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Evaluation of the Intraocular Pressure Measurement in Patients with Primary Open Angle Glaucoma Using Corvis-ST

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The Corneal Visualization Scheimpflug Technology device (Corvis ST tonometry: CST) is a novel noncontact tonometer developed to assess intraocular pressure (IOP) while accounting for the cornea's biomechanical qualities. The aim of this work was to assess reliability and accuracy of corvis-ST tonometer in measurement of IOP in cases of primary open angle glaucoma (POAG).
Methods: This prospective comparative non-interventional study included 70 eyes of patients suffering from bilateral POAG and with clear and virgin corneas. Eyes were divided into two groups: group A (40 eyes of POAG) and group B (30 normal eyes). All patients were subjected to: history taking, examination [visual acuity (VA), slit lamp examination, gonioscopy for angle, posterior segment, optic disc evaluation and IOP measurements] and investigations (Pachymetry and Corvis ST).
Results: There was a significant negative correlation between non-corrected IOP measured by Corvis and corneal biomechanical index in studied glaucoma patients. There is a positive significant correlation between first and second IOP readings by Corvis. This means that the first and second readings of IOP by corvis with interval 30 minutes between the two readings increased together and decreased together (positive relationship).
Conclusions: The IOP measurement in patients with POAG using Corvis-ST has a good reliability.

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Keywords: Intraocular pressure; primary open angle glaucoma; Corvis-ST.

1. INTRODUCTION

The intraocular pressure (IOP) monitoring is critical for glaucoma detection and monitoring [1].

The ideal tonometer is expected to be accurate and to be as little invasive as possible [2].

The Goldmann Applanation Tonometer (GAT) is considered to be the most common method for estimation of intraocular pressure. Unfortunately, it is well established that the accuracy of IOP measurements acquired with the GAT is influenced by corneal characteristics [3].

Previous research has demonstrated that when the central corneal thickness (CCT) is large, the GAT-IOP may be over estimated and when the CCT is small, the GAT-IOP may be underestimated [4].

We introduce Corvis-ST (scheimpflug technology) a novel non contact tonometer mechanism integrated with a scheimpflug camera capable of operating at ultra-high speeds which is non-invasive technique that keep track of the cornea's dynamic response to air impulses has a scheimpflug camera capable of capturing over 4300 images per second [5].

Additionally, IOP and CTT can be precisely quantified using Scheimpflug images [6].

Unlike other methods of IOP measurements in: it gives more precise IOP reading, less reliant on biochemical characteristics of the cornea and CTT, the data are easily to read & interpret, the IOP follow up is nearly organised, non-contact procedure, superficial anaesthesia not required, cross contamination doesn’t occur, and the cornea is not touched directly. It has a lot of uses in clinical ophthalmology as: early ectasia detection, glaucoma diagnostics that evaluate IOP, CTT, and the cornea's deformation reaction, visualize the effect of corneal cross linking and it has a new role enabling the user to email IOP and CTT values, as well as high-speed films, to the patient's mobile device to remind patients of upcoming follow-up exams [7].

The aim of this work was to assess reliability and accuracy of corvis-ST tonometer in measurement of IOP in cases of primary open angle glaucoma.

2. PATIENTS AND METHODS

This prospective comparative non-interventional research enrolled 70 eyes of patients aged more than 40 years old, suffering from bilateral POAG and with clear and virgin corneas.

The study was carried out at Elite Eye Centre in cooperation with the Ophthalmology Department of Tanta University Hospital from December 2019 to December 2020.

Exclusion criteria were closed angle glaucoma, Secondary glaucoma (e.g. traumatic or inflammatory), eyes with pathologic characteristics of the cornea, like keratoconus or Fuch's endothelial dystrophy, advanced glaucoma, uncontrolled glaucoma, history of intraocular surgery or penetrating eye trauma and other ocular pathology like RD or chronic intraocular inflammations.

The eyes were classified into two categories. The first group (40 eyes of POAG) and the second group (30 normal eyes).

All patients were subjected to: history taking [systemic diseases, ocular surgeries, ocular diseases or trauma, family history of glaucoma (1st degree relative), history of drug intake (systemic or topical as steroids)], examination [visual acuity (VA), examination by slit lamp, gonioscopy for angle, optic disc evaluation, posterior segment, and IOP measurements] and investigations

2.1 Investigations

Pachymetry: to measure central corneal thickness and corrected IOP according to CCT.

The device & methods:

- Ultrasonic Pachymetry (Sonomed, 300p, Pac Scan).
- By using local anesthetic eye drops (Benoxinate hydrochloride 4%) and multiple reading / one-point mode which allowed obtaining up to (5) readings at one point at the center of the cornea.
- The corrected IOP was calculated for the effect of central corneal thickness using (modified Ehler’s formula).

2.2 Corvis ST

The device (Oculus Corvis ST (Wetzlar, Germany, type 72100).

2.3 The Method

The patient was comfortably positioned, with the chin and forehead properly aligned. The patient was instructed to direct his or her attention to the middle red LED (light emitting diode). A frontal view camera equipped with a keratometer-style projection device was attached. The exam was intended to terminate automatically when alignment with the cornea's first purkinje reflex was achieved. Additionally, manual release was feasible. The Scheimpflug camera monitored at a rate of over 4300 frames per second. The cornea responded to a collimated air puff that was measured.

The Scheimpflug camera was equipped with a blue light LED (455 nm, UV-free) and covered an area of 8.5 mm horizontally of a single slit. The recording time was 30 ms, allowing for the acquisition of 140 frames. Each image had 576 measurement points, allowing for dynamic examination of the deformation process. Each frame was subjected to advanced algorithms for the detection of corneal outlines.

2.4 Statistical Analysis

SPSS v25 was used for statistical analysis (IBM Inc., Chicago, IL, USA). The mean and standard deviation (SD) of quantitative variables were calculated and compared using the paired Student's t-test for the same group. Qualitative variables were presented as frequency and percentage (%). Pearson correlation was done to estimate the degree of correlation between two quantitative variables. A P value of 0.05 with two tails was judged significant.

3. RESULTS

Table 1 shows patient demographic data in the studied groups.

In group A the mean non-corrected IOP measured by Corvis was significantly higher than that measured by Goldmann in the same patients. The mean corrected IOP measured by Corvis was significantly higher than that measured by Goldmann in the same patients.

In group B, the mean non-corrected IOP measured by Corvis was significantly higher than that measured by Goldmann in the same group. The mean corrected IOP measured by Corvis was significantly higher than that measured by Goldmann in the same group Table 2.

Table 1. Patient demographic data

		Group A (n=40)	Group B (n=30)
Age (years)		51.7±11.5	49.6±14.11
Sex	Male	20 (50%)	14(46.7%)
	Female	20 (50%)	16(53.3%)
Eye	Right	19 (47.5%)	15(50%)
	Left	21(52.5%)	15(50%)

Data are presented as mean ± SD or frequency (%)

Table 2. Intraocular pressures measurements in group A and B

	Goldman	Corvis ST	P value
Group A (n=40)			
Non corrected IOP	14.63±4.75	Air puff IOP 16.80±5.01	<0.001*
Corrected IOP	IOP corrected by CCT 14.88±2.99	IOP corrected by corneal hysterisis 16.34±2.78	0.006*
Group B (n=30)			
Non-corrected IOP	12.48±2.03	15.14±2.14	<0.001*
Corrected IOP	12.76±1.92	15.07±1.81	<0.001*

**: Significant p value < 0.05, IOP: intraocular pressure, CCT: central corneal thickness*

In group A there was a significant positive correlation between non-corrected IOP measured by Corvis and non-corrected IOP measured by Goldmann (the readings of non-corrected IOP from the two devices increased together and decreased together), There was a significant positive correlation between corrected IOP measured by Corvis and non corrected IOP measured by Goldmann (the readings of corrected IOP from the two devices increased together and decreased together). In group B there was a significant positive correlation between non-corrected IOP measured by Corvis and non-corrected IOP measured by Goldmann. There was a significant positive correlation between corrected IOP measured by Corvis and non corrected IOP measured by Goldmann Fig. 1.

There was an excellent agreement (which means that the reliability of measurement of non-corrected IOP by GAT and Corvis in group A is excellent because ICC more than 0.90) in the measurements of non-corrected IOP between corvis and Goldmann by 0.906. There was a good agreement in the measurements of corrected IOP between Corvis and Goldmann by 0.842 in group A. There was an excellent agreement in the measurements of non-corrected IOP between Corvis and Goldmann in group B by 0.927. There was a good agreement in the measurements of corrected IOP between Corvis and Goldmann in group B by 0.737 Table 3.

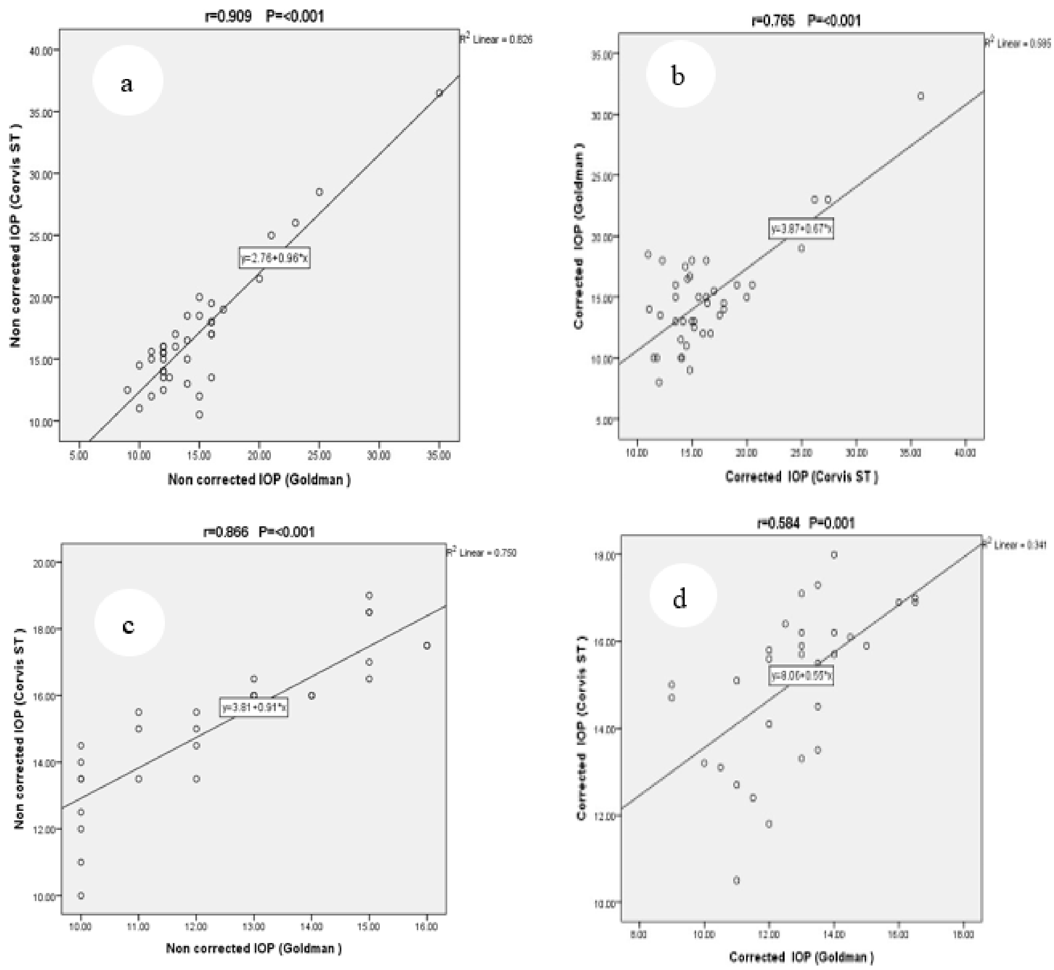

Fig. 1. (a) Correlation between non-corrected IOPmeasured by Corvis ST and corrected IOPmeasured by Goldman group A (b) Correlation between corrected IOP measured by Goldman and corrected IOP measured by Corvis ST in group A, (C)Correlation between non-corrected IOPmeasured by Corvis ST and corrected IOPmeasured by Goldman group B, (d) Correlation between corrected IOPmeasured by Corvis ST and corrected IOPmeasured by Goldman in group B

Table 3. Interclass correlation coefficients between Goldmann and Corvis ST in groups A and B

	Group A			
	ICC	**95% CI**		**p**
Non corrected IOP	0.906	0.409	0.969	<0.001*
corrected IOP	0.842	0.670	0.920	<0.001*
	Group B			
Non-corrected IOP	0.927	0.848	0.965	<0.001*
Corrected IOP	0.737	0.447	0.875	<0.001*

**: Significant p value < 0.05, IOP: intraocular pressure, CCT: central corneal thickness*

Table 4. Mean difference between Goldmann and Corvis ST intraocular pressure measured in studied two groups

	Mean difference
Group A	
Non corrected IOP (NC IOP Goldmann – NC IOP corvis)	-2.16±2.09
Corrected IOP (Corrected IOP Goldmann – corrected IOP corvis)	-1.46±3.21
Group B	
Non corrected IOP	-2.70±1.08
Corrected IOP	-2.30±1.70

Data are presented as mean ± SD, IOP: intraocular pressure

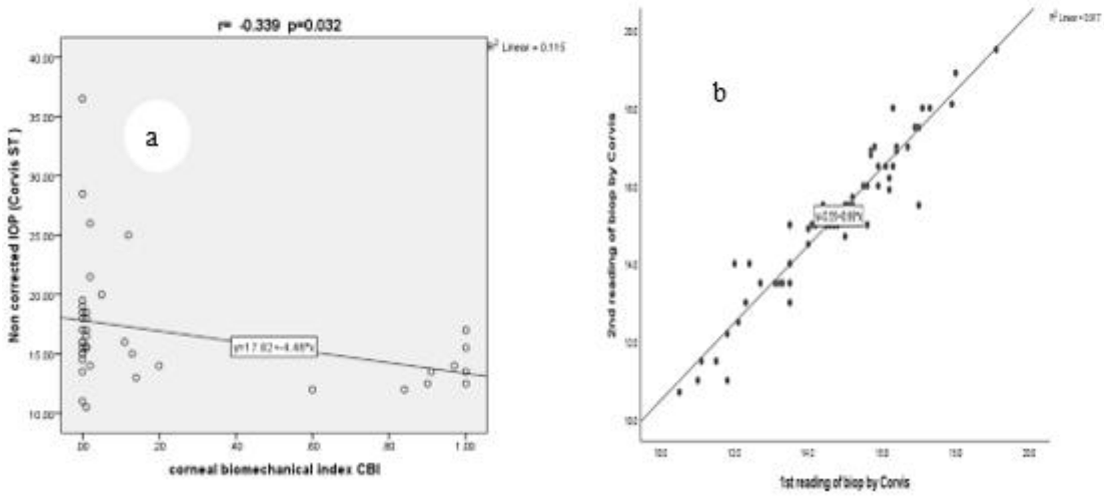

Fig. 2. (a) Correlation between corvis biomechanical index (CBI) and non- corrected measured by Corvis ST in glaucoma patients and (b) Correlation between first and second readings for Corvis ST

In group A, the mean differences between the mean non-corrected IOP measured by Corvis and Goldmann was 2.16 ± 2.09 and Corvis has higher readings than Goldmann. The mean differences between the mean corrected IOP by Corvis and Goldmann was 1.46 ± 3.21 and the Corvis has higher readings than Goldmann. In group B The mean differences between the mean non-corrected IOP by Corvis and Goldmann was 2.7 ± 1.08 and the Corvis has higher readings than Goldmann. The Mean difference between the mean corrected IOP by Corvis and Goldmann was 2.3 ± 1.7 and Corvis has higher readings than Goldmann. This means that corvis had higher readings in all measurements Table 4.

There was a significant negative correlation between non-corrected IOP measured by Corvis and corneal biomechanical index in group A. There was a negative non-significant correlation between corrected IOP measurement by Corvis and CBI in group A. There was a negative non-significant correlation between the non- corrected and corrected IOP measured by Corvis and CBI in group B.

There is a positive significant correlation between first and second IOP readings by Corvis.

This means that the first and second readings of IOP by corvis with interval 30 minutes between the two readings increased together and decreased together (positive relationship) Fig. 2.

4. DISCUSSION

There has been a resurgence of interest in more precise IOP measurement; The Corneal Visualization Scheimpflug Technology device (Corvis ST tonometry: CST) is a novel noncontact tonometer designed to IOP while accounting for the cornea's biomechanical features. CST, like ORA, employs a quick air puff, but unlike ORA, an ultra-high speed Scheimpflug camera is used to see the corresponding corneal movement directly. CS generate biomechanical corrected IOP (bIOP) readings that are corrected for the CCT and other parameters [10].

In our study, the Corvis ST had statistically significant higher readings of both non-corrected IOP and bIOP than non-corrected IOP and IOP corrected by central corneal thickness measured by Goldmann tonometer in the two studied groups. The CST/derived bIOP measurements had a good reliability. There was no significant relationship between bIOP and Corvis biomechanical index (CBI), and the interclass correlation coefficient (ICC) of CST ranged between (0.92- 0.96) for IOP.

A study by L Reznicek, et al. [11] involved 188 eyes, 142 glaucoma-affected eyes, 10 ocular hypertension-affected eyes, and 36 control eyes who underwent IOP measurement by GAT and CST. The study showed that the mean CST-IOP was 15.4 ± 5.6 mmHg and the mean GAT-IOP was 14.5±4.8 mmHg so CST had higher readings than GAT in all studied groups. Also, the study showed that CST demonstrates high reproducibility and accuracy in healthy people and patients of glaucoma compared to GAT.

Similarly, L Ramm et al. [12] published a study that involved 94 healthy eyes who underwent IOP measurement by CST and GAT. The mean bIOP was 13.5±2.4 mmHg considered higher than the mean GAT-IOP which was 12.9±2.4 mmHg. Also, a study by Ye et al. [13] involved 122 eyes with OAG and hypertension of the eye and assessed IOP measurement by CST and GAT found the mean CST-IOP was 15.2±3.0 mmHg and the mean GAT-IOP was 14.1±3.2 mmHg so CST had higher readings than GAT.

Another study by A Smedowski, et al. [14] involved 192 eyes, they examined 152 normal eyes and 40 eyes with various diseases. for IOP by CST and GAT, showed that the mean bIOP was 16.1±4.0 mmHg and GAT-IOP was 15.6±3.5 mmHg, so CST had higher readings in both studied groups.

As regard the repeatability of CST, BT Lopes, et al. [15] published a study that involved 32 healthy volunteers who were examined by CST using three different devices for taking three different measurements to each subject and the study showed that there was good repeatability and reproducibility for IOP measurement by CST.

Another study by R Vinciguerra., et al. [16] included 4 groups, the first group involved 41 eyes with high tension POAG, the second group involved 33 eyes with normotensive glaucoma ,the third group involved 45 eyes with ocular hypertension and the fourth group involved 37 controls underwent IOP measurement by CST and GAT , the study showed that between GAT-IOP and bIOP, there was a significant difference in all studied groups and demonstrated that corneal biomechanics may be a significant influence in determining IOP.

In terms of the correlation between IOP and CCT Masto Matsuura, et al. [17] published a study that involved 141 eyes, 35 normal eyes and 106 glaucoma-affected eyes examined by CST and GAT then the relation between IOP and biomechanical properties (CCT, CH) were analysed and demonstrated a significant correlation between GAT-IOP and CCT.($P < 0.001$) whereas bIOP was not associated with CCT in a significant way ($P = 0.19$) and significantly related to CH.

As regard the interclass correlation coefficient of CST ML Salvetat, et al., (2015) (100) published a study which showed that the interclass correlation coefficient of CST ranged between

(0.95- 0.99) for IOP, so CST was excellent for IOP measurement. On the other hand, it contrasted with our study in the correlation between bIOP and GAT-IOP because it showed that bIOP underestimated GAT-IOP by 1.4±2.7 mmHg.

The results of M Matsuura, et al. [4] supported our study in assessment of reliability of CST, this study involved 141 eyes, 106 glaucomatous eyes and 35 healthy eyes underwent IOP measurement by GAT and CST and CST were carried conducted 3 times for each member with an interval of 1 min, CST showed good reliability. On the other hand, it found bIOP had no significant difference from GAT-IOP.

On the contrary, another study by Y Nakao, et al. [18] published and involved 90 POAGpatients assessed for IOP measurement by CST and GAT, it showed that the mean CST-IOP was 9.7±2.5 mmHg and the mean GAT-IOP was 13.6±2.2 mmHg, so CST-IOP was significantly lower than GAT-IOP. Also, Jiaxu Hong et al., (2013) (2) published a study that involved 59 participants included 36 glaucomatous patients and 23 controls underwent IOP measurement by CST and GAT, the mean bIOP for all examined eyes was 18.9±5.8 mmHg considered slightly decreased than the mean GAT-IOP which was 20.6±5.7 mmHg.

Matsuura et al. [19] stated that Glaucomatous visual field progression and severity can be examined even more precisely when CST-derived measures are used. Another factor to consider is the link between the IOP readings obtained with each instrument and the biomechanical features of the cornea., because CCT can impact IOP measurements such as GAT, and also advancement of glaucoma are connected with several corneal biomechanical features such as CCT, ORA CH, and also CST (Hirasawa et al. [20] Matsuura et al. [21] concluded that While ORA parameters are very reproducible, some CST parameters are less so. CST parameters exhibit a strong correlation with ORA results; Yet, the strength of these associations is somewhat tenuous Matsuura et al. [4] concluded that The bIOP demonstrated superior precision and repeatability in the measurement of IOP.

5. LIMITATIONS

The sample size was relatively small. The study was in a single center. The follow up of patients was limited for relatively short period.

6. CONCLUSION

Our prospective comparative study has shown that the IOP measurement in patients with POA Gusing Corvis-ST has a good reliability.

CONSENT AND ETHICAL APPROVAL

The patient provided written informed consent. The research was done after approval from the Ethical Committee Tanta University Hospitals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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