Contact Lens & Anterior Eye 38 (2015) 28–33

Contents lists available at ScienceDirect

Contact Lens & Anterior Eye

journal homepage: www.elsevier.com/locate/clae

Assessment of corneal morphological changes induced by the use of daily disposable contact lenses

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ARTICLE INFO

Article history:
Received 28 January 2014
Received in revised form 5 August 2014
Accepted 28 August 2014

Keywords:
Corneal thickness
Corneal curvature
Daily disposable contact lenses

ABSTRACT

Purpose: To assess the effect of different disposable soft contact lenses upon corneal thickness, and upon anterior and posterior corneal curvatures using a dual-Scheimpflug imaging based device.
Methods: Twenty-eight young, healthy subjects wore four different types of daily disposable soft contact lenses on four different days: Dailies Total1, Proclear 1 Day, Clariti 1-Day and 1-Day Acuvue Moist. The lenses had different material and water content. Pachymetry maps and keratometry values were obtained using the Galilei G4 twice a day: one before putting the lens on and one after an eight-hour period of contact-lens wear. Measurements were also recorded without any contact lenses being worn during a day.
Results: Clariti 1-Day lens caused the greatest thickening in the central ($8.9 \pm 2.8\,\mu m$; $p < 0.01$) and in the peripheral cornea ($10.1 \pm 4.6\,\mu m$; $p < 0.01$), whereas Dailies Total1 was the lens that had the most similar behaviour to the non-contact lens scenario. All the lenses caused a slight flattening in the anterior corneal curvature, except Clariti 1-Day, which induced a very slight steepening. The four lenses caused a steepening of different magnitude in the posterior corneal curvature.
Conclusions: The magnitude of the changes introduced by the use of soft contact lenses over the eight-hour wearing period was rather small. Thus it is probable it will not influence the vision nor the comfort of the subject. Also, variations on corneal parameters seem to depend on the type of contact lens used.

1. Introduction

Disposable soft contact lenses are very popular nowadays for people who have refractive errors, such as myopia, hyperopia, astigmatism or presbyopia. There are also contact lenses for aesthetic purposes. It seems logical that disposable soft contact lenses could modify the morphology of the anatomical surface where they are fit: the cornea. There are a lot of studies documenting the changes undergone by the cornea which are induced by the use of contact lenses, both rigid gas permeable [1,2] and soft [3–5] ones. These changes in corneal shape or morphology were evaluated using different techniques.

It is also well known that the cornea undergoes through some changes during the day. These changes are natural and happen as a result of the own metabolism of the cornea and the tear layer. The natural modifications experienced by the cornea are generally small in magnitude, but it is important to have them in consideration for clinical – e.g. refractive surgery – and research purposes. The natural diurnal changes suffered by the cornea in its thickness [6,7] and curvatures [8,9] are well studied. In order to comprehend better the changes in corneal shape caused by the wearing of contact lenses, diurnal changes that cornea goes through need to be known. This way, the real modifications that contact lenses introduce in the cornea can be studied.

Currently, there are several techniques which allow us to measure the corneal changes previously mentioned. The Galilei G4 (Ziemer, Switzerland) is a non-invasive optical diagnostic system designed for the analysis of the anterior segment of the eye, based on a rotating Dual-Scheimpflug and a Placido tomography system. This device allows the evaluation of the diurnal natural changes undergone by the corneal shape (thickness and curvatures) and also the changes caused by the use of soft contact lenses in a fast and easy way.

Disposable soft contact lenses are in constant evolution and there are a wide variety of materials, water content, designs, etc. It is expected that this range of different parameters causes a variety

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http://dx.doi.org/10.1016/j.clae.2014.08.004
1367-0484/

of results in the change of the curvatures and thickness of the cornea. Wearing time and frequency in the use of soft contact lenses may also affect the modifications of these corneal parameters. To the best author's knowledge, no previous study has been carried out evaluating these changes in corneal shape, using the Galilei G4.

The purpose of this study was to evaluate changes that may occur in corneal shape (i.e. curvatures and thickness) as a result of wearing four different types of disposable soft contact lenses during an eight hours period of time. In order to achieve this, a non-invasive technique was performed, using the Galilei G4. This method allows us to determine whether or not corneal parameters suffer modifications over time due to the wearing of each soft contact lens that took part in this study.

2. Methods

2.1. Subjects

Twenty-eight left eyes [7] from twenty-eight individuals, 11 male and 17 female, aged from 21 to 36 years (mean: 25.7 ± 5.1 years). Spherical refractive errors ranged between −3.50 and −2.75 diopters (D), being the mean spherical refractive error −3.12 ± 0.24 D. All of the subjects had best-corrected visual acuity of 6/6 or better. None of the subjects were a regular user of contact lenses and they were not using any ocular or systemic medication. They presented clear intraocular media and no known ocular pathology. All patients were informed about the details of this study, and a written informed consent was obtained after verbal and written explanation of the nature and possible consequences of the study, in accordance with the Helsinki Declaration. Institutional Review Board approval was required for this study. Subjects having ocular or systemic disease, ocular surgery history, intraocular pressure higher than 21 mmHg, presence of retinal or optic disc pathology were excluded from this study. A series of preliminary tests were conducted to ensure that all subjects had normal anterior segment, and central corneal thickness.

2.2. Contact lenses

Four different types of daily disposable contact lenses, each one from a different commercial brand, were evaluated: Dailies Total1 (Alcon, www.alcon.com), Proclear 1 Day (CooperVision, www.cooopervision.com), 1-Day Acuvue Moist (Johnson & Johnson Vision Care, www.jnjvision.com) and Clariti 1-Day (Sauflon, www.sauflon.com). The main technical specifications of the lenses under evaluation are summarized in Table 1. All the contact lenses used on every subject's eye were fitted in an optimal or acceptable way and all of them had a power of −3 D. The lens power and total diameter were checked by one of the authors and found to conform to the manufacturers stated tolerances. Subjects wore a different type of contact lens in the left eye on four separate days, during a period of 8 h each day. New lenses were used for each subject and for each trial. All the four types of contact lenses were worn by each study participant in a randomized order.

2.3. Galilei G4

The Galilei G4 is a non-invasive optical diagnostic system designed for the analysis of the anterior segment of the eye, based on a rotating Dual-Scheimpflug and a Placido tomography system. The Galilei uses a monochromatic diode emitting blue light at 470 nm and combines dual Scheimpflug cameras and a Placido disc to measure both anterior and posterior corneal surfaces. During the rotating scan, the Placido and Scheimpflug data of the corneal information are simultaneously obtained. Two Scheimpflug slit images are made by the dual camera from opposite sides of the illuminated slit, and the data are averaged. Meanwhile, the dual camera simultaneously tracks decentration due to eye movements. Studies have reported the Galilei to be highly repeatable and reasonably accurate for measuring corneal thickness [10,11] and corneal curvatures [12].

Anterior and posterior corneal topography and regional corneal thickness were measured using the Galilei G4. Baseline measurements, approximately at 10 am (at least 2 h after subjects reported time of waking, in order to avoid the peak in corneal thickness immediately after waking [13]) and at 6 pm, were taken during two days on the left eye without any contact lenses being worn in order to record each individual's natural diurnal variations in corneal thickness and curvature. For the contact-lens scenario, measurements of the cornea were also taken twice a day: once before the contact-lens insertion around 10 am; at least 2 h after subjects reported time of waking. The other one was taken around 6 pm, after an eight-hour period of wearing each contact lens, and it was completed within 10 min of lens removal for each lens. A recovery period of 3 days was allowed for the individuals between lenses, in order to let the cornea to restore its normal state in case any changes were caused by the lenses.

2.4. Data analysis

Corneal thickness and curvature data were exported from the Galilei. In order to compare the baseline measurements with post-lens removal measurements, thickness and curvature difference values were calculated for all the 28 subjects and for each of the four lens types. Also, diurnal changes were obtained calculating the difference between measurements taken in the morning and the ones taken in the afternoon when the subjects were not wearing any lenses.

In this study, the data from all the subjects were averaged. A repeated measures analysis of variance (ANOVA) was used to analyze changes in corneal curvature and thickness because of contact lens wear, with lens type, corneal region and time as within-subject factors using SPSS Statistics v.17.0 (www.ibm.com/software/analytics/spss/). Statistical significance was set at $p = 0.05$.

3. Results

3.1. Diurnal changes

Data was averaged considering two corneal zones: a central and mid-peripheral zone of 5 mm diameter and a peripheral annulus from 5 to 8 mm (Fig. 1a). A significant difference was found between the morning and the afternoon measurements when the subjects were not wearing any contact lenses. The group mean diurnal change in corneal thickness for the non-contact lens scenario showed a significant thinning of −2.0 ± 1.7 μm ($p = 0.037$) in the central corneal region and −4.6 ± 2.8 μm ($p = 0.012$) in the peripheral annular corneal region. Considering the cornea divided in four different zones (nasal, temporal, inferior and superior), as it can be seen in Fig. 1b, a significant thinning was found in each one of the four zones: −1.8 ± 1.6 μm for the nasal quadrant, −2.4 ± 2.6 μm in the temporal one, −2.0 ± 2.1 μm in the inferior one, and −3.1 ± 2.7 μm in the superior quadrant. The anterior corneal curvature showed a slight significant steepening of −0.01 ± 0.01 mm ($p = 0.047$), whereas the posterior corneal curvature exhibited a slight non-significant flattening of 0.01 ± 0.02 mm ($p = 0.055$). All these changes should and were taken into consideration when analyzing corneal changes using contact lenses, due to their magnitude.