

Original Article

Corneal Biomechanical Changes Following Toric Soft Contact Lens Wear

Somayah Radaie-Moghadam¹, MS; Hassan Hashemi², MD; Ebrahim Jafarzadehpur¹, PhD
Abbas Ali Yekta³, PhD; Mehdi Khabazkhoob⁴, PhD

¹Noor Research Center for Ophthalmic Epidemiology, Noor Eye Hospital, Tehran, Iran

²Noor Ophthalmology Research Center, Noor Eye Hospital, Tehran, Iran

³Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran

⁴Department of Medical Surgical Nursing, School of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract

Purpose: To determine the effect of using toric soft contact lenses on corneal biomechanical properties.

Methods: We enrolled 33 healthy patients with mean age of 23.18 ± 4.06 and minimal cylinder power of 1 D (-1.98 ± 0.808 SD) and negative history of contact lens use; keratoconic patients were excluded from the study. Toric soft contact lenses (BIOFINITY, Comfilcon A, Coopervision, Southampton, UK) were fitted in all participants. The Ocular Response Analyzer (Reichert Ophthalmic Instruments, Depew, New York, USA) was used to measure corneal hysteresis (CH), corneal resistance factor (CRF), and the Pentacam HR (Oculus, Inc., Lynnwood, WA, USA) was used to measure central corneal thickness (CCT) and mean keratometry (K mean) before and one week, one month, and three months after using the toric soft contact lenses.

Results: CH and CRF were decreased significantly one month after using the contact lens; mean CH decreased from 9.99 ± 1.44 to 9.59 ± 1.54 mmHg, and mean CRF decreased from 9.96 ± 1.71 to 9.63 ± 1.73 mmHg ($P = 0.013$ and $P = 0.017$, respectively). Mean CCT and K mean did not show a significant change during the period of toric soft contact lens use.

Conclusion: CH and CRF decreased significantly one month after fitting toric soft contact lenses while CCT and K_{mean} did not change significantly. Corneal biomechanical parameters may alter with toric soft contact lens use and such changes may have implications with long-term use such lenses.

Keywords: Corneal Hysteresis; Corneal Resistance Factor; Toric Soft Contact Lens

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INTRODUCTION

The human cornea is anisotropic and shows different physical characteristics under pressure applied in

different directions. Studies have shown that contact lens fit results in changes in corneal shape and thickness.^[1] Numerous investigations have reported central corneal edema following short-term use of soft contact lenses both with open^[2] or closed eyes.^[2,3] Moreover, there are reports of anterior corneal topographic changes with polymethylmethacrylate (PMMA),^[4] rigid gas permeable,^[5,6] soft hydrogel,^[7] and silicone hydrogel^[8] contact lenses. These lenses can steepen or flatten the central cornea, causing changes in regular or irregular

Correspondence to:

Ebrahim Jafarzadehpur, PhD. Noor Research Center for Ophthalmic Epidemiology, Noor Eye Hospital, No. 96, Esfandiar Blvd., Valiasr Street, Tehran 19686, Iran.
E-mail: jafarzadehpour.e@iums.ac.ir

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astigmatism, reduce radial symmetry,^[9] and alter higher-order aberrations.^[10]

Tyagi et al^[11] reported changes in corneal thickness and topography after fitting 2 types of soft (hydrogel and silicone hydrogel) and 2 types of toric soft (hydrogel and silicone hydrogel) contact lenses. In addition to the above-mentioned corneal changes which are mostly physical, few studies have investigated corneal biomechanical changes following the daily use of toric soft contact lenses. Two previous studies reported alterations in CH and CRF after 2 to 3 hours of wearing soft bandage contact lenses.^[11,12]

Based on these studies, it may be assumed that long-term use of soft contact lenses may cause alterations in corneal biomechanical properties. We are unaware of any published study on the long-term results of using these lenses. The present study aimed to evaluate the effect of toric soft contact lens wear on corneal biomechanical properties over a three-month period.

METHODS

This study enrolled a consecutive series of patients with refractive errors visited at a private hospital and scheduled to use toric soft contact lenses for the first time. The study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran and was conducted in accordance with the tenets of the Declaration of Helsinki. All participants provided written informed consent. Inclusion criteria consisted of age between 18 to 30 years and best corrected vision of 20/20. Exclusion criteria were history of using any type of contact lenses, history of systemic or ocular disease or surgery, use of systemic or topical ocular medications, dry eye, topographic or clinical keratoconus, and irregular astigmatism.

Examinations were performed by an ophthalmologist prior to the use of the toric soft lens (BIOFINITY, Comfilcon A, Coopervision, Southampton, UK) and included a complete examination of the anterior and posterior segments, fundus examination, and measurement of intraocular pressure. Then the patient was referred to the contact lens clinic, and the following examinations were conducted in the following order: Manifest refraction was performed using an auto-refractometer (RM8800, Topcon Corporation, Tokyo, Japan) followed by subjective refraction which was refined using a cross cylinder and the red-green technique. Best-spectacle corrected visual acuity (BSCVA) was measured using a projector chart.

The Ocular Response Analyzer (ORA) (Reichert Ophthalmic Instruments, Depew, New York, USA) was used to measure corneal biomechanical indices including corneal hysteresis (CH) and corneal resistance factor (CRF). Four measurements were performed in each eye, and mean values for CH and CRF with standard deviation of ≤ 0.8 were considered as acceptable. All

ORA measurements were performed by an expert optometrist.

Central corneal thickness (CCT) was measured by Pentacam HR (Oculus, Inc., Lynnwood, WA, USA) as other conventional methods such as ultrasonic pachymetry is contact method that may cause some changes for cornea. Keratometry was measured both with Javal keratometer and Pentacam HR finding. As the all the patients' astigmatism was regular corneal curvature showed high agreement with two methods of conventional keratometry and Pentacam findings.

All participants were instructed not to wear the toric soft contact lenses on the day of follow-up examinations which were performed one week, one month, and three months after fitting the toric soft contact lens. Measurements (tear evaluation, CCT, K_{mean} , CH, and CRF) were taken at 12 MD to reduce variations due to short-term effects of the contact lens. Main outcomes measured were alterations in CH, CRF, central corneal thickness, and K_{mean} after toric soft contact lens wear.

Data were presented as mean and standard deviation. The Shapiro-Wilk test was employed to test normal distribution of the data, and the Mauchly test was used to evaluate sphericity of the data. We used repeated measures analysis of variance to compare CH, CRF, CCT, and K_{mean} measured at different time points for both conditions of sphericity and non-sphericity of the data. Pair-wise comparison was performed with the Bonferroni method. Spearman and Pearson correlation coefficients were used to evaluate correlations between the variables. *P* values less than 0.05 were regarded as significant.

RESULTS

A total of 66 eyes of 33 patients with mean age of 23.18 ± 4.06 (range, 18-30) years including 66.7% female subjects were enrolled. The Kolmogorov-Smirnov test showed normal distribution of data in all cases. Mean (\pm SD) sphere, cylinder and duration of toric soft contact lens use were -1.96 ± 2.01 D, -1.98 ± 0.81 D, and 7.94 ± 2.40 hours, respectively.

Figure 1 presents mean and standard deviation of CH measured before and after fitting the toric soft contact lens. There was a significant difference among CH values measured at different time points, based on repeated measure ANOVA ($P < 0.05$). Pairwise comparisons showed that CH at week 1 was significantly different from that measured at month 1; other pairwise comparisons of CH, i.e., between baseline and month 1 ($p = 0.99$), between baseline and month 3 ($P > 0.99$), between week 1 and month 3 ($P = 0.943$) and between month 1 months 3 ($P = 0.422$), showed no significant difference.

In a similar fashion and following the same trend, alterations in CRF during the study period were statistically significant ($P < 0.01$). Pairwise comparisons

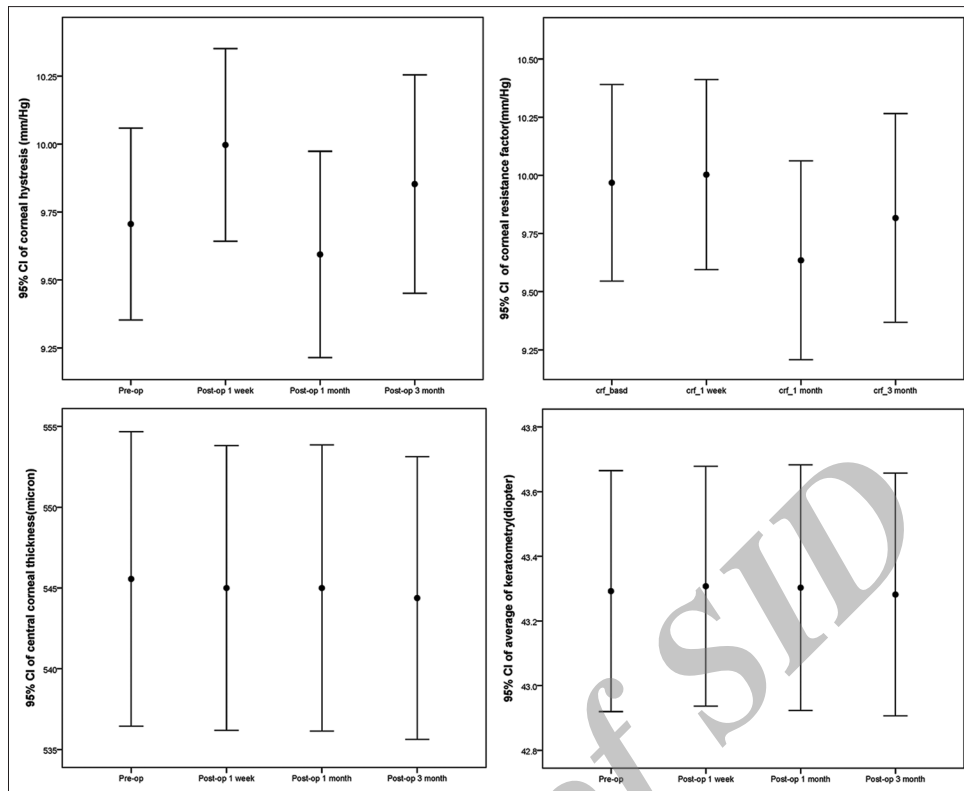


Figure 1. Mean and 95% confidence intervals for corneal hysteresis, corneal resistance factor, central corneal thickness, and mean keratometry indices at different time points.

showed that only differences between baseline and month 1 values ($P = 0.017$) and between week 1 and month 1 values ($P = 0.007$) were significant, while other comparisons were not ($P = 0.1$ for comparison between baseline and week-1 values, $P = 0.91$ for comparison between baseline and month-3 values, $P = 0.379$ for comparison between week-1 and month-3 values, and $P = 0.58$ for comparison between month-1 and month-3 values). Changes in CCT and K_{mean} at different time intervals were not significant ($P = 0.816$ and 0.636 , respectively) [Figure 1].

A significant negative correlation was observed between CH and CRF measured one month after fitting the toric soft contact lens and the duration of lens wear ($r = -0.282$, $P = 0.017$ and $r = -0.324$, $P = 0.006$, respectively). Moreover, a significant negative correlation was observed between CRF measured one month after fitting the lens and astigmatism ($r = -0.329$, $P = 0.005$).

Table 1 was shown the Correlation coefficient between CH and CCT at different time intervals.

DISCUSSION

Toric soft contact lenses are very popular these days,^[13] making it important to evaluate associated changes in corneal biomechanics. Based on our findings, mean CH decreased by 0.4 mmHg one month after fitting the toric soft contact lens as compared to week-1 values. No

significant difference was observed between other time intervals. CH changes showed a considerable correlation with K_{mean} and CCT at all time intervals, but no significant correlation was observed one month after fitting the lens. Therefore, CH is probably independent of mean corneal curvature, and CCT and is probably correlated with factors other than K_{mean} and CCT.

Soft contact lenses usually cause stromal corneal edema which increases spacing between collagen fibrils and affects the biomechanical properties.^[14] This corneal edema and biomechanical changes are observed immediately after removing the lens. In our study, however, CH was evaluated 15 hours after discontinuing the toric soft contact lens, at the time which corneal edema is decreased but not completely resolved; this usually takes 15 days after removing the soft contact lens, according to a report by Nourouzi et al^[15] Therefore, it seems that the corneas were edematous to some extent which could explain the decreased corneal hysteresis. The changes in this metric observed one month after fitting the toric soft contact lens showed a significant inverse correlation with more prolonged use of the lens. These findings support a report by Lau^[12] who observed that mean CH decreased by 0.6 mmHg immediately after using soft contact lenses for 2 hours, but no significant difference was observed after 60 minutes of removing the lens. In contrast, Lu et al^[11] showed that CH did not change significantly 3 hours after fitting soft contact

Table 1. Correlation coefficient between corneal hysteresis and corneal resistance factor at different time intervals

	CCT before fitting the lens	CCT one week after fitting the lens	CCT one month after fitting the lens	CCT three months after fitting the lens
CH before fitting the lens				
<i>r</i>	0.31	0.378	0.325	0.432
<i>P</i>	<0.001	<0.001	0.005	<0.001
CH one week after fitting the lens				
<i>r</i>	0.415	0.404	0.402	0.458
<i>P</i>	<0.001	<0.001	<0.001	<0.001
CH three months after fitting the lens				
<i>r</i>	0.344	0.346	0.335	0.401
<i>P</i>	0.005	0.004	0.006	<0.001

CH, corneal hysteresis; CRF, corneal resistance factor

lenses and during corneal swelling (10% increase in CCT). This discrepancy between our study and the study by Lu et al^[11] may be explained by the longer follow-up period in our investigation.

In our study, mean CCT was $545.56 \pm 37.06 \mu\text{m}$ before fitting the toric soft contact lens, and no significant difference was observed after three months of contact lens use. Our findings are not consistent with the results of Lu et al^[11] and Lau.^[12] They reported that CCT increased 2 and 3 hours after using soft contact lenses with closed eyes. Furthermore, many studies have reported an increase in CCT following the short-term use of soft and toric soft contact lenses with open eyes.^[1] In general, soft contact lenses cause corneal hypoxia and edema due to minimizing tear pumping. As a result, increased CCT following the use of soft contact lenses is considerable. In the present study, CCT was measured after the short-term effects of the lens had resolved, which can explain why we observed no changes in this measurement after contact lens wear.

In our study, mean corneal curvature was $43.29 \pm 1.51 \text{ D}$ before fitting the toric soft contact lens and did not change significantly after three months of using the lens. Corneal curvature was measured after the short-term and transient effects of the toric soft contact lenses on corneal hydration had resolved, and because of a decreased in stromal edema, it was restored to its baseline values. This finding is supported by Lau^[12] who also reported the mean central corneal radius did not change significantly after use of soft contact lenses with closed eyes. On the other hand, the lack of changes in corneal curvature could be attributed to low sample size in our study.

According to a study by Tyagi et al,^[1] there is subtle flattening in the anterior corneal surface and steepening in the posterior corneal surface 8 hours after using toric soft and soft contact lenses. They concluded that posterior curvature was more affected by the soft contact

lens, which they attributed to differences in structure and composition of the stroma.

In summary, our study showed that CH and CRF decreased one month after fitting the toric soft contact lens but returned to baseline values after three months. Mean CCT and corneal curvature did not change significantly during the study period. It seems that the cornea first responds to the stress of the lens and then copes with it.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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