https://doi.org/10.21516/2072-0076-2020-13-2-23-28

Estimation of the accuracy and informativeness of measuring intraocular pressure in patients with their contact lenses on by transpalpebral scleral tonometry

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Purpose: *to compare the tonometry results obtained by transpalpebral scleral tonometry and pneumotonometry for patients with their contact lenses on.* ***Material and methods.*** *Intraocular pressure (IOP) was measured in 30 (60 eyes) patients with various refraction errors including 5 patients (10 eyes) aged 11–63 (45.0 ± 21.0) years with hyperopia of +1.75 to +9.0 D (+4.4 ± 2.6 D) and 25 patients (50 eyes) aged 12–57 (26.4 ± 13.5) years with myopia of -0.5 to -11.25 D (-4.4 ± 2.4 D). In most of cases patients used soft daily disposable contact lenses (regular or multifocal). IOP was determined in both eyes of each patient using 1) transpalpebral scleral tonometry (EASYTON tonometer), and 2) corneal pneumotonometry. IOP was first measured when the patient was without their contact lenses, by both methods consecutively. 20 minutes after putting the lenses on, IOP was measured once again. Each measurement was taken three times and the average IOP value was determined. The data were analyzed using parametric statistics: the mean value and the standard deviation (M±SD) of each parameter were calculated.* ***Results.*** *On average, patients without contact lenses showed transpalpebral IOP (IOPtr) of 16.3 ± 2.9 mmHg in the right eye (OD) and 16.6 ± 3.2 mmHg in the left eye (OS) and pneumotonometry IOP (IOPpn) of 16.0 ± 3.8 in OD and 15.6 ± 3.3 mmHg in OS. When the lenses were put on, the values of IOPtr stayed practically the same: 16.0 ± 3.9 mmHg in OD and 16.7 ± 3.1 mmHg in OS. IOPpn also changed insignificantly: 15.7 ± 2.9 mmHg in OD and 15.5 ± 2.8 mmHg in OS, but individual IOPpn data scattered more when the lenses were put on. IOPtr of hyperopic patients both with the lenses (19.5 ± 3.9 mmHg in OD and 19.7 3 .3 mmHg in OS) and without them (19.3 ± 2.8 mmHg in OD and 19.6 ± 3.1 mmHg in OS) was higher than IOPpn both with the lenses (14.0 ± 1.8 mmHg in OD and 14.2 ± 1.7 mmHg in OS) and without them (13.5 ± 2.7 mmHg in OD and 13.2 ± 1.6 mmHg in OS). A higher IOPtp in the hyperopic group seems more plausible because most patients in this group were significantly older than in myopic group. In hyperopic patients, IOPpn level in lenses tended to be higher than without them, while IOPtr was the same in either case. It may be due to the fact that contact lenses for high hyperopia are rather thick, which affects the air impact on the cornea during pneutonometry. In the myopic group the difference between IOPtr (15.2 ± 3.5 mmHg in OD and 16.0 ± 2.7 mmHg in OS) and IOPpn (16.1 ± 2.9 mmHg in OD and 15.9 ± 3.0 mmHg in OS) in lenses and IOPtr (15.7 ± 2.6 mmHg in OD and 15.9 ± 2.9 mmHg in OS) and IOPpn (16.6 ± 3.8 mmHg in OD and 16.1 ± 3.4 mmHg in OS) without them was insignificant.* ***Conclusion.*** *Transpalpebral scleral tonometry using (EASYTON) is an adequate method to measure IOP of patients with contact lenses on and can be the method of choice in a some of clinical cases, since its results and their repeatability are not affected by factors associated with the presence of a contact lens.*

Keywords: transpalpebral scleral tonometry; contact lens; pneumotonometry; refraction anomalies
Conflict of interests: there is no conflict of interests.

Financial disclosure: No author has a financial or property interest in any material or method mentioned.
For citation: Kushnarevich N.Yu., Iomdina E.N., Bessmertny A.M., Kuzin M.N. Estimation of the accuracy and informativeness of measuring intraocular pressure in patients with their contact lenses on by transpalpebral scleral tonometryю Russian ophthalmological journal. 2020; 13 (2): 23–8 (In Russian). https://doi.org/10.21516/2072-0076-2020-13-2-23-28

Contact vision correction is known to be one of the most commonly used types of optical correction. [1, 2].

Contact lenses (CLs) have a number of indisputable advantages over spectacle correction. New technologies allowing the development of more comfortable and optically diversified lenses expand their applicability as they can be used by patients of nearly all ages and those needing more complex corrective lenses [3–5].

In addition, modern CLs are not only used as a correction means aimed at improving visual acuity, but also as an optical "tool1" able to control refractogenesis and, thereby, to inhibit myopia development. Such CLs, bifocal or multifocal, are increasingly prescribed to children and adolescents for constant wearing in order to prevent myopia development [6–9]. There is a growing interest in contact correction of presbyopia, especially by multifocal CLs [10, 11].

Patients using CLs need to be regularly monitored by an ophthalmologist or optometrist. Examination for such patients must include measurement of intraocular pressure (IOP). Tonometry is especially important in adult patients with high-grade refractive errors, since such patients are at risk of primary glaucoma developing [12, 13].

However, many patients are unwilling to remove their contact lenses and then put them on again just for IOP measurement at the eye doctor's office and therefore avoid it, postponing IOP measurement until next time when they plan to come with no lenses on. Often, a revisit is delayed indefinitely, and the patient's IOP level remains beyond medical control.

It seems therefore expedient to introduce into clinical practice modern tonometry methods that allow IOP measurements in patients wearing contact lenses with no loss in measurement accuracy.

However, transpalpebral tonometers operating on the "rebound" principle (which means that the freely falling rod interacts with the eyeball through the eyelid [14, 15]), despite certain advantages [16, 17], are not widely used in the clinic due to insufficient measurement accuracy, especially if IOP is high [15].

At the same time, in recent years, a new type of transpalpebral tonometer has been developed (EASYTON intraocular pressure tonometer, YIME JSC, Russia), based on a different physical principle. The tonometer's operating principle of IOP measurement consists in recording the frequency of forced oscillations of the eyeball under the impact of the tonometer's vibrator [18].

During the measurement, the rod is placed in the sclera area of the eyelid, pressing it with a load of approximately 10 g. Thus, a unified rod-eye biomechanical system is created whose oscillation frequency is determined by the actual intraocular pressure.

The excitation of oscillations is carried out by a short electromagnetic pulse acting on the vibrator's rod. The movement of the rod is transmitted to the eye through the eyelid in the form of a short-term exposure, which excites the forced oscillations of the eye tissues.

The conversion of mechanical vibrations of the eye tissues into an electrical signal is carried out by the tonometer's electromagnetic system structurally connected with the rod.

The oscillation period is measured by the tonometer and is used to calculate IOP displayed on the tonometer's screen.

In a targeted experimental study tonometric IOP was compared with the true gauge pressure inside the eye. It made possible to choose the optimal design parameters of the EASYTON tonometer sensor, ensuring the required accuracy of transpalpebral scleral tonometry [19].

Contraindications to the EASYTON tonometer use are: pathological conditions of the upper eyelid (inflammatory diseases, scars, eyelid deformation), severe scleral pathology in the measurement area.

The tonometer has two IOP measurement modes: tonometric IOP measurement mode (Maklakov scale), true IOP measurement mode (Goldman scale).

Since IOP is measured through the eyelid, contact of the tonometer rod with the cornea, as well as the use of anesthetics are excluded.

The **PURPOSE** of this work was to assess the accuracy and information value of IOP measurement by transpalpebral scleral tonometry using the EASYTON tonometer in patients wearing contact lenses.

MATERIAL AND METHODS

The study included 30 patients (60 eyes) aged from 11 to 63 years old with various refractive errors using soft CLs (conventional or multifocal) to correct eyesight, including;

5 patients (10 eyes) aged from 11 to 63 years old (average age is M ± SD: 45.0 ± 21.0 years old) with hypermetropia +1.75 to +9.0 D (average +4.4 ± 2.6 D); as well as 25 patients (50 eyes) aged from 12 to 57 years old (average 26.4 ± 13.50 years old) with myopia -0.5 to -11.25 D (average — 4.4 ± 2.4 D).

EASYTON intraocular pressure tonometer manufactured by Yelatma Instrument Making Enterprise, JSC was used to conduct transpalpebral tonometry.

The IOP values obtained by transpalpebral tonometry were compared with the IOP values determined by the non-contact method — corneal pneumotonometry using a corneal pneumotonometer made in the USA. As known, the use of corneal pneumotonometry is contraindicated in pathological conditions of the cornea: erosions, ulcers, corneal oedema, after keratoplasty or penetrating eye injury. At the same time, in these conditions, IOP can be determined using transpalpebral scleral tonometry.

The format of the comparative study provided for the aggregation of contraindications to the use of both methods for measuring IOP, therefore, the following exclusion criteria were taken into account when forming the patient sample:

— pathological conditions of the upper eyelid (inflammatory diseases, scars, eyelid deformation);

— severe scleral pathology in the measurement area projection;

— erosion, ulcers, corneal oedema;

— prior keratoplasty;

— prior penetrating eye injury.

Patients enrolled in the study gave a voluntary informed consent for participation in it.

All the patients underwent a standard ophthalmological examination: biomicroscopy, determination of eyesight acuity, autorefractometry, a thorough examination of fundus. The data obtained were entered into the individual record file of the study participant.

IOP was measured in the patient's sitting position, on the right and left eyes, sequentially by the EASYTON transpalpebral tonometer (in the "Goldman scale" measurement mode).

When measuring IOP using the EASYTON tonometer, the tonometer rod was installed on the patient's upper eyelid in the sclera region corresponding to corona ciliaris in the 12-hour meridian.

IOP was first measured without contact lenses, then the patient put on the lenses, and after 20 minutes a second measurement was carried out using each of the two tonometers. Each measurement (both by the EASYTON tonometer and the pneumotonometer, with lenses on and off, on the right and left eyes) was performed three times and the results were logged in the individual record file of the study participant. For further analysis, the average value of three IOP measurements was calculated for each type of measurement.

The statistical processing of the obtained data included the determination of the mean value and standard deviation ($M \pm SD$), as well as Student's criterion. The parameter values were considered different if $p < 0.05$.

RESULTS AND DISCUSSION

The average values of the obtained IOP values of the right (OD) and left (OS) eyes on the whole for the entire group of examined patients are shown in Table 1.

A comparative analysis of the obtained data showed that the IOP values measured in the same study participants for the same eyes, both with and without CLs, did not statistically significantly differ from each other ($p > 0.5$) both by the transpalpebral tonometry and by pneumonometry. However, in this case, the individual IOP values determined using the EASYTON tonometer in patients with CLs were generally closer to the values obtained without lenses than the similar values obtained by pneumonometry.

It is interesting that in a short message on the possibility of using the transpalpebral tonometer operating on the "rebound" principle to measure IOP in young patients in the CLs [20], there was a statistically significant difference between the data obtained with this tonometer from the results of determining IOP using the corneal pneumotonometer.

The data presented proves the possibility and expediency of IOP determination in patients with CLs using the EASYTON transpalpebral tonometer and indicates the accuracy and information content of the measurements.

It is of interest to separately analyze the results of IOP determination in groups of patients with myopic and hyperopic refraction, since the CLs used to correct hyperopia and myopia differ not only in curvature, but also in the central zone thickness, which can affect the results of pneumotonometry conducted for patients in Cls.

According to the data shown in Table 2, the IOP values obtained using the EASYTON, both with and with-

Table 1. Values of IOP (mm Hg) for the right (OD) and the left (OS) eyes, obtained using EASYTON and Reichert 7 AutoTonometer, on the whole for the entire group of examined patients ($M \pm SD$)

IOP measurement conditions	EASYTON		Pneumotonometer	
	OD	OS	OD	OS
Contact lens off	16.3 ± 2.9	16.6 ± 3.2	16.0 ± 3.8	15.6 ± 3.3
Contact lens on	16.0 ± 3.9	16.7 ± 3.1	15.7 ± 2.9	15.5 ± 2.8

Table 2. IOP (mmHg) measurement results obtained in right (OD) and left (OS) eyes of examined patients with hyperopia (10 eyes) using EASYTON and pneumotonometer ($M \pm SD$)

IOP measurement conditions	EASYTON		Pneumotonometer	
	OD	OS	OD	OS
Contact lens off	19.3 ± 2.8	19.6 ± 3.1	13.5 ± 2.7	13,2 ± 1,6
Contact lens on	19.5 ± 3.9	19.7 ± 3.3	14.0 ± 1.8	14,2 ± 1,7

out lenses, turned out to be higher than those measured using pneumotonometry ($p < 0.05$). Since the average age of the examined patients with hypermetropia was statistically significantly higher than in the group as a whole and than of myopic patients, we can assume that the IOP in these patients should be higher on the average (an increase in IOP with advancing age is a well-known fact), which was shown by the transpalpebral scleral tonometry data.

It should be noted that the pneumotonometry results in this group in the lenses were slightly higher (by 0.5–1.0 mmHg) than without lenses, which is apparently due to the effect of CLs, correcting hyperopic refraction (thicker in the center than myopic), on the cornea interaction and air impulse of the pneumotonometer. This indicates slightly higher accuracy of transpalpebral scleral tonometry in patients with hyperopic refraction with CLs in comparison with the pneumotonometry.

In the group of patients with myopia, the difference between the results of transpalpebral scleral tonometry and pneumotonometry carried out both for patients wearing contact lenses and without them was statistically insignificant, which indicates the interchangeability of these measurement methods in this category of patients (Table 3).

The study also monitored the occurrence of adverse effects associated with tonometry. No adverse effects of the EASYTON tonometer and pneumotonomer over the entire study period were detected in any of the participants.

CONCLUSIONS

The results of the comparative study prove the real possibility of accurate determination of IOP in patients with CLs using the EASYTON transpalpebral tonometer and indicate the informativity of the measurements. The absence of any adverse effects during the study confirms the safety of transpalpebral tonometry using the EASYTON tonometer in patients with CLs. The use of transpalpebral scleral tonometry may be preferable in a number of clinical cases, since, unlike corneal pneumotonometry, the factors related to the presence of a CLs (its thickness, corneal fitting, presence of tear fluid, etc.) do not affect the results and repeatability.

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Table 3. IOP (mmHg) measurement results obtained in right (OD) and left (OS) eyes of examined patients with myopia (50 eyes) using EASYTON and pneumotonometer (M ± SD)

IOP measurement conditions	EASYTON		Pneumotonometer	
	OD	OS	OD	OS
Contact lens off	15.7 ± 2.6	15.9 ± 2.9	16.6 ± 3.8	16.1 ± 3.4
Contact lens on	15.2 ± 3.5	16.0 ± 2.7	16.1 ± 2.9	15.9 ± 2.9

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Author's contribution: Nina Yu. Kushnarevich — design of the study, clinical examinations; Elena N. Iomdina — development of research concept and design, data processing, writing the article; Alexandr M. Bessmertny — clinical examinations, analysis of the results; Mikhail N. Kuzin — design of the study, technical support.

Originally received: 01.04.2020. Final revision: 05.04.2020. Accepted: 09.04.2020

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