to compare intraocular pressure (IOP) level as measured with Goldmann applanation tonometry (GAT) and Icare rebound tonometry (RBT; Icare Finland Oy, Vantaa, Finland) in patients with varied central corneal thickness (CCT).

Methods: Total of 138 eyes of 138 consecutive patients from glaucoma department were studied. Ultrasound pachymeter was used to measure CCT in all cases and patients were divided into 3 groups according to CCT. Group 1 comprised patients with thin CCT (<520 μ), Group 2 was made up of patients with normal CCT (520-570 μ), and patients with thick CCT (>570 μ) composed Group 3. IOP was measured with RBT, which uses average of 6 readings, followed by GAT. Measurements of groups were compared.

Results: Mean age of patients was 59.4±10.9 years. Mean CCT value was 494.9±15.9 μ in Group 1 (n=40), 549.1±16.3 μ in Group 2 (n=52), and 604.0±22.2 μ in Group 3 (n=46). Mean IOP measurement obtained by GAT and RBT was 13.2±4.0 and 13.8±3.9 mmHg, respectively, in Group 1 (p=0.013), 16.9±3.2 and 16.8±3.1 mmHg in Group 2 (p=0.745), and 18.1±3.4 and 18.4±3.8 mmHg in Group 3 (p=0.359). Mean difference in IOP for entire study group between GAT and RBT was -0.21±1.7 mmHg (p=0.15). This difference was statistically significant only in Group 1 (p=0.013). Positive correlation was found between CCT and measurement via both GAT and RBT (p<0.01). There was no correlation between CCT and difference in IOP obtained by RBT and GAT.

Conclusion: Icare RBT demonstrated agreement with Goldmann applanation tonometry, except in thin corneas.

Keywords: Corneal thickness, goldmann applanation tonometry, Icare rebound tonometry.

Introduction

Accurate determination of intraocular pressure (IOP) is fundamental in diagnosis, monitoring, and treatment of glaucoma, as elevated IOP is the primary treatable risk factor.

Thickness of the cornea affects measurement of IOP with most non-invasive methods due to variance in resistance to tonometer probe. Thick cornea may give rise to overestimation of IOP, whereas underestimation of IOP is probable with thinner cornea.

Goldmann applanation tonometer (GAT) is currently the most widely used device in clinical practice for IOP measurements, and is considered criterion standard. However, it changes in central corneal thickness (CCT), corneal structure, and curvature are known to affect results (1, 2).

Icare rebound tonometer (RBT; Icare Finland Oy, Van-

Address for correspondence: Isil Pasaoglu, MD. Beyoglu Goz Egitim ve Arastirma Hastanesi, Bereketzade Cami Sokak, 34421 Beyoglu, Istanbul, Turkey
Phone: +90 212 251 59 00 **E-mail:** ibasgil@yahoo.com
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taa, Finland) is a portable handheld tonometer and does not require any topical anesthetic. IOP measurements obtained with this tonometer have also been shown to be influenced by CCT, with higher IOP readings in thicker corneas (3, 4). RBT has been shown to correlate well with GAT and is generally accepted to be dependent on corneal parameters. RBT readings have, on average, been higher than GAT readings in previous studies (5–7).

The aim of this study was to compare IOP level measured with GAT and RBT in patients with varied CCT.

Methods

This cross-sectional study was conducted in the glaucoma department of tertiary eye center. Study was performed in accordance with Declaration of Helsinki principles and the local medical ethics committee approved the research. Written, informed consent was obtained from all participants.

Total of 138 eyes of 138 patients were enrolled in the study. Only one eye per patient was randomized.

All study participants underwent detailed ophthalmological examination, including medical history, best-corrected visual acuity, slit-lamp biomicroscopy, fundoscopy, and IOP measurement using GAT and RBT.

Two methods of IOP measurement were performed by 2 physicians blinded to other results. Appropriately calibrated tonometers were used with 10-minute interval, beginning with RBT (Icare Pro, Icare Finland Oy, Vantaa, Finland). Eye was then anesthetized using Alcaine 0.5% solution (Alcon Laboratories Inc., Fort Worth, TX, USA), and fluorescein strip was applied to the inferior conjunctival fornix. Second physician took GAT (AT900; Haag Streit Diagnostics, Köniz, Switzerland) measurements using cobalt blue filter of biomicroscope.

For RBT, the patient was asked to look straight ahead to distant point while the examiner brought tonometer near the patient's eye. Tip of the probe is positioned in front of the central cornea at distance of 4 to 8 mm for measurement. RBT software is programmed for 6 individual IOP measurements. After sixth measurement, the letter P appears in instrument display, followed by IOP reading. Software discards highest and lowest IOP readings automatically and calculates average IOP value of remainder. Quality of measurements is also provided along with IOP measurements in a color scale on Icare Pro device.

CCT of patients was measured with ultrasonographic pachymetry (DGH-550, DGH Technology Inc., Exton, PA, USA). Patients were divided into 3 groups according to CCT. Group 1 comprised patients with thin CCT (<520 μ), Group 2 was made up of patients with normal CCT (520–570 μ), and patients with thick CCT (>570 μ) composed Group 3. GAT and RBT measurements were compared between groups.

Table 1. Comparison of mean intraocular pressure measurement obtained using Goldmann applanation tonometer and rebound tonometer

Groups	GAT (mmHg)	RBT (mmHg)	p
Group 1	13.2±4.0	13.8±3.9	0.013*
Group 2	16.9±3.2	16.8±3.1	0.745
Group 3	18.1±3.4	18.4±3.8	0.359

GAT: Goldmann applanation tonometer; RBT: rebound tonometer.

Statistical analysis was performed with SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA) software. Kolmogorov-Smirnov test was used to evaluate normality of distribution for all IOP measurements. Results were analyzed with independent samples t-test, paired samples t-test, analysis of variance, and Pearson correlation coefficient. P value of <0.05 was considered statistically significant.

Results

Total of 138 eyes of 138 patients, 50 males (63.8%) and 88 females (36.2%), were included in the study. Mean age was 59.4±10.9 years.

Mean CCT value was 494.9±15.9 μ in Group 1 (n=40), 549.1±16.3 μ in Group 2 (n=52), and 604.0±22.2 μ in Group 3 (n=46).

Mean IOP measurements obtained using GAT and RBT are provided in Table 1. Mean difference in IOP between GAT and RBT methods was -0.21±1.7 mmHg for entire study group (p=0.15). Difference in readings of 2 devices between 3 groups were statistically significant only in Group 1 (p=0.013).

Positive correlation between CCT and measurements via both GAT and RBT were found (p<0.01). There was no correlation between CCT and difference in IOP between RBT and GAT measurements (p=0.58).

Discussion

GAT is current criterion standard and most widely used method of measuring IOP, but CCT affects accuracy of this tonometer. New devices, such as RBT, offer alternative technique for IOP measurement. RBT is practical to use and measurements are comparable to GAT. Also, it does not require slit-lamp and is more comfortable for patients, due to lack of need for topical anesthesia (8, 9–12). Present study was investigation of whether RBT would produce comparable results to GAT in cases of different corneal thickness.

Several published studies have evaluated accuracy of RBT in healthy patients and in those with glaucoma. Reports indicated that IOP value was greater using RBT compared with GAT (7, 12–16).

Kim et al. demonstrated that in their study group, with or without glaucoma, RBT IOP measurement was higher than GAT reading, with mean difference of 1.92±3.29 mmHg. Difference between RBT and GAT did not vary over wide range of CCT (16).

Salim et al. reported mean difference of 2.45±2.12 mmHg with higher average results for RBT in their study group of glaucoma patients, and significant correlation was found between GAT and CCT and between RBT and CCT (12).

Fernandes et al. found mean difference of 1.34±2.03 mmHg between the 2 devices in normal subjects, with values reflecting overestimation of IOP in RBT results compared with GAT (17).

Conversely, another study demonstrated that mean IOP measurement was significantly lower with RBT device compared with GAT in study of normal eyes and eyes with primary open-angle glaucoma (18). This study also found that IOP readings with RBT and GAT were significantly directly related to CCT in subjects with normal cornea.

In our study, it was determined that RBT measurement was on average 0.21±1.7 mmHg higher than GAT measurement among all groups (p=0.15).

Whether cornea is considered thin or thick depends on definition of "normal" or "average" CCT. Mean CCT for specific populations is in range of 530–550 μ (19).

Some studies in the literature have stated that CCT affected IOP measurement with RBT (5, 6, 15); however, others did not find this relationship (7, 16). In our study, significantly positive correlation between CCT and IOP readings with GAT and RBT devices was found.

There is significant controversy regarding influence of CCT on RBT measurements compared with GAT. Some studies have suggested overestimation of IOP with RBT relative to GAT as CCT increased (3, 20–24), and others have suggested that GAT and RBT are equally affected by CCT (7, 13, 25–27).

In our study, RBT readings were significantly higher than GAT measurements in thinner corneas (Table 1). To the best of our knowledge, this is first study that emphasizes statistically significant difference in measurements with RBT and GAT in thinner corneas. Individuals with thinner corneas may have more accurate measurement with RBT than with GAT.

In conclusion, although RBT has been shown to correlate well with GAT, it overestimated IOP readings in glaucoma patients, especially in thinner corneas. Both GAT and RBT measurements have significantly positive correlation with CCT.

Disclosures

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Involved in design and conduct of the study (IP, CA, OO, NA, BS, BB, MT); preparation and review of the study (IP, CA, BS, FEO, MT); data collection (IP, CA, OO, NA); and statistical analysis (IP, CA, BS, FEO).

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