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The impact of silicone hydrogel contact lenses on the measurement of intraocular pressure using non-contact tonometry

Uticaj silikon hidrogel kontaktnih sočiva na merenje intraokularnog pritiska metodom nekontaktne tonometrije

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Abstract

Background/Aim. Measurement of intraocular pressure (IOP) over therapeutic silicone hydrogel soft contact lenses by a non-contact method of tonometry could be applied in opthalmologic practice but the results obtained are still controversial. The aim of this study was to evaluate the effect of spherically designed silicone hydrogel soft contact lenses and their power on values of IOP measured by using a non-contact tonometry method. **Methods.** We measured IOP with and without spherical silicone hydrogel soft contact lenses on 143 eyes of 80 subjects who did not have any ocular or systemic diseases. **Results.** The Wilcoxon statistical analysis test for ranking average values of IOP measured on 143 eyes over a spherical silicone hydrogel soft contact lenses showed significantly higher values compared to those measured with no contact lenses (15.81 ± 3.46 mm Hg *vs* 14.54 ± 3.19 mm Hg; respectively; Z = -5.224, $p = 0.001$). Refractive power analysis of the contact lenses of -9.00D to +6.00 D showed a significant difference of IOP in the range from 0.00D to -6.00D. **Conclusion.** Non-contact tonometry is not an accurate method of IOP measuring over spherical silicone hydrogel soft contact lenses which belong to therapeutic contact lenses.

Keywords:
intraocular pressure; tonometry, ocular; diagnostic errors; contact lenses, hydrophylic.

Apstrakt

Uvod/Cilj. Mada se u oftalmološkoj praksi može primetiti metod merenja intraokularnog pritiska preko terapijskih mekih kontaktnih sočiva od silicon hidrogel materijala, dobijeni rezultati još uvek su kontroverzni. Cilj rada bio je ispitivanje uticaja mekih kontaktnih sočiva od silikon hidrogel materijala sfernog dizajna i njihove refraktivne jačine na izmerene vrednosti intraokularnog pritiska metodom nekontaktne tonometrije. **Metode.** Intraokularni pritisak je meren bez i sa silikon hidrogel kontaktnim sočivima sfernog dizajna na 143 oka kod 80 osoba koje nisu imale očne ili sistemske bolesti. **Rezultati.** Analiza srednjih vrednosti intraokularnog pritiska Vilkoksonovim testom rangova pokazala je statistički značajno više vrednosti preko silikon hidrogel mekih kontaktnih sočiva sfernog dizajna nego bez kontaktnih sočiva (15,81 ± 3,46 mmHg *vs* 14,54 ± 3,19 mmHg; Z = -5,224, $p = 0,001$). Analiza refraktivne jačine kontaktnih sočiva od -9,00D do +6,00D pokazala je značajnu razliku intraokularnog pritiska u rangu od 0,00D do -6,00D. **Zaključak.** Nekontaktna tonometrija nije statitički pouzdana metoda merenja intraokularnog pritiska preko silikon hidrogel kontaktnih sočiva sfernog dizajna, kojima pripada i terapijsko kontaktno sočivo.

Ključne reči:
intraokularni pritisak; tonometrija, očna; dijagnostičke greške; kontaktna sočiva, hidrofilna.

Introduction

Measurement of intraocular pressure (IOP) over therapeutic silicone hydrogel soft contact lenses using a non-contact method of tonometry could be applied in ophthalmologic practice, particularly in patients with corneal decompensation and subsequent bullous keratopathy, post-surgical sutures or exposed suture knots other important conditions

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with corneal pain, and for facilitating healing [1]. The detecting of increased IOP and applying adequate treatment may help reduce the incidence and prevalence of glaucoma in these patients. The therapeutic silicone hydrogel contact lenses also may aid in sealing leaky wounds after cataract, penetrating keratoplasty or glaucoma filtering surgery [2–4].

Sugimoto-Takeuchi et al. [5] suggest the possibility of precise measurements of IOP over therapeutic soft contact lenses using a non-contact tonometry method. There are also studies that suggest the negligible effect of therapeutic soft contact lenses and soft contact lenses of low power on the value of IOP measured through them [6–11]. These studies suggest that changes of measured IOP depend on the refractive power and central thickness of soft contact lenses, although the results are still controversial.

The aim of this study was to analyze the effect of spherical silicone hydrogel soft contact lens and their refractive power (myopic and hyperopic) on IOP measured with a non-contact tonometer.

Methods

Subjects

This study included 143 eyes of 80 subjects (male and female), aged 25.41 ± 7.11 (15–47) years, tested in contact lens practice in 2013 and 2014. The subjects had no ocular and systemic disease, no corneal astigmatism greater than 1.50 D cylinder or no contraindication to wearing soft contact lenses. Exclusion criteria were: corneal pathology before and after surgery. Patients with glaucoma were excluded. We measured IOP of each subject using non-contact tonometry with and without soft contact lenses. All subjects were evaluated by slit lamp examination and corneal topography. Informed consent was obtained from each subject after explanation of the procedure. The study was conducted by the ethical standards of the Declaration of Helsinki.

Materials

The group involving 143 eyes were fitted with monthly replacement silicone hydrogel soft contact lenses (Ciba Vision, Bausch + Lomb, CooperVision) with the same modalities of wearing.

All tonometry measurements were carried out with a non-contact tonometer (Topcon CT – 80A Computerized Tonometer Topcon, Tokyo, Japan).

We used a corneal topography and a biomicroscopy for anterior segment evaluation (CA100 Topcon, Sl8 Z Topcon, Tokyo, Japan).

Procedures

All IOP measurements were performed on contact lenses in the 143 eyes using non – contact tonometry before the inserting of spherical silicone hydrogel soft and seven days after the wearing them.

In order to prevent the possible effect of multiple consecutive measurements of IOP in a non-contact tonometer, IOP was measured three times at 2-min intervals and the mean values were calculated for each recorded IOP [12].

Five different ranks of refractive power were used: rank 1 [from 0.00 diopters (D) to-3.00D, n = 83], rank 2 [from -3.25D to -6.00, n = 48], rank 3 [from -6.25D to -9.00D, n = 3], rank 4 [from +0.25D to+3.00D, n = 3] and rank 5 [from +3.25D to +6.00D, n = 6].

Statistics

Statistical analysis was based on SPSS 20.0. In the descriptive statistics, measures of central tendencies were used. A test of normality was performed with the Shapiro-Wilk test. For comparative statistical procedures ring, we used non-parametric tests: the Spearman's rank correlation test and the Wilcoxon Signed Rank test. For comparing the effect size, we used Cohen`s (1988) criterion.

The Shapiro-Wilk test did not confirm normal distribution for all analyzed variables and because of that nonparametric tests in the study were used.

Results

The mean value of the measured IOP in 143 eyes of 80 subjects before inserting spherical silicone hydrogel soft contact lenses was 14.54 ± 3.19 mm Hg (min = 7 mmHg, max = 23 mmHg). The measured mean IOP with the spherical silicone hydrogel soft contact lenses was 15.81 ± 3.46 mmHg (min = 8 mmHg, max = 24 mmHg) (Table 1). The non-parametric Wilcoxon Signed Rank test was used to compare IOP values between these groups, and it was found that there was a highly significant difference (p=0.001). The size effect between variables compared using Cohen's (1988) criterion was r = 0.2.

The Spearman's rank correlation test of non-parametric statistics was used for repeated measurements and for comparing IOP values at five different powers. To compare groups, they were divided into five ranks and in each rank the IOP with and without spherical silicone hydrogel soft contact lenses was measured. In the first rank from 0.00D to -3.00D (n = 83) there was a statistically significant difference (p = 0.001). The average IOP was significantly greater in this rank after the wearing of spherical silicone hydrogel soft contact lenses. The average IOP measured in the second rank

Table 1

Descriptive statistics of intraocular pressure (IOP) measurements on 143 eyes with and without soft contact lenses

IOP without contact lenses (mmHg)		IOP with contact lenses (mmHg)		*p*-values
mean ± SD	min−max	mean ± SD	min−max	
14.54 ± 3.19	7−23	15.81 ± 3.46	8−24	0.001

SD − standard deviation.

of -3.25D to -6.00D (n = 48) was significantly higher after wearing the spherical silicone hydrogel soft contact lenses than before wearing them, $p = 0.001$ (Table 2). The size effect between variables which was compared using Cohen's (1988) criterion was $r = 0.67$ (a big effect).

Statistical analysis of the third rank of -6.25D to -9.00D (n = 3), the fourth rank of +0.25D to +3.00D (n = 3), and the fifth rank of +3.25D to +6.00D (n = 6) showed no statistically significant differences in IOP measurements with and without the spherical silicone hydrogel soft contact lenses (Table 2). The number of subjects in these ranks was insufficient for performing the reliable statistical evaluation.

Change in measured IOP (ΔIOP) as a function of lens power (x) of silicone hydrogel contact lenses had the following characteristics: in 1st rank ΔIOP was + 1.16 mmHg, in 2nd rank ΔIOP was +1.31 mmHg, in 3rd rank ΔIOP is + 2.00 mmHg, in 4th rank ΔIOP was +1.00 mmHg, and in 5th rank ΔIOP was +2.34 mmHg (Table 3). Relationships between ΔIOP and lens power revealed the algorithm by which we can predict the real IOP.

We found that a silicone hydrogel contact lens significantly influences IOP measurements using non-contact tonometry ($p = 0.001$). Analysis of the impact of the refractive power ranking of silicone hydrogel soft contact lenses on IOP values, measured with a non-contact tonometer showed significantly higher IOP values for lens power 0.00D ≤ -6.00D in comparison to IOP values measured before inserting lenses.

Firat et al. [13] conclude that silicone hydrogel soft contact lens use does not significantly affect IOP values measured with a non-contact tonometer, but it affects IOP values measured with Pascal dynamic contour tonometry in 0.00D power. In our study, we did not measure IOP over silicone contact lenses with 0.00D power. However, we found that silicone hydrogel contact lenses in ranks 4 and 5 from +0.25D to +6.00D did not significantly influence the IOP measurements using non-contact tonometry, while in ranks 1 and 2 from 0.25D to -6.00D they influenced statistically the values of IOP. We did not test the 0.00D power of the contact lens because we included healthy patients, with only refractive error and without any ocular disease. Recent studies have shown that IOP measurements over hydrogel soft contact lenses with non-contact tonometry depend

Table 2

Comparison of the impact of intraocular pressure (IOP) within the same rank, without and with contact lense

Ranks	D level from	D level to	Z	*p*-values
1	0.00	-3.00	2.743	0.001
2	-3.25	-6.00	4.833	0.001
3	-6.25	-9.00	0.546	0.585
4	+0.25	+3.00	1.129	0.259
5	+3.25	+6.00	0.060	0.952

D − diopters.

Table 3

Change in measured intraocular pressure (IOP), (ΔIOP) as a function of lens power (x) of silicone hydrogel contact lenses (Si Hy CL)

Range (D)	n	Mean IOP without Si Hy CL	Mean IOP with Si Hy CL	**ΔIOP**	*p*-values
1 0.00 to -3.00	86	14.57	15.73	+1.16	0.001
2 -3.25 to -6.00	48	14.66	15.91	+1.31	0.001
3 -6.25 to -9.00	3	15.00	17.00	+2.00	0.585
4 +0.25 to +3.00	3	11.66	12.66	+1.00	0.259
5 +3.25 to +6.00	6	14.66	17.00	+2.34	0.952

D – diopters.

Discussion

Silicone hydrogel contact lenses due to their high oxygen permeability materials are now much more used than conventional hydrogel contact lenses. We tested the effect of silicone hydrogel contact lenses on the value of IOP by non-contact tonometry for glaucoma screening and its potential applicability in contact lens practice.

on the lens power [10, 11, 14, 15]. Liu et al. [11] compared the IOP using non-contact tonometry taken without a contact lens and with different myopic contact lens power from -3.00D to -12.00D. They found a statistically significant difference in IOP values in lens power from -6.00D and below.

The different results found in the present studies may be attributed to different study designs. In our study, we obtained IOP measurements after the insertion of the silicone hydrogel contact lenses which are different to the hydrogel soft contact lenses. Silicone hydrogel material has low water content, lower modulus of elasticity and a relatively high modulus of rigidity and it differs from hydrogel material which has high water content and relatively low modulus of rigidity. We measured IOP seven days after contact lenses had been worn according to the daily regimen of wear, while in other studies the IOP was measured 30 min after insertion of soft contact lenses [13]. In other studies, IOP was measured at baseline, immediately after contact lens removal or displacement, and 5 minutes thereafter [16, 17].

Zeri et al. [15] consider the possibility that the tonometry result can be influenced by central corneal resistance. Corneal resistance is influenced by corneal thickness, corneal curvature, and corneal biomechanical factors. IOP value will be overestimated in eyes with thick corneas, a steep corneal curvature, and high corneal hysteresis. When a soft contact lens is fitted, the "new" body composed of cornea and contact lens has a greater central thickness than the cornea alone, a possible different external surface curvature depending on the contact lenses power and, presumably, different biomechanical characteristics, depending on the lens material mechanical property as in Young's modulus [15].

Conclusion

According to the results of our study, the spherical silicone hydrogel contact lenses of power from 0.00D to -6.00D significantly affect intraocular pressure values measured using non-contact tonometry. For intraocular pressure measurement over the silicone contact lenses with power from 0.00D to – 6.00D non-contact tonometry is not a reliable method. We can advise accurate measurement of IOP over silicone hydrogel contact lenses in contact lens practice, eventually making a tentative assessment of IOP adding ΔP to given rank.

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Conflict of interest

The authors declare no conflict of interest.

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