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

Snežana Pešić*, Svetlana Jovanović†, Miloš Mitrašević‡, Biljana Vuletić§, Milena Jovanović║, Zorica Jovanović*

University of Kragujevac, *Faculty of Medical Sciences, Kragujevac, Serbia; Clinical Center “Kragujevac”, †Department of Ophthalmology, ‡Department for Hospital Organization, Planning, Evaluation and Hospital Healthcare Information Technology, §Department of Pediatrics, Kragujevac, Serbia

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 ophthalmologic 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 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.

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.

Apstrakt

Uvod/Gilj. Mada se u oftalmološkoj praksi može primetiti metod merenja intraokularnog pritiska preko terapijskih mekih kontaktnih sočiva od silicon hidrogel materijala, dobijeni rezultati još uvak su kontroverzni. Cilj rada je ispitivanje uticaja mekih kontaktnih sočiva od silicon hidrogel materijala sfenog dizajna i njihove refraktnije jačine na izmerene vrednosti intraokularnog pritiska metodom nekontaktne tonometrije. Metode. Intraokularni pritisak je meren bez i sa silicon hidrogel kontaktnim sočivima sfenog dizajna na 143 oka kod 80 osoba koje nisu imale očne ili sistemskе bolesti. Rezultati. Analiza srednjih vrednosti intraokularnog pritiska Vilkoxonovim testom rangova pokazala je statistički značajno više vrednosti preko silicon hidrogel mekih kontaktnih sočiva sfenog 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 range od 0,00D do -6,00D. Zaključak. Nekontaktna tonometrija nije statistički pouzdana metoda merenja intraokularnog pritiska preko silicon hidrogel kontaktnih sočiva sfenog dizajna, kojima pripada i terapijsko kontaktno sočivo.

Kljучне реци: intraokularni pritisak; tonometrija, oјна; dijagnostичке greške; kontaktna sočiva, hidrofilna.

Correspondence to: Svetlana Jovanović, Clinical Center "Kragujevac", Clinic of Ophthalmology, Zmaj Jovina 30, 34 000 Kragujevac, Serbia. E-mail: drsvetlanajovanovic@yahoo.com
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 pa-
tients. 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. 3 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 sug-
gest 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 spher-
ical 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 con-
tact 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 eva-
luated by slit lamp examination and corneal topography. In-
fomed 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 re-
placement 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).

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

<table>
<thead>
<tr>
<th></th>
<th>IOP without contact lenses (mmHg)</th>
<th>IOP with contact lenses (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean ± SD</td>
<td>14.54 ± 3.19</td>
<td>15.81 ± 3.46</td>
</tr>
<tr>
<td>min-max</td>
<td>7–23</td>
<td>8–24</td>
</tr>
</tbody>
</table>

SD – standard deviation.

We used a corneal topography and a biomicroscopy for an-
terior segment evaluation (CA100 Topcon, S18 Z. Topcon,
Tokyo, Japan).

**Procedures**

All IOP measurements were performed on contact len-
ses 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 con-
secutive measurements of IOP in a non-contact tonometer,
IOP was measured three times at 2-min intervals and the me-
an 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 de-
scriptive 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 distribu-
tion for all analyzed variables and because of that nonpara-
metric tests in the study were used.

**Results**

The mean value of the measured IOP in 143 eyes of 80 su-
bjects 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 variab-
les 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 com-
paring 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

(14.54 ± 3.19, n = 83) there was a statistically significant difference

(15.81 ± 3.46, n = 48). 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

We used a corneal topography and a biomicroscopy for an-
terior segment evaluation (CA100 Topcon, S18 Z. Topcon,
Tokyo, Japan).
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 (\( \Delta \text{IOP} \)) as a function of lens power (x) of silicone hydrogel contact lenses had the following characteristics: in 1st rank \( \Delta \text{IOP} \) was + 1.16 mmHg, in 2nd rank \( \Delta \text{IOP} \) was +1.31 mmHg, in 3rd rank \( \Delta \text{IOP} \) is + 2.00 mmHg, in 4th rank \( \Delta \text{IOP} \) was +1.00 mmHg, and in 5th rank \( \Delta \text{IOP} \) was +2.34 mmHg (Table 3). Relationships between \( \Delta \text{IOP} \) 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 \( \leq \) -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 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

<table>
<thead>
<tr>
<th>Ranks</th>
<th>D level from</th>
<th>D level to</th>
<th>Z</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>-3.00</td>
<td>2.743</td>
<td>0.001</td>
</tr>
<tr>
<td>2</td>
<td>-3.25</td>
<td>-6.00</td>
<td>4.833</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>-6.25</td>
<td>-9.00</td>
<td>0.546</td>
<td>0.585</td>
</tr>
<tr>
<td>4</td>
<td>+0.25</td>
<td>+3.00</td>
<td>1.129</td>
<td>0.259</td>
</tr>
<tr>
<td>5</td>
<td>+3.25</td>
<td>+6.00</td>
<td>0.060</td>
<td>0.952</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Rank (D)</th>
<th>n</th>
<th>Mean IOP without Si Hy CL</th>
<th>Mean IOP with Si Hy CL</th>
<th>( \Delta \text{IOP} )</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>86</td>
<td>14.57</td>
<td>15.73</td>
<td>+1.16</td>
<td>0.001</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>14.66</td>
<td>15.91</td>
<td>+1.31</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>15.00</td>
<td>17.00</td>
<td>+2.00</td>
<td>0.585</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>11.66</td>
<td>12.66</td>
<td>+1.00</td>
<td>0.259</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>14.66</td>
<td>17.00</td>
<td>+2.34</td>
<td>0.952</td>
</tr>
</tbody>
</table>

Table 3

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.
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. In other studies, IOP was measured at baseline, immediately after contact lens removal or displacement, and 5 minutes thereafter.

Zeri et al. 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.

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 $\Delta P$ to given rank.

Acknowledgement

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Conflict of interest

The authors declare no conflict of interest.

REFERENCES


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