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Original research

Comparison of current tonometry techniques in measurement of intraocular pressure

Behrooz Kouchaki [a], Hassan Hashemi [b,a], Abbasali Yekta [c], Mehdi khabazkhoob [d,a,*]

[a] Noor Research Center for Ophthalmic Epidemiology, Noor Eye Hospital, Tehran, Iran
[b] Noor Ophthalmology Research Center, Noor Eye Hospital, Tehran, Iran
[c] Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
[d] Department of Medical Surgical Nursing, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Purpose: To compare four tonometry techniques: Goldmann applanation tonometer (GAT), Dynamic contour tonometer (DCT), Non-contact tonometer (NCT), and Ocular Response Analyzer (ORA) in the measurement of intraocular pressure (IOP) and the impact of some corneal biomechanical factors on their performance.

Methods: In this cross-sectional study, volunteers with normal ophthalmic examination and no history of eye surgery (except for uncomplicated cataract surgery) or trauma were selected. Twenty-five subjects were male, and 21 were female. The mean age was 48 ± 19.2 years. Anterior segment parameters were measured with Scheimpflug imaging. IOP was measured with GAT, DCT, NCT, and ORA in random order. A 95% limit of agreement of IOPs was analyzed. The impact of different parameters on the measured IOP with each device was evaluated by regression analysis.

Results: The average IOP measured with GAT, DCT, NCT, and ORA was 16.4 ± 3.5, 18.1 ± 3.4, 16.2 ± 3.9, and 17.3 ± 3.4 mmHg, respectively. The difference of IOP measured with NCT and GAT was not significant ($P = 0.382$). Intraocular pressure was significantly different between GAT with DCT and IOP CC ($P < 0.001$and $P = 0.022$, respectively). The 95% limit of agreement of DCT, NCT, and IOPCC with GAT was −5.7 to 2.5, −4.1 to 4.7, and −5.3−3.7 mmHg, respectively. Simple regression model corneal resistance factor (CRF) and CCT and multivariate model CRF had a significant relationship with IOP measured with the four devices.

Conclusion: Although the mean difference of measured IOP by NCT, DCT, and ORA with GAT was less than 2 mmHg, the limit of agreement was relatively large. CCT and CRF were important influencing factors in the four types of tonometers.

Keywords: Intraocular pressure; Tonometry; Goldmann applanation tonometer; Dynamic contour tonometer; Non-contact tonometer; Ocular response analyze

Introduction

Accurate intraocular pressure (IOP) measurement has an important role in diagnosis and follow-up of patients with glaucoma. All common methods of IOP measurement are transcorneal. Hence, corneal characteristics can affect their measurements. For example, various studies have shown that goldmann applanation tonometer (GAT) gives a higher IOP in thicker corneas and a lower pressure in thinner ones. Non-contact tonometers like GAT are also seemingly affected by central corneal thickness (CCT).[1,2] On the other hand, CCT is only one of the many factors that affect transcorneal IOP measurement. Several studies indicated that other properties such as visco-elastic properties of the cornea can also have an effect on it.[3]

In recent years, dynamic contour tonometer (DCT) and ocular response analyzer ORA have been introduced as

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* Corresponding author. Department of Medical Surgical Nursing, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
E-mail address: khabazkhoob@yahoo.com (M. khabazkhoob).
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methods that are less affected by the biomechanical corneal properties.[4]

This study compared existing tonometers and the impact of some of corneal structural and biomechanical properties on IOP measured with GAT, DCT, non-contact tonometer (NCT), and ORA in a sample of the Iranian population.

Methods

This cross-sectional study was done in the Glaucoma Clinic of Noor Eye Hospital. Volunteers were selected among people who met the inclusion criteria. The Ethics Committee of Tehran University of Medical Sciences approved the study protocol, which was conducted in accord with the tenets of the Declaration of Helsinki. First, ophthalmology examinations including visual acuity measurement, slit lamp examination, and fundus examination were performed. Subjects with abnormal ocular examination, history of ocular surgery (except for uncomplicated cataract surgery), and trauma were excluded. Scheimpflug imaging (Pentacam HR (Oculus, Inc., Lynnwood, WA)) was performed for qualified people by a trained technician to assess corneal curvature, radius, and topographic maps, as well as corneal thickness and volume, and depth of anterior chamber. In the next step, low coherence interferometry (IOL Master, Carl Zeiss Meditec, Germany) was performed by another technician. Since Pentacam and IOL Master are non contact methods, they were chosen for the measurements. To minimize the possible effect of a measurement on the others, measurements with GAT, DCT, NCT, and ORA were performed in random order. Measurements with GAT were performed twice on each eye, and the average of the measurements was recorded. The test was repeated if the difference between the two measurements was more than 3 mmHg. To measure the IOP, NCT uses a very short pulse of air to applanate the cornea. The device uses an infrared light source and a sensor to receive the reflected light. When the cornea becomes flat, the sensor detects maximal light reflection, and IOP is recorded at this point. Measurements with NCT (Keeler Pulsair EasyEye tonometer, Nigeria) were performed three times, and the average value was recorded. Again, if the difference between the measurements was more than 3 mmHg, the extreme number was discarded, and another measurement was performed.

Dynamic contour tonometer (Pascal DCT, Swiss Micro-technology AG, Port, Switzerland) is a digital contact tonometer. The concave contact surface has a diameter of 7 mm, and the mean apical radius of curvature is 10.5 mm. It could be fitted on most corneas in normal range. There is a sensor at the center of the tip. When the tip of tonometer fits on the corneal surface, the sensor measures the transcorneal pressure. The assumption is that it does not cause significant distortion of the cornea and is less affected by corneal thickness and corneal curvature. Intraocular pressure is shown on a digital display. In addition, it shows a number as the quality of measurement. Only measurements with a quality of 1 or 2 were accepted. If the quality was more than 2, measurements were repeated to achieve a quality of 2 or less; otherwise, the subject was excluded from the study. The ocular response analyzer (ORA) (Reichert Ophthalmic Instruments, Depew, NY) also uses an air pulse and a light sensor like NCT, but it records IOP at two applanation positions (inward and outward). Because of the viscoelastic properties of the cornea, inward applanation pressure and outward applanation pressure are not the same. The difference is defined as corneal hysteresis (CH) which is a measure of viscoelastic properties of the cornea. Based on CH, the device calculates the intraocular pressure as IOP CC and is claimed that it is less dependent on biomechanical properties of cornea. It also offers an IOP called IOP G, a similar IOP obtained from GAT. Another parameter is CRF which is calculated based on CH and a coefficient. It is an expression of corneal rigidity. A normal ORA graph has regular and relatively symmetric appearance of the peaks. The measurements with ORA were taken down by a trained technician. The measurements were done 4 times, and the average value was recorded.

Statistical analysis

Statistical analysis of this study was conducted by the Statistical Package for Social Sciences (SPSS) Version 20.0 (Chicago, IL, USA) and MedCalc V13 (MedCalc, USA).

Pearson correlation coefficient was used for showing the correlation CCT and CV with CRF and CH. To demonstrate the agreement of each tonometer with GAT, Bland and Altman plot with a 95% limit of agreement was used. Paired *t* test was used for comparison between the two devices. Simple and multivariate linear regression analysis was used to study the relationship between factors such as corneal thickness, volume, curvature, axial length, and CRF, with intraocular pressure measured with each device. The coefficients were then reported. A *P*-value less than 0.05 was considered significant.

Results

Forty-six eyes of 25 males (54.3%) and 21 females (45.7%) were analyzed. The mean age of the subjects was 48 years (SD 19.2, range 18–80 years). Table 1 shows characteristics of the studied parameters.

Table 2 shows the relationship between the studied variables and IOP measured with the four devices. Age and sex did not have a significant relationship with the IOP measured with any device. Simple regression analysis showed that CH has a significant effect on IOP measured with NCT and IOP G. Linear regression analysis showed that CRF has a significant effect on IOP measured with all devices. The highest effect of CRF on IOP was with NCT, and the least was with IOPCC. CCT had a significant effect on IOP measured with all devices in simple regression model. The highest effect of corneal thickness was on IOP measured with IOP G followed by NCT, and the minimum effect observed with IOPCC. In a multivariate model, it was shown that only CRF had a significant correlation with IOP measured with the four devices.

The analysis of CH and CRF relationship with studied variables showed a direct and significant relation between CH, and also CRF with CCT and corneal volume.

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