

# Comparative study between ocular pressure measurements made by rebound tonometer, pneumatic tonometer, Goldmann tonometry

## *Estudo comparativo entre as medidas da pressão ocular dos tonômetros de rebote, pneumático e de Goldmann*

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### ABSTRACT

**Objective:** To compare the result between two types of tonometers, using as gold standard the aplanation tonometry, relating to the corneal thickness and its validations as instruments of population screening. **Methods:** A comparative cross-sectional study was carried out with 400 eyes from the ophthalmology clinic of Adachi Ophthalmology, in Macapá (Amapá), between the mean values of ocular pressure measured by the Icare<sup>®</sup> tonometer, the Pneumatic Tonometer and the Goldmann Flattening Tonometry as a function of corneal thickness. They were divided according to ECC in 3 groups. Group 1: 260 eyes with ECC <530 $\mu$ ; group 2: 217 eyes with ECC between 530 $\mu$  and 590 $\mu$ ; and, group 3: 157 eyes with ECC > 590 $\mu$ . **Results:** The mean ECC obtained in pachymetry was 557 $\mu$ , ranging from 651 $\mu$  to 477 $\mu$  (standard deviation of 32.9). The mean IOP obtained by PT was 19.4 mmHg (with a standard deviation of 2.32); by Icare<sup>®</sup> was 16.7mmHg (standard deviation of 2.12); and in the TAG it was 15.5 mmHg (standard deviation of 2.02). For pachymetry less than 530 $\mu$  and greater than 590 $\mu$ , PIOM did not differ significantly between TAG and Icare<sup>®</sup> ( $p = 0.232$ ), and a statistically significant difference was obtained for corneas with ECC between 530 and 590  $\mu$ . The IOP obtained by the PT was significantly higher than the mean ocular pressure of the TAG and Icare<sup>®</sup> ( $p < 0.001$  for both) in all groups. **Conclusions:** All three methods can be used in screening campaigns, but Icare<sup>®</sup> proved to be more reliable than TP, with values obtained statistically more reliable when compared to TP. There is sufficient agreement between Icare and TAG to recommend its use.

**Keywords:** Intraocular pressure; Glaucoma; Cornea; Tonometer; Pachymeter

### RESUMO

**Objetivo:** Comparar o resultado entre dois tipos de tonômetros, tendo como padrão ouro a tonometria de aplanção, relacionando com a espessura corneana e suas validações como instrumentos de rastreamento populacional. **Métodos:** Estudo transversal comparativo, realizado com 400 olhos do ambulatório de oftalmologia da Adachi Oftalmologia, em Macapá (Amapá), entre os valores médios da pressão ocular medidos pelo tonômetro Icare<sup>®</sup>, o Tonômetro Pneumático e o Tonômetro de Aplanção de Goldmann em função da espessura corneana. Foram divididos conforme a ECC em 3 grupos. Grupo 1: 260 olhos com ECC < 530 $\mu$ ; grupo 2: 217 olhos com ECC entre 530 $\mu$  e 590 $\mu$ ; e, grupo 3: 157 olhos com ECC > 590 $\mu$ . **Resultados:** A ECC média obtida na paquimetria foi de 557 $\mu$ , variando de 651 $\mu$  a 477 $\mu$  (desvio padrão de 32.9). A PIO média obtida pela TP foi de 19,4 mmHg (com desvio padrão de 2,32); pelo Icare<sup>®</sup> foi de 16,7mmHg (desvio padrão de 2,12); e, na TAG foi de 15.5 mmHg (desvio padrão de 2,02). Para paquimetrias inferiores a 530 $\mu$  e superiores a 590  $\mu$  a PIOM não diferiu significativamente entre a TAG e Icare<sup>®</sup> ( $p = 0,232$ ), sendo estatisticamente significativa diferença obtida para córneas com ECC entre 530 e 590  $\mu$ . A PIO obtida pelo TP foi significativamente maior do que a pressão ocular média dos TAG e Icare<sup>®</sup> ( $p < 0,001$  para ambos) em todos os grupos. **Conclusões:** Os três métodos podem ser utilizados em campanhas de rastreamento, porém o Icare<sup>®</sup> se mostrou mais confiável que a TP, com valores obtidos estatisticamente mais confiáveis quando comparados à TP. Existe suficiente concordância entre o Icare e a TAG para recomendar o seu uso.

**Descritores:** Pressão intraocular; Glaucoma; Córnea; Tonometria; Paquimetria

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## INTRODUCTION

**P**rogressive aging of the population causes an increase in the incidence of Glaucoma demanding improvement in the methods of population screening. Measurement of intraocular pressure (IOP) is the primary screening, diagnosis and follow-up method for patients with Glaucoma. Traditionally Goldman Applanation Tonometry (GAT) is considered the gold standard. However, a cornea with approximately 500 $\mu$  thick was standardized at its conception.<sup>(1)</sup> The progression of technology allowing precise measurement of corneal central thickness (CCT), and modern refractive surgery techniques leading to a thinning of this tissue, led IOP alterations to be described varying according to corneal thickness.<sup>(2)</sup>

The corneal thickness and its relation with glaucoma were well demonstrated by the Ocular Hypertension Treatment Study (OHTS)<sup>(2)</sup> which pointed it as a predictive factor of glaucoma. According to the study, patients with thinner corneas are more likely to progress to glaucoma, a hypothesis also raised by other studies.<sup>(3-5)</sup>

In 1973, Forbes<sup>(6)</sup> introduced a new method of measuring ocular pressure without corneal contact: pneumatic tonometers (PT). They produce an air jet leading to corneal applanation. Concomitantly, it projects a collimated light beam, being picked up by the apparatus receptor. A light reception peak reaches its maximum level when the cornea is applanated, indicating the IOP value.

Several methods of measuring IOP have been proposed to reduce the dependence on corneal thickness. Recently a tonometer that does not deform the cornea was launched, the Pascal Tonometer or dynamic contour tonometer (DCT), which in theory is not influenced by the CCT. The end of the tonometer cylinder which comes into contact with the cornea has a concave surface that works as a sensor allowing a measurement of IOP without causing corneal deformation.<sup>(7)</sup> However, its difficult manipulation and learning curve make it little applicable to population screening units.<sup>(8)</sup>

For these purposes, the ideal method should be fast, practical, with a small learning curve, good reproducibility of results, good accuracy, and preferably not affected by central corneal thickness (CCT).



**Figure 1:** Photo of the iCare TAO1i model used.

Also recently launched, the Icare rebound tonometer (Tiolat Oy, Helsinki, Finland) (Figure 1) uses a very light probe to make momentary and smooth contact with the cornea. It records the

IOP due to the deceleration of a stem probe. The device allows measurement in resistant patients as children, patients in bed, and in screening campaigns due to the practicality and low learning curve, not requiring instillation of anesthetic eye drops.

## OBJETIVES

The objective of the present study was to compare the Icare<sup>®</sup> rebound tonometer, the Pneumatic Tonometer, and the Goldman Tonometer in relation to the corneal thickness, and the validation of the Icare<sup>®</sup> rebound tonometer as a population screening instrument.

## METHODS

Two hundred adult patients (400 eyes) were randomly selected from the ophthalmology ambulatory of Clínica Adachi Oftalmologia (Macapá, AP), being 110 males and 90 females. The average age of patients was 49 years (ranging from 38 to 61 years).

A comparative cross-sectional study between the ocular pressure values measured by the Icare<sup>®</sup> model TAO1i (Tiolat Oy, Helsinki, Finland), the CT 60 Pneumatic Tonometer (Topcon, Japan), and the Goldmann Applanation Tonometer (Nikon, Japan) and for examination of the corneal thickness was performed using the Oculus non-contact pachymeter (Oculus company, Wetzlar, Germany).

Patients were instructed to measure the IOP with the three different methods. They all had their ocular pressure measured by the same technicians, and underwent a non-contact pachymetry test immediately before the measurements. The exams were carried out successively and with a maximum interval of 15 minutes between them, under normal conditions, without pharmacological mydriasis. The sequence used was Pachymetry, TP, tonometry by Icare<sup>®</sup> and TAG. For the latter, anesthetic eye drops and fluorescein dye were instilled immediately prior to measurement.

The eye drops used in the study were proximetacaine hydrochloride 0.5% (Visonest<sup>®</sup>, Allergan) as an anesthetic, and fluorescein sodium (Allergan).

Pre-existing eye diseases, history of ocular surgery, and family history of glaucoma were considered the exclusion criteria.

In order to verify the normality of the variables, the Kolmogorov-Smirnov test was used, and the Friedman non-parametric test was used to compare the average pressure values between the treatments. In cases where the Friedman test was significant, the Dunn-Bonferroni test<sup>(9)</sup> was used for multiple comparisons.

## RESULTS

In our sample, CCT values obtained in pachymetry were 557 $\mu$ , ranging from 651 $\mu$  to 477 $\mu$  (standard deviation of 32.9). The average ocular pressure measurement obtained by TP was 19.4 (with a standard deviation of 2.32); in the tonometry obtained by Icare<sup>®</sup> the average was 16.7 (standard deviation of 2.12); and in TAG the average was 15.5 (standard deviation of 2.02).

The results were stratified according to central corneal thickness (CCT), and divided into 3 groups. Group 1: 260 eyes with CCT <530 $\mu$ ; group 2: 217 eyes with CCT between 530 $\mu$  and 590 $\mu$ ; and group 3: 157 eyes with CCT >590 $\mu$ , and presented in table 1.

**Table 1**  
Average values of intraocular pressure by treatment and pachymetry

Pachymetry	Treatment*			Dunn – Bonferroni Test P-value			
	TAG (1)	ICare (2)	TP (3)	Friedman Test p – valor	(1) X (2)	(1) x (3)	(2) X (3)
< 530	15.19±0.20	15.10±0.23	17.00±0.24	< 0.001	0.232	< 0.001	< 0.001
530 – 590	14.73±0.23	15.22±0.27	17.59±0.27	< 0.001	0.003	< 0.001	< 0.001
> 590	15.40±0.25	15.60±0.30	19.33±0.32	< 0.001	0.527	< 0.001	< 0.001

For pachymetry less than 530 $\mu$  the average ocular pressure did not differ significantly between GAT and Icare<sup>®</sup> ( $p = 0.232$ ). The average ocular pressure in the pneumatic tonometer was significantly higher than the average ocular pressure of GAT and Icare<sup>®</sup> ( $p < 0.001$  for both).

When Pachymetry was between 530 and 590 $\mu$  the average ocular pressure in Icare<sup>®</sup> was significantly higher than the average ocular pressure measured by GAT ( $p = 0.003$ ), and the average ocular pressure in the pneumatic tonometer was significantly higher than the average ocular pressure measured by GAT and Icare<sup>®</sup> ( $p < 0.001$  for both).

The average ocular pressure of patients with pachymetry greater than 590 $\mu$  did not differ significantly between GAT and Icare<sup>®</sup> ( $p = 0.527$ ), whereas the average ocular pressure measured by the pneumatic tonometer was significantly higher than the average ocular pressure measured by GAT and Icare<sup>®</sup> ( $p < 0.001$  for both).

In the comparison of the aplanation method with Icare<sup>®</sup>, pachymetry greater than 590 $\mu$  and lower than 530 $\mu$  showed no significant difference, then we can use the “p” values to say that the results were more similar in the following order: pachymetry greater than 590 $\mu$ , followed by pachymetry lower than 530 $\mu$ .

Thus, the statistical analysis of the general group reveals that there was a statistically significant difference between the three methods ( $p > 0.05$ ). Although GAT and Icare<sup>®</sup> are very close, in some patients there may be value discrepancies.

## DISCUSSION

In countries with large geographic disproportions where it is difficult for this population to have access to primary care and secondary prevention, it is essential to promote campaigns to detect silent pathologies, including glaucoma. However, GAT is extremely unproductive in these events, and there is a need for more agile methods with proven accuracy.

It has already been demonstrated by other authors that the measurement of intraocular pressure is influenced by central corneal thickness, and it is an important predictive factor for the accuracy of the method.<sup>(10,11)</sup>

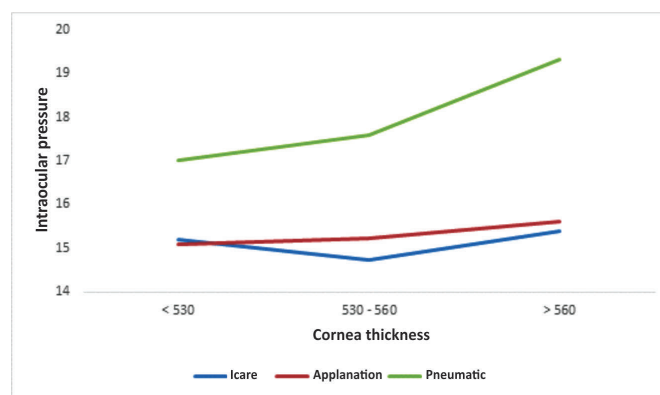
CCT can interfere in the tonometry result due to the force required for its aplanation, and there may be false elevation in thick corneas, and low values in thin corneas.<sup>(12)</sup> After testing several methods correlating with CCT, Tonnu et al. found that TP is more influenced by CCT, presenting the highest blood pressure levels.<sup>(13)</sup>

Several authors have already demonstrated the comparability between the GAT and the Icare tonometer.<sup>(14-16)</sup> However, they did not correlate it with corneal central thickness, and used a

new Icare<sup>®</sup> tonometer model. The model chosen by us has easy manipulation as its main characteristic, which makes it suitable for screening campaigns. It is a model of low learning curve, and extreme agility to carry out more complex tasks such as ocular pressure measurement in children, the elderly with difficulties in locomotion, and patients in bed.

When we search for agreement among the methods used, the closest approach to GAT was Icare<sup>®</sup>. When examined from the CCT perspective (Figure 2) in the group with 530 < CCT < 590, the IOP found was 14.73  $\pm$  0.23 by GAT, and 15.22 $\pm$ 0.27 by Icare<sup>®</sup>, being more similar between them than the values obtained by the TP, although with statistically significant difference. Then it is in a better position than TP to be used for detecting normal blood pressure levels, increasing the reliability of the exam in screening systems.

In our series, we recently found the studies of Kato<sup>(17)</sup>, and we found a concordance between the IOPm measured by GAT and Icare, with a slight tendency to undervalue, whereas TP is in disagreement with the tendency to overestimate the IOP.



**Figure 2:** Comparative IOPm between the three CCT groups with the three apparatuses.

## CONCLUSION

In our study, we found a statistically significant difference among the methods used in patients with corneas with a central thickness between 530 and 590 $\mu$ . However, when comparing outside this central thickness spectrum, GAT was coincident with the measurement by the Icare<sup>®</sup> tonometer. The pneumatic tonometry presented discrepant results, being statistically significant in all 3 groups. We conclude that the three methods can be used in screening campaigns, but in patients with corneas

with a thickness of less than 530 $\mu$  and greater than 590 $\mu$  Icare® proved to be more reliable than the TP, thus, statistically the values obtained by Icare® are more compared to TP. There is sufficient agreement between Icare and GAT to recommend its use.

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