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ORIGINAL ARTICLE

Overnight corneal swelling with high and low powered silicone hydrogel lenses☆

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Oxygen transmissibility;
Optical pachometry;
Corneal thickness

Abstract
Purpose: To compare central corneal swelling after eight hours of sleep in eyes wearing four different silicone hydrogel lenses with three different powers.
Methods: Twenty-nine neophyte subjects wore lotrafilcon A (*Dk*, 140), balafilcon A (*Dk*, 91), galyfilcon A (*Dk*, 60) and senofilcon A (*Dk*, 103) lenses in powers −3.00, −10.00 and +6.00 D on separate nights, in random order, and on one eye only. The contra-lateral eye (no lens) served as the control. Central corneal thickness was measured using a digital optical pachometer before lens insertion and immediately after lens removal on waking.
Results: For the +6.00 D and −10.00 D, lotrafilcon A induced the least swelling and galyfilcon A the most. The +6.00 D power, averaged across lens materials, induced significantly greater central swelling than the −10.00 and −3.00 D (Re-ANOVA, $p < 0.001$), ($7.7 \pm 2.9\%$ vs. $6.8 \pm 2.8\%$ and $6.5 \pm 2.5\%$ respectively) but there was no difference between −10.00 and −3.00 D. Averaged for power, lotrafilcon A induced the least ($6.2 \pm 2.8\%$) and galyfilcon A the most ($7.6 \pm 3.0\%$) swelling at the center (Re-ANOVA, $p < 0.001$). Central corneal swelling with +6.00 D was significantly greater than −10.00 D lens power despite similar levels of average lens transmissibility of these two lens powers.
Conclusions: The differences in corneal swelling of the lens wearing eyes are consistent with the differences in oxygen transmission of the silicone hydrogel lenses. In silicone hydrogel lenses central corneal swelling is mainly driven by central lens oxygen transmissibility.

☆ A summary of this work was presented as two posters at the American Academy of Optometry annual meeting, October 2008, Anaheim, CA.

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PALABRAS CLAVE
Edema corneal;
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paquimetría óptica;
espesor de la córnea

Edema corneal durante la noche, con el uso de lentes de hidrogel de silicona de alta y baja potencia

Resumen
Objetivo: Comparar el edema central de la córnea tras ocho horas de sueño, en ojos con cuatro lentes diferentes de hidrogel de silicona de tres potencias diferentes.
Métodos: Veintinueve pacientes no usuarios de lentes de contacto llevaron lentes de lotrafilcon A (Dk, 140), balafilcon A (Dk, 91), galyfilcon A (Dk, 60) y senofilcon A (Dk, 103) con potencias de −3,00, −10,00 y +6.00 D durante noches diferentes, en orden aleatorio, y en un solo ojo. El ojo contra-lateral (sin lente) se utilizó como control. El espesor central de la córnea se midió utilizando un paquímetro óptico digital antes de la inserción e inmediatamente tras la retirada de la lente al despertar.
Resultados: Para +6,00 D y −10,00 D, lotrafilcon A produjo el menor edema, comparado con galyfilcon A. La potencia +6,00 D, promediada en los materiales de las lentes, produjo un edema central considerablemente mayor que las potencias −10,00 y −3,00 D (Re-ANOVA, $p < 0{,}001$), (7,7 ± 2,9% frente a 6,8 ± 2,8% y 6,5 ± 2,5% respectivamente), pero no existió diferencia entre −10,00 y −3,00 D. Promediando las potencias para cada lente, lotrafilcon A produjo el menor edema en el centro (6,2 ± 2,8%) y galyfilcon A la mayor (7,6 ± 3,0%) (Re-ANOVA, $p < 0{,}001$). El edema corneal central con +6,00 D fue considerablemente superior que la de la potencia de lente −10,00 D, a pesar de los niveles similares de transmisibilidad media de la lente de estas dos potencias.
Conclusiones: Las diferencias en cuanto a edema de la córnea de los ojos portadores de lentes son consistentes con las diferencias en cuanto a transmisión del oxígeno de las lentes de hidrogel de silicona. En las lentes de hidrogel de silicona, el edema corneal central es principalmente debido a la transmisibilidad del oxígeno central de la lente.

Introduction

Hypoxia induced corneal swelling is a well known phenomenon and one of the primary indices of corneal physiological change during contact lens wear. Holden and Mertz[1] hypothesized that the minimum oxygen transmissibility (Dk/t) of a lens should be $87 \pm 3.3 \times 10^{-9}$ (cm ml O_2)/(ml s mmHg) in order to prevent overnight lens induced corneal swelling. More recently, a value of 125×10^{-9} (cm ml O_2)/(ml s mmHg) has been proposed as the critical Dk/t of a lens to prevent lens-induced overnight corneal anoxia.[2] Studies have shown that silicone hydrogel lenses induce less corneal swelling compared to conventional hydrogel lenses when worn overnight (Bergenske P, Mueller N, Caroline P, Smythe J, Mai-Le K. Uniformity of overnight corneal swelling with extended wear contact lenses. Optom Vis Sci. 2001;78(12S):198; Bullimore MA, Nguyen M, Bozic J, Mitchell GL. Overnight corneal swelling with 7-day continuous wear of soft contact lenses. ARVO Meeting Abstracts. 2002;43:3100; Fonn D, Moezzi A, Simpson T, Situ P. Confirmation of a yoked corneal swelling response between the test and contralateral control eye. Optom Vis Sci. 2004;81(12S):30).[3,4] Although all −3.00 D silicone hydrogel contact lenses meet the Holden and Mertz criterion of 87×10^{-9} (cm ml O_2)/(ml s mmHg) for the central lens transmissibility, no one has reported the effect of higher powered silicone hydrogel lenses (decreased Dk/t) on central corneal swelling. Previous corneal swelling studies with silicone hydrogel lenses including a previous study by the current authors[5] used low powered silicone hydrogel lenses and compared between the lens types. Although Steffen et al.[6] studied overnight swelling with silicone hydrogel lenses in a range of powers between −1.00 to −6.00 D to correct 25 adapted daily soft contact lens wearers it is unclear how many subjects wore higher powered lenses in this dispensing study and they did not compare corneal swelling across lens powers.

Previous studies with conventional hydrogel lenses showed greater central corneal swelling with higher minus lens powers than lower minus powers with the same material, central thickness and central oxygen transmissibility (Dk/t).[7–9] Tomlinson and Bibby[10] showed that the central corneal swelling in minus powered hydrogel lenses was underestimated and in plus powered lenses was overestimated based on the central lens transmissibility. These findings led to the conclusion that the central lens transmissibility is a poor predictor of the magnitude of central corneal swelling and the response is influenced by the averaging of the lens oxygen transmission.[7,10–14] To our knowledge no one appears to have investigated the influence of local central compared to average Dk/t of silicone hydrogel lenses to determine the primary driver of overnight central corneal swelling with these lenses.

The main aims of this study were to compare differences in central corneal swelling between different silicone hydrogel lens materials in high and low powered lenses and to determine if at high levels of oxygen transmissibility central corneal swelling with silicone hydrogel lenses can still