Cholesterol Penetration into Daily Disposable Contact Lenses Using a Novel In Vitro Eye-Blink Model

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Introduction

- Daily disposable (DD) lens materials continue to show an increase in use for practitioners and patients and provide lens wearers with a decreased proportion of complications, improved comfort and visual acuity, and lower quantities of lens deposits.  
- Lipid uptake on silicone hydrogel (SH) DDs is far less than on their daily wear material counterparts.  
- However, current in vitro methods/model to evaluate tear film (TF) deposition on various contact lens (CL) materials do not simulate physiological eye conditions, such as tear flow or blink motion.  
- Several unique in vitro eye models have been developed to include tear flow or tear replenishment, intermittent air exposure, or in vivo healing.  

Materials & Methods

- Three silicone hydrogel (SH) and four conventional hydrogel (CH) DD were tested: 
  - Deleitlon A (Dailles Total, Alcon)  
  - Somotilom A (claritin 1 day, CooperVision)  
  - Naradlon A (T-1 Day Acuvue TruEye, Johnson & Johnson)  
  - Etachilon A (T-1 Day Acuvue Moist, Johnson & Johnson)  
  - Outdoor B (BioMedicon 1 day, CooperVision)  
  - Nisotilom A (Biocompatibles ODElay, Bausch + Lomb)  
  - Nelflon A (DailiesAquComfoPlus, Alcon)  

- CLs were incubated for 4 hours (h) and 12 h in an artificial tear solution (ATS) containing a variety of proteins and lipids (mucin, albumin, tyrosine, triolein, cholesterol ester, cholesterol oleate, phosphatidylcholine, oleic acid methyl ester).  
- In addition, a small amount of cholesterol, labeled with 7-nitrobenz-2-oxa-1,3-diazol-4-yl (NBD) fluorophore, was added to the ATS.  
- Contact lenses (n=3) were incubated at room temperature (21°C), employing two different methods:  
  - in a vial containing 3.5 mL of ATS on an orbital shaker, and  
  - using our novel in vitro eye-blink model (OcuFlow), which consist of a "corneal/ocular eye piece" and a "eyelid piece" that are attached to two individual actuators, which enable us to simulate a blinking motion.  
    Furthermore, through a microfluidic pump, we simulated a physiological tear flow of 1.3 μL/min.

Purpose

- To determine differences in lipid uptake penetration, comparing a traditional static incubation method with a novel in vitro eye model.

Materials & Methods cont’d

- After incubation, the central and peripheral 5 mm of each CL were punched out and mounted on a microscope slide.  
- Subsequently, the penetration of NBD-cholesterol within the lens materials was determined by laser scanning confocal microscopy (LCSM) with argon laser at 488 nm.  
- CLs were optically scanned at 0.5 μm intervals (2 stack).  
- The fluorescence intensity profile of each CL sample was calculated with ImageJ software, using the "Plot Z axis profile" module.  
- Curves of relative intensity of fluorescence (RIF) were plotted using Graphpad Prism

Results

- Penetration profiles of the TF lipid vary between the static and the eye-blink (OcuFlow) model incubation methods.  
- Incubating the lenses traditionally (in a vial) showed lipid uptake throughout the lens material, starting from both sides of the contact lens.  
- However, employing our eye-model (OcuFlow), cholesterol penetration was less and can be seen starting from the front surface of the lenses.  
- SHs showed higher RIF than CH lens materials, except for nesfoton A.  
- Furthermore, RIF varied between incubation methods, incubation time, lens materials, and between the centre and periphery of the lens materials, with the traditional method showing more RIF than our novel eye-model (OcuFlow).

Conclusions

- The results of this study provide new insight and a novel in vitro approach on the penetration of tear film components onto contact lenses.  
- Furthermore, we can show that the traditional methods used for in vitro lens incubation expose the materials to amounts of ATS that exceed physiological limits, which can lead to overestimating lipid deposition.  
- This novel eye-blink platform (OcuFlow) is able to better simulate on-eye conditions than previous models and will help to further our knowledge about the interactions between CLs and TF components in vivo.

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References