

# REBOUND TONOMETRY IN A CLINICAL SETTING. COMPARISON WITH APPLANATION TONOMETRY

## TONOMETRÍA DE REBOTE EN LA PRÁCTICA CLÍNICA. COMPARACIÓN CON TONOMETRÍA DE APLANACIÓN

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### ABSTRACT

**Purpose:** Rebound tonometry has recently been modified for its use in humans. The purpose of our study was to determine the precision of the ICare<sup>®</sup> rebound tonometer (RBT) as compared with the Goldmann applanation tonometer (GAT).

**Methods:** Patients were recruited from our Hospital's Glaucoma Unit. In each patient, intraocular pressure (IOP) was measured without anaesthesia using the RBT and ten minutes later using the GAT. Central corneal thickness (CCT) was measured by pachymetry.

**Results:** Sixty-eight patients were recruited (132 eyes). Mean IOP readings with RBT were 18.9 SD 7.2 mmHg and were 15.5 SD 5.7 mmHg with GAT ( $p < 0.001$ ). There was a good correlation between both instruments ( $r = 0.87$ ,  $p < 0.001$ ). In most cases (84.6%) the IOP measured with the RBT was greater than that measured with the GAT. The mean difference between both instruments was  $3.4 \pm 3.6$  mmHg. There was a trend towards greater differences between those obtained using the RBT than the GAT when IOP values were higher. A statistically

### RESUMEN

**Objetivo:** La tonometría de rebote ha sido recientemente adaptada para su utilización en humanos. El objetivo de nuestro estudio es determinar la precisión del tonómetro de rebote (TRB) ICare<sup>®</sup> en comparación con el tonómetro de aplanación Goldmann (TAG).

**Métodos:** Se reclutaron pacientes de la Unidad de Glaucoma de nuestro centro. En cada paciente se midió la presión intraocular (PIO) con el TRB sin anestésico y tras diez minutos con el TAG. Se empleó la paquimetría para determinar el grosor corneal central (ECC).

**Resultados:** Se reclutaron 68 pacientes (132 ojos). La media de PIO obtenida con el TRB fue de 18,9 [Desviación estándar (DE) 7,2 mmHg] y de 15,5 (DE 5,7 mmHg) con el TAG ( $p < 0,001$ ). Existe una buena correlación entre los dos aparatos ( $r = 0,87$ ,  $p < 0,001$ ). En la mayoría de los casos (84,6%) la PIO obtenida con el TRB fue mayor que la obtenida con el TAG. La diferencia media entre los dos instrumentos fue de 3,4 (DE 3,6 mmHg). Se aprecia una tendencia a la sobreestimación de la PIO con el

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significant correlation was found between IOP readings with both tonometers and CCT, with higher differences being seen as the CCT increased.

**Conclusion:** The RBT can be employed in a clinical setting taking into account that it usually overestimates IOP as compared with the GAT. It could be especially useful in glaucoma screening campaigns since it can be operated by a trained technician (*Arch Soc Esp Oftalmol* 2007; 82: 273-278).

**Key words:** Rebound tonometry, applanation tonometry, glaucoma, pachymetry, intraocular pressure.

TRB, siendo ésta mayor para valores de PIO más elevados medidos con TAG. Se encontró una correlación estadísticamente significativa de la PIO obtenida con ambos tonómetros y el ECC, con mayor sobreestimación con TRB cuanto mayor es la paquimetría.

**Conclusiones:** El TRB puede ser aplicado en la práctica clínica teniendo en cuenta que habitualmente sobreestima la PIO con respecto al TAG. Podría ser especialmente útil en campañas de screening de glaucoma al poder ser manejado por técnicos entrenados.

**Palabras clave:** Tonometría de rebote, tonometría de applanación, glaucoma, paquimetría, presión intraocular.

## INTRODUCTION

Recent research suggests that glaucomatous optic neuropathy has a multifactor origin; nevertheless, intraocular pressure (IOP) remains the only factor to be effectively acted upon. Goldmann Tonometer is considered the standard pattern in IOP assessment, although its measurements are influenced by corneal thickness and yield inaccurate results in certain pathologies affecting the ocular surface (1). Therefore, efforts to find a tool capable of measuring IOP in an accurate and reproducible fashion are constant.

Rebound tonometry was initially developed in order to measure IOP in a non-invasive way in experimental glaucoma models (2), where initial results have been encouraging in terms of friendly use, accuracy and reproducibility (3-8). This led to the design of a manual tonometer based on the rebound principle for use in human beings: ICare® (Tiolat Oy, Helsinki, Finland).

The rebound tonometer (RBT) consists of an assembly of two coaxial coils which impel a magnetized probe towards the cornea and detect the deceleration of the probe as a result of eye contact. This deceleration speed is related to the IOP. The probe used is disposable. A plastic cover in the tip reduces the risk of corneal injury (fig. 1).

There are few studies published which assess this method's reproducibility and accuracy in human beings (9-12). The present study was designed to assess the usefulness of the RBT in clinical settings, comparing the resulting measurements with an ICare® tonometer with those obtained from Goldmann



Fig. 1: ICare Rebound Tonometer with disposable probe.

applanation tonometer (GAT; Haag-Streit, Köniz, Switzerland), as well as the impact of the central corneal thickness (CCT) on the resulting IOP measurements.

## SUBJECTS, MATERIAL AND METHODS

A transversal study was performed on 68 consecutive patients at the Glaucoma Unit in our center. The study included patients diagnosed with glaucoma, patients suspected of suffering from glaucoma and patients who did not exhibit any signs of glaucomatous neuropathy. Patients suffering from acute corneal pathologies were excluded. A history of previous eye surgery was not used as criteria for exclusion.

The study complies with the regulations contained in the Declaration of Helsinki and patients were asked to give their informed consent. IOP was first measured via RBT, without external anesthesia.

The tool was designed to take up to six rapid consecutive measurements and eliminates the highest and the lowest. It automatically estimates the mean value and the standard deviation (SD) for the remaining four measurements.

Since the RBT yielded a high SD, the six measurements were repeated. After a ten minute interval, three consecutive measurements were performed with GAT and instillation of external anesthesia, using the mean value of all three for the statistical analysis. CCT was measured in all patients via ultrasound pachymetry (Pacline V1<sup>®</sup>, Optikon 2000, Rome, Italy), performing 3 measurements and using the mean value of all three for statistical analysis.

The statistical analysis was performed using the SPSS 12.0 software for Windows (SPSS Inc. Chicago, Illinois).

The Kolmogorov-Smirnov test was used to check whether quantitative data followed a regular distribution pattern. IOP measurements were compared using the Student t test. The Spearman linear correlation test was used to determine the relation between RBT and GAT.

In order to assess the degree of concordance between both methods and the presence of systematic biases, a Bland-Altman plot was built to assess the difference between the RBT and GAT measurements against the mean value of the two. The impact of CCT on the IOP obtained through both methods was determined by analyzing the correlation between the pachymetry and IOP values.

## RESULTS

The study included 136 eyes belonging to 68 patients. All patients were white except for one black person, 36 of them were males. Patients' age ranged between 26 and 92 years old (65.7 years on average with a 14.87 SD.) Nineteen (19) patients did not exhibit glaucomatous pathologies; 22 patients reported ocular hypertension and 27 had been diagnosed with glaucoma, in most cases open-angle primary glaucoma (70.4 percent.) Forty-three (43) eyes had a history of previous eye surgery, although no history of corneal surgery was reported.

IOP could be measured in all patients in a reliable fashion with both tonometers.

In the whole series of 136 eyes, the mean IOP obtained through the RBT was 18.9 (with a 7.2 mmHg SD) and 15.5 (with a 5.7 mmHg SD) with GAT ( $p < .001$ .) The resulting IOP range with the RBT stood between 3 and 55 mmHg, whereas the GAT's range was 3 to 36 mmHg. There is a strong correlation between both devices ( $r = .87$ ,  $P < .001$ ; fig. 2.) For 115 eyes (84.6%), the IOP obtained through the RBT was greater than the one obtained from the GAT. The mean difference between both devices was 3.4 SD 3.6 mmHg. In 39.7% of cases, the difference between the measurements of both tonometers was below 2 mmHg.

The Bland-Altman plot analysis (fig. 3) showed a statistically non-significant tendency to an overestimation of IOP with the ICare<sup>®</sup> tonometer regarding the highest IOP values obtained through the GAT. The sample was divided into two groups based on the median of the IOP values obtained through a GAT; Table I shows the mean value for the IOP difference between both tonometers for each group. No statistically significant differences were found in either group ( $p = .072$ ). A weak and yet statistically significant correlation was found between the IOP obtained with both tonometers and the CCT (RBT  $r = .175$ ,  $p = .041$ ; GAT:  $r = .239$ ,  $p = .005$ .) Table II shows the values for the difference between

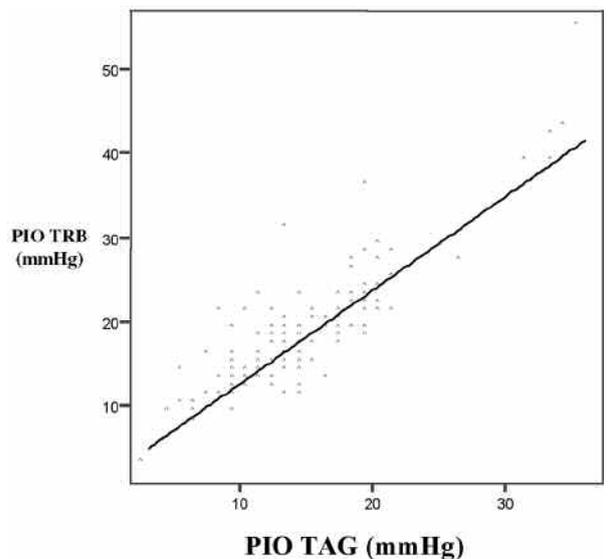


Fig. 2: Correlation between intraocular pressure (IOP) with rebound tonometry (RBT) and Goldmann Applanation tonometry (GAT).

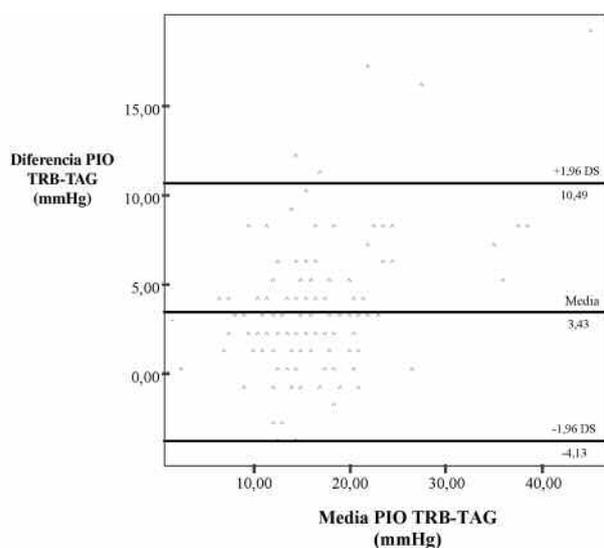


Fig. 3: Gráfico de Bland-Altman.

en both tonometers once the sample was divided into three groups based on the CCT terciles.

There is a tendency to overestimate the IOP with an RBT when facing greater corneal thickness, although no statistically significant results were obtained for any of the three groups.

No complications were detected with either tonometer.

## DISCUSSION

Until now, the RBT was mainly used on animals used for experimental purposes, revealing itself as an

easy-to-use, fast and reliable method for IOP measurement (3-8). Danias et al. (6) found a close correlation between the real IOP and the RBT measurements in cannulated mouse eyes in the 3.7 and 44.1 mmHg range. The Kontiola group proved that reproducibility of the RBT measures was good as long as it was placed at a distance between 3 to 5 mm from the cornea and an impact angle below 25° with respect to the visual axis in the corneal apex. Despite the existence of a close correlation between the manometric ocular pressure in rats and the rebound tonometry ( $r^2 = .95$ ), the later showed a tendency to underestimate the IOP (4). In other studies with animals, this tendency towards underestimation was confirmed, and the repeated RBT measurements led to a decrease in IOP (8); also, the use of anesthetics resulted in a reduction of IOP values yielded by the RBT (7).

Today, there are few studies on the reproducibility and accuracy of rebound tonometry in human beings. Kontiola carried out a clinical study aimed at comparing IOP measurements with the Pulsair 3000® air tonometer and the RBT in elderly patients without anesthesia; in 71.7 percent of all patients, the IOP difference yielded by both tonometers was less than 2 mmHg (9.) Ninety-five (95) percent of patients did not experiment any pain with the RBT. After comparing the RBT and GAT in 36 patients, Kontiola found a .82 correlation coefficient between the two devices (3).

This value is similar to the one found by Martínez de la Casa et al. in the most extensive study published so far which compared the RBT with the «standard pattern» (10), similar to the .87 obtained in the present study.

**Table I. Differences in intraocular pressure (IOP) between the rebound tonometer (RBT) and the Goldmann applanation tonometer (GAT) based on the Goldmann tonometry values**

IOP GAT (no. of eyes)	≤ 15 mmHg (n=76)	> 15 mmHg (n=60)	P (Student t test)
IOP difference RBT-GAT (mean SD)	3.29 SD 3.40 mmHg 3.60 SD 3.65 mmHg	.072	

IOP: intraocular pressure; GAT: Goldmann applanation tonometry; RBT: rebound tonometry; SD: standard deviation.

**Table II. Differences in IOP between RBT and GAT based on the central corneal thickness (CCT)**

CCT (no. of eyes)	≤ 538 μm (n= 46)	539-565 μm (n=44)	>565 μm (n=46)
Mean difference RBT-GAT SD (mmHg)	2.61 SD 2.62	3.50 SD 3.48	4.17 SD 4.35

IOP intraocular pressure; RBT rebound tonometry; GAT Goldmann applanation tonometry; SD standard deviation.

Martínez de la Casa et al. analyzed the reproducibility of the RBT, obtaining interobserver correlation coefficients greater than .73 and an .82 interobserver correlation (10).

Despite the excellent correlation coefficients obtained through comparison between RBT and GAT, there is considerable disagreement regarding these measurements.

The statistical analysis shows that, even though the measurements obtained with both devices in the present study exhibit a good correlation, the RBT yields systematically an IOP value greater than the one yielded by the GAT. This way, the IOP value yielded by the GAT could be estimated using the following formula:  $IOP = 2.48 + 0.69 * IOP \text{ ICare}^{\text{®}}$ . These results are similar to those obtained by Martínez de la Casa (10), where the RBT yielded IOP value averaging 1.8 (SD 2.8 mmHg), exceeding those obtained via GAT.

Other studies performed on healthy subjects found mean differences of 1.34 mmHg and 3.35 mmHg between the RBT and GAT or applanation tonometry with Perkins tonometer, respectively, resulting once again in an overestimation by the rebound tonometry (11,12). The differences between results obtained from studies on humans and animals may be due to the fact that rebound tonometries have been modified for use in human beings. Even though repeated measurements using RBT in animals are known to have resulted in a decrease of the IOP (8), this study estimates that the ten minutes elapsed between the two measurements were enough to allow for IOP recovery. García-Resúa et al (12) found a greater overestimation with RBT in patients with higher IOP according to GAT. The present study could not confirm that overestimation is greater as IOP values increase.

The rebound tonometry reveals a statistically significant relation with the central corneal thickness, exhibiting a behavior similar to applanation tonometry, with higher values in thick corneas and lower in thin corneas. This would confirm the findings reported by Martínez de la Casa (13).

According to our study, it is impossible to conclude that IOP values vary depending on the value of pachymetry.

Since there were no patients with a history of corneal eye surgery, it is possible to state that the remaining eye surgery did not influence the results obtained.

Currently, the main advantage of RBTs derives from the fact that measurements may be obtained

without the need to instill external anesthetics and with a minimal subjective nuisance, making this device especially useful in glaucoma population screening campaigns, as long as applanation tonometries are not feasible, since IOP measurements may be performed by any trained personnel (10,11,13). Another advantage is its suitability in animal models, due to the minimum corneal space required for measurement. Similarly, it could prove useful in children, since RBTs are not as bulky as GATs and may cause less anxiety in kids.

On the other hand, since it requires less space in terms of corneal contact, even if the child blinks, the device may be capable of measuring IOP.

The ICare<sup>®</sup> tonometer may be easily applied to obtain IOP measurements, taking always into account its limitations with respect to GAT.

Higher measurements are expected from RBT compared to GAT. New studies would be useful in assessing the accuracy of ICare<sup>®</sup> and the validity of results in the IOP range and in the presence of ocular pathologies usually encountered in clinical settings, including corneal pathologies which hinder GAT performance.

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