Comparison of IOP correction factor provided with scheimflug camera (pentacam) with that provided by Ocular Response Analyzer (ORA) and their correlations with various corneal parameters for finer refinement of IOP measurements for Normal individuals.

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Abstract: Objective: To compare the IOP correction factor provided with Pentacam with that provided by Ocular Response Analyzer (ORA) for finer refinement of IOP measurements for Normal individuals. **Methods:** 69 eyes of 38 healthy Egyptian patients without ocular pathology or previous intraocular surgery were included in the study, of which there was 50 female eyes and 19 male eyes.The age ranged from 18-49 years (mean 27.62±8.51 Years).The spherical equivalent ranged from +3.75 to -11.5 diopters (D) (mean -4.28±3.28D). All cases were subjected to full ophthalmological examination including uncorrected and best corrected visual acuity,refraction,slit lamp examination, Scheimflug imaging (i:e Pentacam, (ALLEGRO Oculyzer Version 1074; Allergo, Germany) and Ocular Response Analyzer (ORA) (Reichert Ophthalmic Instruments, Inc., Buffalo, NY,USA). For each studied item,mean value and standard deviation were calculated by statistical analysis. Comparison(t-test) and Pearson correlation tests were also done. **Results:** The correction factor for IOP provided by pentacam ranged from -6.5 to 3.6mmHg (mean -0.61±2.35mmHg) while that provided by ORA ranged from -3.6 to 4.1mmHg (mean -0.32±1.88mmHg), comparison by t-test revealed a non significant difference (t-test= 0.54 (p = 0.62 i.e;>0.05)**.** Studying the effect of age on the results revealed a non significant difference i.e:t- test showing a value of 1.01(*p*=0.32 i.e >0.05 for Pentacam and. t- test showing a value of 0.82(*p* =0.41 i.e >0.05 for ORA. ***Regarding intraocular pressure (IOP) correction factor provided by Pentacam:*** A highly significant correlation (*p* =<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry, corneal hysteresis and corneal resistance factor. A statistically significant correlation "r"=-0.22(*p* =<0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in the posterior float, while a non significant correlation (*p* =>0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings.and the central protrusion in anterior float. ***Regarding intraocular pressure (IOP) correction factor provided by ORA:*** A highly significant correlation (*p* =<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry, the corneal hysteresis and the corneal resistance factor.A statistically significant correlation "r"=0.38(P=<0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings. A non significant correlation (*p* =>0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in anterior float and and the central protrusion in the posterior float. **Conclusions:** A non significant difference exists between IOP correction factor obtained by pentacam and ORA and the results were not affected by age but there was a statistically significant correlation between IOP correction factor and the central corneal thickness, corneal hysteresis and corneal resistance factor with both machines. Therefore both machines can be used with reasonable comparable accuracy for finer refinement of IOP for ophthalmic patients.

[Tamer A. Refai. **Comparison of IOP correction factor provided with scheimflug camera (pentacam) with that provided by Ocular Response Analyzer (ORA) and their correlations with various corneal parameters for finer refinement of IOP measurements for Normal individuals.** *Nat Sci* 2014;12(3):115-120]. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 17

Keywords: Pentacam IOP correction factor, ORA IOP correction factor,central corneal thickness, Corneal hysteresis, Corneal resistance factor.

1. Introduction:

Ophthalmologic examinations and important in the management and follow-up of patients with glaucoma [(1)]. Goldmann applanation tonometry (GAT) has been considered the gold standard for IOP measurement based on the assumption that the eye is a uniform sphere with an infinitely thin dry membrane. In practice, corneal thickness and curvature are uneven and the tear fim may affect the surface tension of the eye[(2)]. Measured values of intraocular pressure are influenced by corneal thickness and rigidity[(3-5)]. Some studies had used scheimflug camera (pentacam) to correct for IOP measurements[(6,7)]. Other studies had used Ocular Response Analyzer for refinement of Intraocular pressure measurement [(8,9)].

In this study, I compared the IOP correction factor provided with Pentacam with that provided by Ocular Response Analyzer (ORA) for finer refinement of IOP measurements for Normal individuals.

2. Methods:

A total of 69 eyes of 38 Egyptian patients were included in the study, of which there was 50 female eyes and 19 male eyes.The age ranged from 18-49 years (mean 27.62±8.51 Years).The spherical equivalent ranged from +3.75 to -11.5 diopters(D) (mean -4.28±3.28D).All cases were subjected to full ophthalmological examination including uncorrected and best corrected visual acuity, refraction,slit lamp examination, Scheimflug imaging(i:e Pentacam, (ALLEGRO Oculyzer Version 1074; Allergo, Germany) and Ocular Response Analyzer (ORA) (Reichert Ophthalmic Instruments, Inc., Buffalo, NY,USA).Exclusion criteria included corneal pathologic conditions that could affect measurement of IOP or central corneal thickness (CCT) like keratoconus and pellucid marginal degeneration; previous corneal, refractive, or glaucoma surgery; secondary glaucomas and concomitant autoimmune or collagen vascular disease that could affect ocular rigidity.

The Scheimflug imaging (pentacam) consists of a rotating Scheimpflug camera and a monochromatic slit light source at 475 nm that rotate together around the optical axis of the eye. Within 2 seconds, the system rotates 180° and acquires 25 images that contain 500 measurement points on the front and back corneal surfaces to draw a true elevation map and the computer software allow the creation of sagittal and tangential maps[10].The following criteria were reported and included in the study; the central corneal thickness (CCT) in microns(µ),the flattest and steepest keratometric(K) readings in diopters (D) within central 3 mm ring, the Ehlers formula for central corneal thickness IOP correction factor in mmHg (being most widely accepted formula) and the maximal protrusion in the anterior and posterior floats in µ for the central 4 mm ring. Only reliable examinations(i.e with Quality specification (QS) denoting OK were included in the study.

The Ocular Response Analyzer utilizes a dynamic bi-directional applanation process to measure biomechanical properties of the cornea and the intraocular pressure of the eye. A precisely metered collimated air-pulse causes the cornea to move inwards, past applanation, and into a slight concavity. Milliseconds after applanation, as the air pulse force decreases, the cornea begins to return to its normal configuration. In the process, it once again passes through an applanated state. An electro-optical system monitors the curvature of the cornea throughout the deformation process taking 400 data samples during the 20-millisecond measurement. Two independent pressure values are derived from the inward and outward applanation events. Viscous damping in the cornea results in an offset between the inward and outward pressure values. The difference between these two pressure values is Corneal Hysteresis (CH)[11].The following criteria were reported and included in the study; CH (Corneal Hysteresis) which is a measure of viscous damping in the cornea, CRF(Corneal Resistance Factor) which is a measure of the total viscoelastic response of the cornea, the Goldmann-correlated IOP measurement (IOPg) which simulates IOP measured by Goldmann tonometer and the Corneal-Compensated Intraocular Pressure (IOPcc) that takes corneal biomechanical properties into consideration. The IOP correction factor was calculated for each eye by subtracting the the Corneal-Compensated Intraocular Pressure (IOPcc) from the Goldmann-correlated IOP measurement (IOPg). Only reliable examinations (i.e with wave front score (WS) above 7 were included in the study.

For each studied item, mean value and standard deviation were calculated by statistical analysis. Comparison (t-test) and Pearson correlation tests were also done.

3. Results:

A total of 69 eyes of 38 patients were included in the study, of which there was 50 female eyes and 19 male eyes.The age ranged from 18-49 years (mean 27.62±8.51 Years).The Average keratometric (K) readings ranged from 40.15 to 47.7Diopters (mean 43.53±1.50). The central pachymetry ranged from 494 to 634µ(mean 551.51±33.97µ).The maximal anterior protrusion in the central 4mm ring ranged from 0 to +21µ(mean 7.71±3.75µ) for the anterior float and from +2 to +25µ(mean 9.77±5.70µ) for the posterior float. The corneal hysteresis(CH) ranged from 7.6 to 14.8 (mean 10.54±1.62) while the corneal resistance factor(CRF) ranged from 7.7 to 14.9 (mean value 10.55±1.82).The intraocular pressure measured by ORA ranged from 10 to 25.2mmHg (mean 15.74±3.01 mmHg) for IOPg and from 9.3 to 22.4mmHg (mean 16.07±2.84mmHg) for IOPcc.The Spherical equivalent (Sph.EQ) ranged from +3.75 to -11.5D(mean -4.28±3.28D).The best corrected visual acuity (BCVA) in Snellen lines ranged from 0.4 to 1.2 (mean 0.88±0.16).

The correction factor for IOP provided by pentacam ranged from -6.5 to 3.6mmHg (mean -0.61±2.35mmHg) while that provided by ORA ranged from -3.6 to 4.1mmHg(mean -0.32±1.88mmHg) ***Table 1 and Chart 1.***Comparison by t-test reveals a value of 0.54 (p = 0.62 i.e;>0.05) denoting non significant difference **Table 1.**

Table 1: showing the average value for intraocular pressure (IOP) correction factor both by pentacam and by ORA,their comparison by t-test and the significance for cases under the study.

Item	Pentacam	ORA	T-test	*P*-value	Significance	Significance
Mean IOP correction factor in mmHg	-0.61±2.35	-0.32±1.88	0.54	0.62	>0.05	Non significant

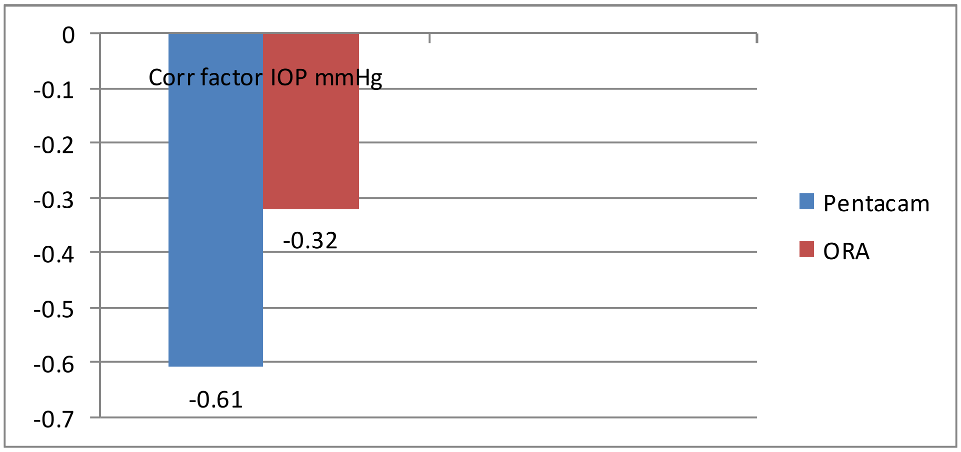

Chart 1: showing the average value for intraocular pressure (IOP) correction factor both by pentacam and by ORA, for cases under the study.

To study the effect of age on the IOP correction factor, patients were divided into two groups :**(Chart 2).**

The first group including eyes of patients below or equal to 25 years of age (n=32 eyes) and

The second group including eyes of patients above 25 years of age (n=37 eyes).

The mean value for IOP correction factor by Pentacam was -0.94±2.80mmHg for the age group below or equal to 25 years and was -0.34±1.90mmHg for the age group above 25 years with t- test showing a value of 1.01(***p***=0.32 i.e >0.05) denoting a non significant difference. The mean value for IOP correction factor by ORA was -0.12±2.16mmHg for the age group below or equal to 25 years and was -0.50±1.63mmHg for the age group above 25 years with t- test showing a value of 0.82(***p***=0.41 i.e >0.05) denoting a non significant difference**(Table 2).**

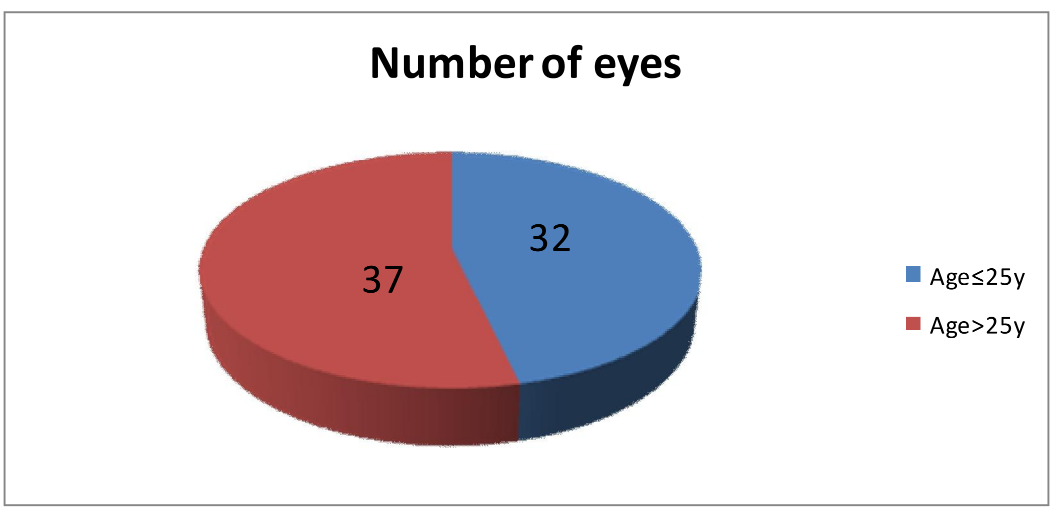

Chart 2: Showing the number of eyes in the two age groups among patients under the study.

Table 2: Showing the mean value for IOP correction factor for two age groups (below or equal to 25 years and above 25 years) both by Pentacam and ORA and their comparison by t-test and their significance for cases under the study.

Item	Age≤25y(n=32 eyes)	Age>25y(n=37 eyes)	T-test	*P*-value	Significance	Significance
Mean IOP correction factor in mmHg by Pentacam	-0.94±2.80	-0.34±1.90	1.01	0.32	>0.05	Non significant
Mean IOP correction factor in mmHg by ORA	-0.12±2.16	-0.50±1.63	0.82	0.41	>0.05	Non significant

Regarding intraocular pressure (IOP) correction factor provided by Pentacam(Table 3):

A highly significant correlation "r"=0.99(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry.

A non significant correlation "r"=0.18(*P*=>0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings.

A highly significant correlation "r"=0.73(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the corneal Hysteresis.

A highly significant correlation "r"=-0.54(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the corneal resistance factor.

A non significant correlation "r"=-0.12 (*P*=>0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in anterior float.

A statistically significant correlation "r"=-0.22(*P*=<0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in the posterior float.

Table 3 :showing correlations between IOP correction factor provided by Pentacam and Various corneal parameters among cases under study.

Correlation between items	Pearson correlation "r"	*P*-value	Significance
Pentacan IOP Corr ***Vs*** Cent.Pachy.	0.99	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** average keratometry	0.18	>0.05	Non significant
Pentacan IOP Corr ***Vs*** CH	0.73	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** CRF	-0.54	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** Cent.protrusion in Ant.float	-0.12	>0.05	Non significant
Pentacan IOP Corr ***Vs*** Cent.protrusion in Post.float	-0.22	<0.05	***Significant***

Regarding intraocular pressure (IOP) correction factor provided by ORA (Table 4):

A highly significant correlation "r"=0.51(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry.

A statistically significant correlation "r"=0.38(*P*=<0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings.

A highly significant correlation "r"=0.84(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the corneal Hysteresis.

A highly significant correlation "r"=0.84(*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the corneal resistance factor.

A non significant correlation "r"=0.01 (*P*=>0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in anterior float.

A non significant correlation "r"=0.08 (*P*=>0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in the posterior float.

Table 4: showing correlations between IOP correction factor provided by Pentacam and Various corneal parameters among cases under study.

Correlation between items	Pearson correlation"r"	*P*-value	Significance
Pentacan IOP Corr ***Vs*** Cent.Pachy.	0.51	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** average keratometry	0.38	<0.05	***Significant***
Pentacan IOP Corr ***Vs*** CH	0.84	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** CRF	0.84	<0.01	***Highly Significant***
Pentacan IOP Corr ***Vs*** Cent.protrusion in Ant.float	0.01	>0.05	Non significant
Pentacan IOP Corr ***Vs*** Cent.protrusion in Post.float	0.08	>0.05	Non significant

4. Discussion:

Elevated IOP remains the most important risk factor for development[12] and progression of open angle glaucoma [13].However IOP is known to be markedly affected by factors like corneal thickness and rigidity([3]).Here comes the importance of using machines that can correct for theses factors. Among most commonly used machines were the Scheimflug camera(pentacam)[6] and the Ocular Response analyzer[14].

*Carmen Lopez-De La Fuentea, et al,*studied Sixty-five healthy eyes from 65 patients with full optometric examination, including central corneal thickness (CCT), and IOP measured with Ocular Response Analyzer (ORA),and they revealed that the mean differences between IOPg-IOPcc was 0.01±1.54mmHg (mean± standard deviation) and that IOPcc had a linear relationship with corneal hysteresis (CH) (r=−0.482)[15]. Their results agreed partially with my study but with lower correction factor than in my study probably because of relatively lower number of eyes than in my study but they did not study the correction factor provided by pentacam.

Shireen Shousha et al[9],studied 10 normal corneas with Goldmann applanation tonometry, air puff tonometry, ocular response analyzer corneal compensated IOP (ORA IOPcc) and Pentacam corrected IOP and had found that The correlation between Pentacam-corrected and preoperative ORA corneal-compensated IOP was strongest for Goldmann applanation tonometry (r = 0.97 and r = 0.858 respectively, $P < 0.001$) but they do not compare between corrective value provided by Pentacam and that provided by ORA(i.e: between IOPg-IOPcc).

Lian Hua Hong et al., [6]in a study, measured IOP of 124 eyes from 62 patients who underwent epipolis laser in situ keratomileusis and was measured with Goldmann applanation tonometry (GAT) at 6 months pre- and post-operatively. The collected data was input into Pentacam, calculated by 5 correction programs, Ehlers, Shah, Dresden, Orssengo / Pye, Kohlhaas, and they found that the Ehlers program is the most accurate among the 5 Pentacam correction programs evaluated in the present study so i used Ehlers correction formula in my study but only on normal individuals that had not undergone any ocular surgery.

In my study,

The correction factor for IOP provided by pentacam ranged from -6.5 to 3.6mmHg (mean -0.61±2.35mmHg) while that provided by ORA ranged from -3.6 to 4.1mmHg(mean -0.32±1.88 mmHg),comparison by t-test revealed a non significant difference (t-test= 0.54 (p = 0.62 i.e; >0.05).Studying the effect of age on the results revealed a non significant difference i.e:t- test showing a value of 1.01(***p***=0.32 i.e >0.05) for Pentacam and t- test showing a value of 0.82 (***p***=0.41 i.e >0.05 for ORA. ***Regarding intraocular pressure (IOP) correction factor provided by Pentacam:***A highly significant correlation (*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry,corneal hysteresis and corneal resistance factor. A statistically significant correlation "r"=-0.22(*P*=<0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in the posterior float, while a non significant correlation (*P*=>0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings. and the central protrusion in anterior float. ***Regarding intraocular pressure (IOP) correction factor provided by ORA:***A highly significant correlation (*P*=<0.01) existed between intraocular pressure (IOP) correction factor and the central pachymetry, the corneal hysteresis and the corneal resistance factor.A statistically significant correlation "r"=0.38(*P* =<0.05) existed between intraocular pressure (IOP) correction factor and the average keratometry readings.A non significant correlation (*P* =>0.05) existed between intraocular pressure (IOP) correction factor and the central protrusion in anterior float and and the central protrusion in the posterior float.

Conclusions:

A non significant difference exists between IOP correction factor obtained by pentacam and ORA and the results were not affected by age but there was a statistically significant correlation between IOP correction factor and the central corneal thickness, corneal hysteresis and corneal resistance factor with both machines. Threrefore both machines can be used with reasonable comparable accuracy for finer refinement of IOP for ophthalmic patients.

Financial disclosure(s):

The author has no proprietary or commercial interest in any of the materials discussed in this article.

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