



Ocular Response Analyzer versus Goldmann Applanation Tonometer for Measurement of Intra-Ocular Pressure

Thesis

Submitted for Partial Fulfillment of the Master Degree in Ophthalmology

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Cairo/2019**

Aknowlegments

First and foremost, I feel always indebted to Allah, the Most Beneficent and Merciful who gave me the strength to accomplish this work,

My deepest gratitude is owed to my supervisor, Prof. Dr. Mohamed Adel Abdelshafik, Professor of Ophthalmology, Faculty of Medicine - Ain Shams University, for his valuable guidance and expert supervision, in addition to his great deal of support and encouragement. I really have the honor to complete this work under his supervision.

I would like to express my great and deep appreciation and thanks to Dr. Ahmed Ibrahim Aboueleinein, Head of Ophthalmology Department - Military Medical Academy., for his meticulous supervision, and his patience in reviewing and correcting this work.

I would like also to thank with all appreciation Dr. Momen Mahmoud Hamdi, Assistant professor of Ophthalmology, Faculty of Medicine - Ain shams University, for the efforts and time he has devoted to accomplish this work.

Last but not least, I can't forget to thank all members of my Family specially my husband and my Parents, for pushing me forward in every step of my life.

LIST OF CONTENTS

Title	Page No.
List of Contents	i
List of Abbreviations	ii
List of Tables	iii
List of Figures	iv
Introduction	1
Aim of the Work	2
Review of Literature	3
▪ Goldmann applanation tonometry	3
▪ Ocular Response Analyzer	9
Subjects and Methods	16
Results	19
Discussion	39
Conclusion	45
Summary	47
References	49
المخلص العربى	1

LIST OF ABBREVIATIONS

Abb.	Full Term
CCT	: Central corneal thickness
CH	: Corneal Hysteresis
CRF	: Corneal Resistance factor
D	: Diopter
F	: Force
GAT	: Goldmann aplannation tonometry
IOP	: Intra ocular pressure
IOP_{cc}	: Intra ocular pressure (Corea-compensated)
IOP_g	: Intra ocular pressure (goldmann-Equivalent)
LOAS	: Lines of agreemants
M	: Mean
mmHg	: Millimeter Mercury
N	: Number
ORA	: Ocular response Analyzer
P	: Pressure
P1	: Peak one
P2	: Peak two
P-value	: Predictive value
R-value	: The correlation coefficient
S	: Surface
SD	: Standard deviation
SE	: Spherical equivalent

LIST OF TABLES

Table No.	Title	Page No.
Table (1):	Baseline Characteristics of the Study Population.....	19
Table (2):	Results of Univariable Regression Analysis	20
Table (3):	Results of Multivariable Regression Analysis.....	21
Table (4):	Correlation between GAT IOP subgroups readings and ORA IOPg readings	23
Table (5):	Correlation between GAT IOP subgroups readings and ORA IOPcc.	25
Table (6):	Correction table used for adjusting GAT IOP based on central corneal thickness based on Ehlers et al.	34
Table (7):	correlation study between Adjusted GAT IOP calculated by Fig.(6) & ORA IOPcc.	35
Table (8):	correlation study between Adjusted GAT IOP & ORA IOPg.	36
Table (9):	Mean , Standard Deviation and 95% Confidence Level of the measured IOP.	38

LIST OF FIGURES

Figure No.	Title	Page No.
Fig.(1):	Goldmann Applanation Tonometer.	3
Fig.(2):	Correct view of the semicircles.....	6
Fig.(3):	Examples of wrong measurement of IOP.	7
Fig.(4):	Corneal astigmatism can significantly affect IOP.....	8
Fig.(5):	Ocular Response Analyzer (ORA).....	9
Fig.(6):	Step of measurment of intra ocular pressure by (ORA).....	10
Fig.(7):	Graphical representation of the applanation events	12
Fig.(8):	Correlation between GAT readings and ORA IOPg readings	22
Fig.(9):	Correlation between GAT readings and ORA IOPcc readings.....	24
Fig.(10):	Correlation between ORA IOPg readings & ORA IOPcc readings.....	26
Fig.(11):	Correlation between CCT& ORA IOPg readings.....	27
Fig.(12):	Correlation between CCT& GAT IOP readings.....	27
Fig.(13):	Correlation between CCT& ORA IOPcc readings.	28
Fig.(14):	correlation between CCT &CH.	29
Fig.(15):	Correlation between CCT & Corneal resistance factor.	29
Fig.(16):	Correlation between CH & CRF.....	30
Fig.(17):	Correlation between CH & ORA IOPcc.	31
Fig.(18):	Correlation between CRF & GAT IOP.....	32
Fig.(19):	Correlation between CRF & ORA IOPg	32
Fig.(20):	Correlation study between CRF& ORA IOPcc readings.....	33
Fig.(21):	correlation study between Adjusted GAT IOP & ORA IOPcc.....	35
Fig.(22):	correlation study between Adjusted GAT IOP & ORA IOPg.	36
Fig.(23):	Bland-Altman plot of the agreement between GAT IOP measurements and ORA IOPg measurements	37
Fig.(24):	Bland-Altman plot of the agreement between GAT IOP measurements and ORA IOPcc measurements.....	38

ABSTRACT

Background: Goldmann applanation tonometry (GAT) has been the gold standard for intraocular pressure(IOP) measurement ,since its appearance in clinical practice around 50 years ago. (1) In spite of being almost unchallenged, the last few years have become a sustained search for a new standard method for IOP measurement,. One such recently marketed instrument is the Ocular Response Analyzer (ORA), which able to detect the corneal biomechanics.

Aim of the Work: is to compare the IOP measurement estimated by Goldmann applanation tonometer to that of ORA and detect the effect of state of refraction, corneal topography and central corneal thickness(CCT) on these measurements.

Patients and Methods: This cross sectional study was done from March 2018 to October 2018 on 65 eyes of patients visiting the outpatient clinic.

Results: The mean GAT IOP was 15.938 ± 6.041 while the mean ORA (IOPcc) and (IOPg) were 19.711 ± 7.59 and 17.242 ± 7.35 mm Hg respectively. There is a strong positive relationship between GAT IOP & ORA IOPg measurement ($r=0.880 - p = <0.001^*$). Also finding a weak yet significant correlation between IOPg and CCT ($r=0.385, p=0.001$). None of the pressure measurements was affected by refraction or corneal curvature significantly.

Conclusion: In conclusion, our results suggest that mean IOPs obtained by ORA were significantly higher than that of GAT with different influencing factors that are not completely understood. caution has to be sought when using the ORA, the values obtained ought not to be used interchangeably with the values obtained by GAT, despite the presence of a positive correlation between these values. This underlines the importance of using one and only method of evaluation of the IOP for every patient in successive follow-up visits.

Key words: Goldmann applanation tonometry, ocular response analyzer, central corneal thickness, intraocular pressure.

INTRODUCTION

Accurate intraocular pressure (IOP) measurement is important in the diagnosis and management of glaucoma. Goldmann applanation tonometry (GAT) is considered the gold standard for IOP measurement; however, various sources of error may affect the accuracy of measurements.⁽¹⁾

Central corneal thickness (CCT) is well known to affect the IOP measured by GAT. Goldmann and Schmidt reported in 1957 that CCT affects IOP measurements⁽²⁾, and thereafter several studies have shown that thinner corneas result in artificially low IOP readings and that thicker corneas cause artificially high IOP readings.⁽³⁾ Then it has been widely documented that Goldmann applanation tonometry measures can be affected by other ocular properties such as corneal curvature.⁽⁴⁾

These findings have prompted the development of numerous formulas and nomograms designed to compensate for the corneal thickness effect on GAT, but none of these methods has been entirely satisfactory.^(1,5)

As a result of efforts to mitigate some of the limitations of conventional tonometry, several new tonometers have appeared on the scene. One such recently marketed instrument, the Ocular Response Analyzer (ORA), is able to establish the biomechanical properties of the cornea and use this information to adjust IOP measurements according to these properties.⁽⁶⁾

AIM OF THE WORK

The aim of this study is to compare the IOP measurement taken with Goldmann applanation tonometer to that of ORA and determine the effect of state of refraction, corneal topography and central corneal thickness on these measurements.

Goldmann applanation tonometry



Fig.(1): Goldmann Applanation Tonometer attached with Slit lamp biomicroscope.⁽⁷⁾

Goldmann applanation tonometry is the standard for IOP assessment in clinical settings and it has been used to measure IOP on the vast majority of clinical trials on glaucoma. Most of the knowledge on glaucoma management derives from GAT data.⁽⁸⁾ Applanation tonometry is based on Imbert-Fick's law, which is a modification of Newton's third law of motion:

$$P = F / S$$

where ***P*** is pressure, ***F*** is force, and ***S*** is surface.

GAT (Fig.1) is a fixed-area applanation tonometry: applanated area is a circle with diameter of 3.06 mm; the force exerted to the eyeball is variable. A prism is mounted on the

tonometer head and is placed against the cornea. Anesthetic eyedrop is required as the probe makes contact with the cornea.

The examiner applies fluorescein into the conjunctival fornix in order to mark the lacrimal film. A cobalt blue filter is used to view two green semicircles. The force applied to the tonometer head is then adjusted using a dial connected to a variable tension spring until the inner edges of the green semicircles in the viewfinder meet as illustrated in **(Fig.2)** , **(Fig.3)**.⁽⁸⁾

The amount of fluorescein is directly related to a correct IOP measurement. If fluorescein staining is low, measures tend to be underestimated by 1.5–9.5 mmHg.⁽⁹⁾ If fluorescein staining is adequate but there is excessive tearing, semicircles will be broader than normal, and this may cause an overestimation of IOP by 2–4.5 mmHg.⁽¹⁰⁾ Measuring IOP without fluorescein is associated with an underestimation up to 5.5 mmHg.⁽¹¹⁾

Factors affecting GAT; includes sclerocorneal characteristics, blepharospasm, and episcleral venous pressure (which may be affected by factors such as ties or tight collars).

The effects of corneal characteristics have been well investigated and it has been confirmed that IOP is affected by such corneal factors including; central corneal thickness (CCT), astigmatism ,corneal curvature, corneal edema.⁽¹²⁾

GAT is based on corneas of normal thickness, i.e., 520 μm . CCT affects IOP in the sense that higher CCT is associated with IOP overestimation and vice versa. When evaluating patients' IOP, it is crucially important to know CCT, in order not to misdiagnose patients with low IOP and thin corneas, or subjects with thick corneas and high IOP.⁽¹³⁾

When regular astigmatism is present (more than 3 D) , an elliptical contact with tonometer head occurs. This results in an underestimation of IOP in with-the-rule astigmatism and an over estimation with against-the-rule astigmatism.⁽¹⁴⁾ as illustrated in **(Fig.4)**.

In order to reduce this error, three options can be used:

1. Align tonometer head at 43° to axis of astigmatism (in negative cylinder).
2. Average IOP readings at 0 and 90° .
3. Average IOP readings at the two main corneal axes.

The effect of corneal curvature is summarized in Steeper corneas give IOP overestimation, as they need to be indented more (i.e., they require more force) to produce the standard area of contact. In contrast, flatter corneas are more easily applanated and this is associated with underestimation. A difference of three diopters in the corneal curvature of two eyes may affect a tonometric variation of 1 mmHg. Within the extreme range of 40 to 49 D, the range of affect on tonometer readings amounts to 3 mmHg for corneas ranging between 40 and 49 diopters.⁽¹⁵⁾

Corneal edema, particularly epithelial edema, is associated with gross errors in IOP measurement. Edematous epithelium is much easier to indent than normal epithelium, and this may lead to errors ranging from 10 to 30 mmHg.⁽¹⁶⁾

One of the other limits of GAT is inter-operator variability, which is known to vary up to 2–3 mmHg.

Due to the high number of possible sources of errors, it has been claimed that newer tonometries may be more reliable than GAT. Though this may be true in theory, in practice it should be kept in mind that most glaucoma literatures (and in particular prospective randomized controlled studies) are based only on GAT.

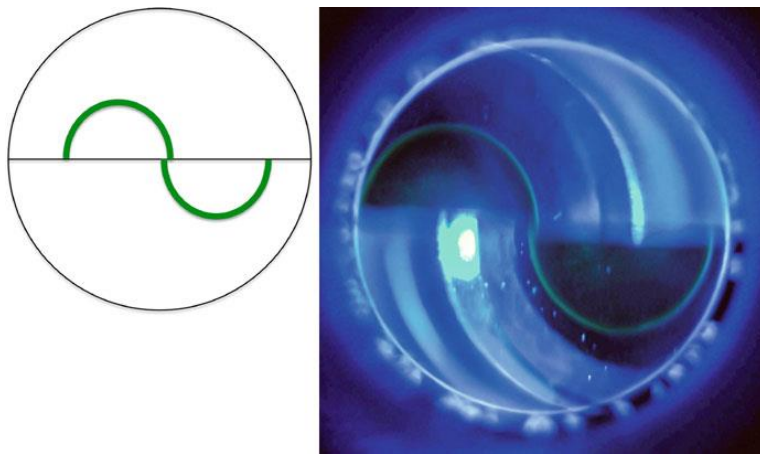


Fig.(2): Correct view of the semicircles. The correct reading is achieved when the inner edges of the green semicircles in the viewfinder meet.⁽⁸⁾

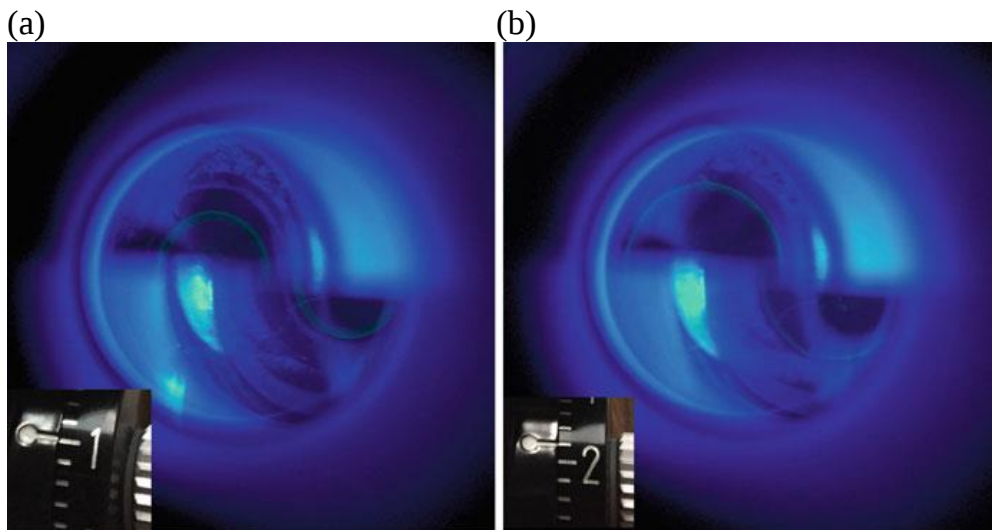


Fig.(3): Examples of wrong measurement of IOP. This patient had IOP of 15 mmHg. (**a**) If the tonometer is positioned at 10 mmHg, the two semicircles are too distant. (**b**) If the tonometer is positioned at 18 mmHg, the two semicircles are too close. The correct position to be obtained is the one of (Fig.2)⁽⁸⁾

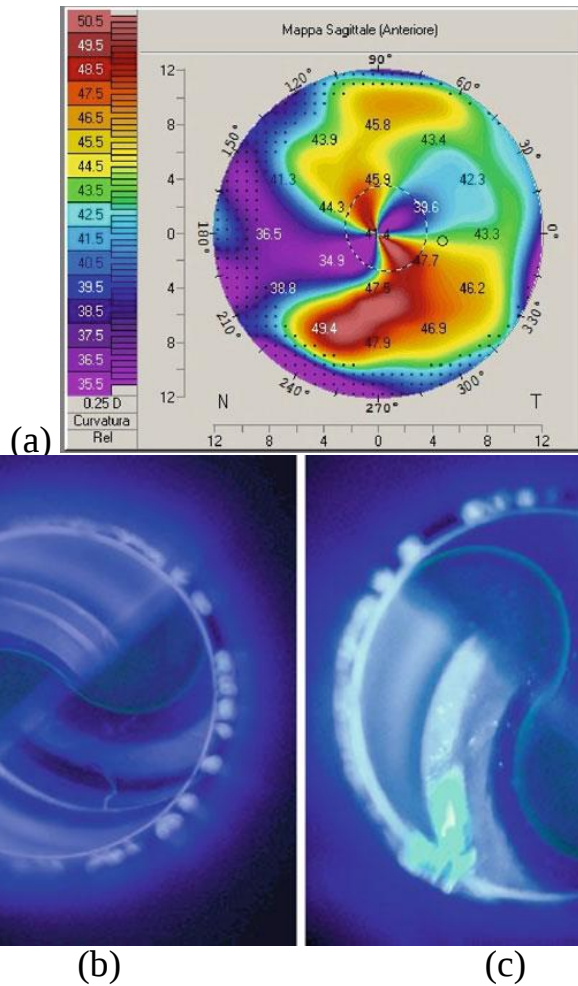


Fig.(4): (a) Corneal astigmatism can significantly affect IOP. This patient had a corneal astigmatism of 13 diopters due to severe pterygium, as shown by corneal topography. (b) IOP measurement showed a difference of 5 mmHg when the prism is positioned at 45°, and (c) 135°; the steeper meridian is the one with the highest reading . In the case of high astigmatism, the most precise IOP reading is the mean of those obtained on the two main meridians.⁽⁸⁾