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## Original article

# Comparison between Goldmann, Icare Pro and Corvis ST tonometry<sup>☆,☆☆</sup>



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## ARTICLE INFO

### Article history:

Received 31 July 2013

Accepted 10 February 2014

Available online 26 September 2014

### Keywords:

Tonometry

Intraocular pressure

Goldmann

Rebound

Corvis ST

Glaucoma

## ABSTRACT

**Purpose:** To compare intraocular pressure (IOP) between the new non-contact tonometer Corvis ST (CST), the Goldmann applanation tonometry (GAT) and Icare Pro rebound tonometer (PRO).

**Methods:** A total of 178 eyes of 178 healthy subjects were selected for the study. Measurements of IOP were made in a random order with GAT, PRO and CST. Central corneal thickness (CCT) was determined by ultrasound pachymetry. The mean of three valid measurements of each variable was used in the statistical analysis. The relationship between the tonometers was established using Bland–Altman plots.

**Results:** Mean IOP was  $15.5 \pm 2.8$  mmHg for GAT,  $15.4 \pm 2.8$  mmHg for CST, and  $14.6 \pm 2.3$  mmHg for PRO. The mean differences between pairs of tonometers were: GAT-PRO =  $0.9 \pm 1.7$  mmHg ( $p < .001$ ), GAT-CST:  $0.1 \pm 2.2$  ( $p = .398$ ), and PRO-CST:  $-0.8 \pm -0.7$  mmHg,  $p < .001$ . A positive relationship was detected between CCT and the three tonometers: GAT:  $r = 0.325$ ,  $p < .001$ ; PRO:  $r = 0.385$ ,  $p < .001$ , and CST:  $r = 0.428$ ;  $p < .001$ .

**Conclusions:** The differences found between PRO and GAT were significantly higher than those found between CST and GAT, which showed non-significant differences. The measurements of the three tonometers were affected by the CCT.

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\* Please cite this article as: Bañeros-Rojas P, Martínez de la Casa JM, Arribas-Pardo P, Berrozpe-Villabona C, Toro-Utrera P, García-Feijó J. Concordancia entre la tonometría de Goldmann, Icare Pro y Corvis ST. Arch. Soc. Esp. Oftalmol. 2014;89:260–264.

☆☆ Presented at the 89th Congress of the Spanish Association of Ophthalmology, Adeje, Santa Cruz de Tenerife, Spain, September 2013.

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## Concordancia entre la tonometría de Goldmann, Icare Pro y Corvis ST

### R E S U M E N

#### Palabras clave:

Tonometría  
Presión intraocular  
Goldmann  
Rebote  
Corvis ST  
Glaucoma

**Objetivo:** Comparar los valores de presión intraocular (PIO) del nuevo tonómetro de no contacto Corvis ST (CST) con la tonometría de aplanación de Goldmann (GAT) y la tonometría de rebote Icare Pro (PRO).

**Material y métodos:** Se seleccionaron 178 ojos de 178 voluntarios sanos a los que se les midió la PIO de manera aleatorizada con CST, PRO y GAT. Se midió el espesor corneal central (GCC) con paquimetría ultrasónica. Para cada variable, se tomaron 3 medidas y la media de las 3 fue introducida en el análisis estadístico. La concordancia entre los tonómetros se determinó mediante las gráficas de Bland-Altman.

**Resultados:** La PIO medias obtenidas con los 3 tonómetros fueron de  $15,5 \pm 2,8$  mmHg para GAT,  $14,6 \pm 2,3$  mmHg para PRO y  $15,4 \pm 2,8$  mmHg para CST. La diferencia media entre pares de tonómetros fue: GAT-PRO =  $0,9 \pm 1,7$  mmHg ( $p < 0,001$ ); GAT-CST:  $0,1 \pm 2,2$  ( $p = 0,398$ ) y PRO-CST:  $-0,8 \pm -0,7$  mmHg,  $p < 0,001$ . En los 3 casos se encontró una correlación significativa con el GCC: GAT:  $r = 0,325$ ,  $p < 0,001$ ; PRO:  $r = 0,385$ ,  $p < 0,001$  y CST:  $r = 0,428$ ;  $p < 0,001$ .

**Conclusiones:** Las diferencias encontradas entre el PRO y el GAT son significativamente mayores que entre el CST y el GAT, sin diferencias significativas entre las medidas de estos 2. Las medidas de los 3 tonómetros se ven afectadas por el GCC.

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## Introduction

Increased intraocular pressure (IOP) is the major modifiable risk factor in development and progression of glaucomatous optic neuropathy.<sup>1</sup> Currently, Goldmann applanation tonometry (GAT) is the most widely used method for measuring IOP; it is based on the Imbert-Flick principle. Therefore, IOP is proportional to the pressure applied on the cornea and corneal thickness (CCT). This influence of CCT<sup>2</sup> and other corneal factors have led to the development of new tonometers in order to provide IOP values independent of corneal properties.

Icare Pro (PRO) rebound tonometry is based on cornea contact by magnetized probe to detect eye-caused deceleration and determine IOP.<sup>3</sup>

Corvis ST (CST) (Fig. 1) gives IOP values corrected by corneal biomechanical parameters and incorporates a Scheimpflug camera (Optikgeräte GmbH, Wetzlar, Germany) for real-time images of the anterior eye chamber, where corneal deformability is displayed in response to an air pulse. Corneal biomechanical parameters provided are: speed, time and length of first and second applanation, maximum concavity, strain amplitude and corneal radius.

The working hypothesis is that our new CST air tonometer provides IOP values similar to those obtained with GAT and PRO and its IOP value is independent of CCT.

## Subjects, material and methods

A total of 178 eyes from 178 healthy volunteers were selected. Each participant signed an informed consent form. The study protocol adhered to the rules of the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of the Hospital Clínico San Carlos. Inclusion criteria for

patients were: adulthood, ability to collaborate with the tests to be performed, ability to give informed consent, refractive errors less than 5 diopters of spherical equivalent or one cylinder less than 2 diopters. We excluded subjects with a history of ocular surgery or trauma, severe or poorly controlled systemic disease, physical or mental difficulties to perform the tests. For each participant, one eye was selected randomly unless only one eye met inclusion criteria.

An automatic randomization sequence was generated by the tool available at [www.randomization.com](http://www.randomization.com) to establish measurements with GAT, CST and PRO. We took three measurements with each tonometer, waiting at least 3 min between measurements, and 5 min between tonometers. After taking IOP measurement with the three tonometers, CCT was measured with ultrasonic pachymetry (Dicon P55, Paradigm Medical Industries Inc., UT, USA), three CCT measurements were taken, and the average of the three was used as a value for statistical analysis. All measurements were performed by the same observer.

Goldmann tonometry (GAT, Haag-Streit, Koeniz, Switzerland): Measurements were taken after instilling fluorescein sodium 2.5 mg/ml and oxybuprocaine hydrochloride 4 mg/ml in aqueous solution (Fluotest eye drops, Alcon Cusi, Barcelona, Spain). We conducted three measurements and used their average.

Corvis ST (Optikgeräte GmbH, Wetzlar, Germany) and Icare PRO (ICare®, Tiolat Oy, Helsinki, Finland): We conducted three valid measurements with CST and PRO and used the average of the three for statistical analysis.

Icare tonometry Pro (Icare, Tiolat Oy, Helsinki, Finland): Rebound tonometry with 1 mm contact surface between probe and corneal apex. We took three measurements with high reliability with this tonometer, knowing that each measurement is the average of six readings. We used the average of the three for statistical analysis.

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