Corneal epithelial permeability during extended wear of disposable contact lenses versus daily wear of soft contact lenses

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Abstract

Aims—The corneal epithelial permeability during extended wear of disposable contact lenses was compared with that during daily wear of soft contact lenses. The study was performed to verify whether the extended wear of disposable contact lenses would result in a higher permeability value than the daily wear of soft contact lenses. A higher permeability makes the cornea more vulnerable for bacterial infections and thus could explain the higher incidence of bacterial keratitis found in extended wear of disposable contact lenses in comparison with the daily wear of soft contact lenses.

Method—The corneal epithelial permeability was determined by fluorophotometry in 33 healthy volunteers after the wear of soft, daily wear contact lenses for at least 6 months. Thereafter the determination was repeated in each volunteer after extended wear of disposable contact lenses for 1 month. The permeability in 34 healthy non-contact lens wearing volunteers was determined as a control. The permeability value was calculated from the amount of fluorescein that passed into the cornea after application by means of an eyebath.

Results—The mean permeability values after daily and extended wear were 0.032 nm/s and 0.031 nm/s, respectively. The values were not significantly different (Wilcoxon paired test $p > 0.5$). The mean permeability for the non-contact lens wearing controls was 0.042 nm/s.

Conclusion—The results do not sustain the explanation that a difference in permeability value is the main cause of the increased incidence of keratitis during extended wear of disposable contact lenses in comparison with daily wear.

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reduced to a minimum and contact lens storage cases and solutions were no longer a source of contamination bacterial keratitis and corneal ulcers still occurred, with a higher risk for extended wear of disposable contact lenses when compared with daily wear of soft contact lenses.^{4 10–18} The overnight wear of contact lenses was found to be the overwhelming risk factor for ulcerative keratitis.^{4 16 18}

The permeability of the corneal epithelium, the most important barrier against micro-organisms and water from outside the eye,¹⁹ has been determined previously.^{20 21} The daily wear of soft contact lenses was found to decrease the permeability value which was attributed to the protection against the exfoliative effect of blinking.²¹ Accordingly the wearing of these contact lenses should result in a decrease in the risk of bacterial infection rather than an increase. On the other hand, the contact lens is applied directly on the cornea and can itself be a source of bacterial contamination. These bacteria may originally be present in the contact lens, contact lens care solution, or elsewhere and can only penetrate the cornea through a defect in its epithelial layer.^{22 23}

Despite these findings in the daily wear of soft contact lenses it is probable that an increase in corneal epithelial permeability indicates damage to the corneal epithelium which might increase its susceptibility to bacterial invasion. Since extended wear of contact lenses induces a higher risk for bacterial infection than daily wear we hypothesise that the permeability of the corneal epithelium might be increased as a result of extended wear in comparison with daily wear, indicating the potential for bacterial invasion.

To check this hypothesis the value of the corneal epithelial permeability was measured by fluorophotometry in volunteers during daily wear of soft contact lenses and compared with the value during extended wear.

Materials and methods

VOLUNTEERS

Volunteers were recruited from an optometric practice in Leiden, the Netherlands. After explanation of the study and informed consent, selection was performed according to the following criteria: (1) intention to start wearing extended wear disposable contact lenses; (2) age between 18 and 50 years; (3) normal aspect of all corneal layers on slit-lamp biomicroscopy; (4) daily wear of hydrogel contact

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Many indications are found in literature about the sight threatening complications caused by the wear of soft contact lenses, such as bacterial keratitis and corneal ulcers. These infections were predominantly attributed to careless handling of the contact lenses or microbial contamination of contact lens storage cases and solutions.^{1–7}

The introduction of extended wear disposable contact lenses was meant to minimise these complication promoting factors.^{8 9} Despite the fact that contact lens handling was

lenses (poly 2-hydroxyethylmethacrylate (HEMA) 38% water) for at least 6 months on a frequent replacement basis (every 6 months). Exclusion criteria were: (1) use of medication, with the exception of oral contraceptives; (2) diabetes mellitus or Graves' ophthalmopathy; (3) long standing wear (>10 years) of polymethylmethacrylate contact lenses in order to exclude morphological changes which could result in physiological alterations; (4) inability to cooperate.

Non-contact lens wearing volunteers were also included for comparison of the method with previous studies.

MATERIALS

The Acuvue disposable contact lens (Vistakon, Johnson & Johnson Vision Products, Inc, Jacksonville, FL, USA), a 58% water content hydrogel lens (Etafilcon A), was used. The fluorophotometric measurements were performed with a scanning fluorophotometer (Fluorotron Master, Coherent Radiation Inc, Palo Alto, CA, USA) fitted with a special lens, 'anterior segment adaptor', for detailed scanning of the cornea.^{20 21} Pachymetry was performed with an ultrasound pachymeter (DHG Technology Inc, Frazer, PA, USA).

METHODS

At the end of the last 6 month period of daily contact lens wear the first determinations of corneal epithelial permeability and corneal thickness were performed as follows. A 1% fluorescein solution was applied to the eyes for 3 minutes using eyebaths, after removal of the contact lenses and biomicroscopic slit-lamp examination of all corneal layers. Then the eyes were rinsed with saline and the concentrations of fluorescein in the corneas were determined with the fluorophotometer. The permeability value was calculated using the formula²⁰:

$$P = \frac{C_c(t_b) \times d}{C_b \times t_b} \times \frac{10^6}{60}$$

Where P =corneal epithelial permeability (nm/s); $C_c(t_b)$ =corneal fluorescein concentration directly after the eyebath (ng/ml); C_b =fluorescein concentration of the eyebath (ng/ml); t_b =bathing time (minutes); d =mean corneal thickness ($=1.25 \times$ the measured thickness in the centre of the cornea (mm)²²); $10^6/60$ =factor for converting mm/min to nm/s.

If necessary a correction for fluorescein still present in tear film was performed.²⁰ The corneal thickness was measured by pachymetry.

Thereafter fitting of the disposable extended wear contact lenses and follow up examinations were performed by an optometrist. Replacement of the lenses took place after 7 days and 6 nights of wearing on extended wear basis. The permeability and the corneal thickness were measured again after 4 weeks of wearing these contact lenses. Since the corneal epithelium has a turnover time of about 7 days

any effect of extended wear on the corneal epithelium can be expected to have occurred within this time.²⁴

The results were statistically evaluated using the Wilcoxon paired rank test for non-parametric paired measurements since the permeability values of the contact lens wearing participants were found not to be distributed normally. The Mann-Whitney test was used for comparison between the contact lens wearers and the controls in this study. Student's t test was used for comparison between the healthy controls of the study and previous studies since these groups were distributed normally.^{20 21}

Results

Thirty three volunteers (nine men and 24 women) aged from 18 to 46 (mean 26.8) years participated in the study. Six people were excluded from the study: three wore the contact lenses for 5 weeks instead of 4 weeks, one person was non-cooperative, and two prematurely stopped wearing disposable contact lenses because of irritated eyes; no residual signs or symptoms were seen at the time of reporting (less than 1 week after removal of the contact lenses).

The corneal epithelial permeability values of the left and right eye were found to be correlated in both sessions (linear correlation coefficients 0.6, $p < 0.005$ and 0.9, $p < 0.0001$, respectively); consequently the mean values of both eyes were used in the study. The permeability values after extended wear of disposable contact lenses were not significantly different from those after daily, soft contact lens wear (mean values 0.032 nm/s and 0.031 nm/s respectively; Wilcoxon paired rank test $p > 0.5$) (Fig 1). No significant difference was found between the mean value of the controls in this study (0.042 (SD 0.017) nm/s) and that in two previous studies (0.038 (0.017) nm/s and 0.040 (0.017) nm/s, Student's t test $p = 0.30$ and $p = 0.59$, respectively).^{20 21} The permeability values of the controls in this study

Figure 1 Corneal epithelial permeability during extended wear of disposable contact lenses versus that during daily soft contact lens wear. The broken line indicates equal permeability values.

Figure 2 Corneal thickness during extended wear of disposable contact lenses versus that during daily soft contact lens wear. Broken line indicates equal thickness.

were significantly different from those after daily wear and disposable extended wear (Mann-Whitney test $p=0.02$ and $p=0.006$, respectively).

The values of the corneal thickness of both eyes were also correlated in both sessions (correlation coefficient 0.96, $p<0.0001$, 0.97 and $p<0.0001$, respectively). The corneal thickness values after wearing extended wear contact lenses were significantly increased in comparison with the values after daily soft contact lens wear (average increase 0.8%; Wilcoxon paired rank test $p=0.04$) (Fig 2).

Discussion

The extended wear of disposable contact lenses and the daily wear of soft contact lenses resulted in similar values of corneal epithelial permeability ($p>0.5$). Twelve participants had higher permeability values during extended wear (mean increase 46%, range 0.6–199%) and 15 participants during daily wear (mean increase 29%, range 5–57%). If the incidence of keratitis depended on the permeability value, it would be expected to occur as frequently during daily wear as during disposable extended wear.

Unfortunately we were not able to measure the permeability immediately after lens removal of the two participants who reported irritated eyes since they reported this days after lens removal. It is possible that if the permeability was largely increased in those participants – for example, as the result of an overwear syndrome (corneal epithelial swelling and pain), this could make the cornea more prone to infection.

The significantly higher mean permeability value found in the non-contact lens wearing controls in comparison with the soft contact lens wearing participants (both daily wear and disposable extended wear) is in accordance with the results of an earlier study.²¹ Apparently the use of soft contact lenses protects the corneal epithelium against the exfoliative effect of blinking.²¹

It can be concluded that the main cause of the increased incidence of keratitis and corneal ulcers during extended wear of disposable contact lenses compared with daily wear of soft contact lenses is not a difference in corneal epithelial permeability.

Other possible causes for the increased incidence of keratitis found in wearers of extended wear contact lenses are: (1) a change of the ocular flora due to extended wear of contact lenses. Until now, no significant difference of the ocular flora between extended and daily wear had been found²⁵; (2) an enhanced adherence of microorganisms to the corneal epithelium during extended contact lens wear. This was found for *Pseudomonas aeruginosa*,^{26 27 28} which is the most common pathogen isolated from ulcers and in contact lens related keratitis^{17 27 29}; (3) changes in the composition of tear film such as an increased level of IgA in rigid gas permeable contact lens wearers, which could protect the cornea against microorganisms attached to the contact lens. Note that no increase in IgA level was found in soft contact lens wearers, resulting in an increased susceptibility to bacterial keratitis.³⁰

The statistically significant increase in corneal thickness found in our study after the extended wear of disposable contact lenses is probably caused by the overnight wear of the contact lenses. The increase was small (0.8%), however, possibly is a result of a corneal adaptation process.³¹

Further investigations to elucidate the cause of the increased incidence of bacterial keratitis and corneal ulcers remain necessary to provide secure extended wear of soft contact lenses.

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