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ORIGINAL ARTICLE

Atomic force microscopy and Langmuir–Blodgett monolayer technique to assess contact lens deposits and human meibum extracts☆

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KEYWORDS
Meibum;
Contact lens deposits;
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Atomic force microscopy (AFM);
Langmuir–Blodgett

Abstract
Purpose: The purpose of this exploratory study was to investigate the differences in meibomian gland secretions, contact lens (CL) lipid extracts, and CL surface topography between participants with and without meibomian gland dysfunction (MGD).
Methods: Meibum study: Meibum was collected from all participants and studied via Langmuir–Blodgett (LB) deposition with subsequent Atomic Force Microscopy (AFM) visualization and surface roughness analysis. *CL Study:* Participants with and without MGD wore both etafilcon A and balafilcon A CLs in two different phases. CL lipid deposits were extracted and analyzed using pressure-area isotherms with the LB trough and CL surface topographies and roughness values were visualized using AFM.
Results: Meibum study: Non-MGD participant meibum samples showed larger, circular aggregates with lower surface roughness, whereas meibum samples from participants with MGD showed more lipid aggregates, greater size variability and higher surface roughness. *CL Study*: Worn CLs from participants with MGD had a few large tear film deposits with lower surface roughness, whereas non-MGD participant-worn lenses had many small lens deposits with higher surface roughness. Balafilcon A pore depths were shallower in MGD participant worn lenses when compared to non-MGD participant lenses. Isotherms of CL lipid extracts from MGD and non-MGD participants showed a seamless rise in surface pressure as area decreased; however, extracts from the two different lens materials produced different isotherms.

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Conclusions: MGD and non-MGD participant-worn CL deposition were found to differ in type, amount, and pattern of lens deposits. Lipids from MGD participants deposited irregularly whereas lipids from non-MGD participants showed more uniformity.

PALABRAS CLAVE
Secreciones de las glándulas de Meibomio;
Depósitos de las lentes de contacto;
Disfunción de las glándulas de Meibomio (MGD);
Microscopio de fuerza atómica (AFM);
Langmuir–Blodgett

Microscopio de fuerza atómica y técnica de la película de Langmuir–Blodgett para evaluar los depósitos y las secreciones de las glándulas de meibomio en las lentesde contacto

Resumen
Objetivo: El objetivo de este estudio exploratorio fue el de investigar las diferencias entre las secreciones de las glándulas de Meibomio, los extractos lipídicos de las lentes de contacto (LC), y la topografía de la superficie de las lentes entre los participantes, con y sin disfunción de las glándulas de Meibomio (DGM).
Métodos: Estudio de las Glándulas de Meibomio: Se recogieron las secreciones glandulares de todos los participantes, estudiándose mediante película de Langmuir–Blodgett (LB) y posterior visualización, utilizando un microscopio de fuerza atómica (AFM) y analizando la rugosidad superficial. *Estudio de las LC:* Los participantes con y sin DGM usaron lentes de etafilcon A y balafilcon A en dos fases diferentes. Se extrajeron y analizaron los depósitos lipídicos utilizando isotermos de área de presión con la usaron, y visualizándose las topografías de la superficie de la LC y los valores de la rugosidad mediante AFM.
Resultados: Estudio de las Glándulas de Meibomio: Las muestras de la secreciones de los participantes sin MGD reflejaron un conglomerado mayor y circular con una superficie menos rugosa, mientras que las muestras de las secreciones de los participantes con DGM reflejaron unos conglomerados más lipídicos, con mayor variabilidad de tamaño, y una mayor rugosidad en la superficie. *Estudio de las LC*: Las LC de los participantes con DGM mostraron una mayor cantidad de depósitos de película lagrimal, con una superficie menos rugosa, mientras que las LC de los participantes sin DGM reflejaron una menor cantidad de depósitos y una mayor rugosidad en la superficie. Las profundidades de los poros de balafilcon A eran menores en las lentes de los participantes con DGM, que en los participantes sin DGM. Los isotermos de los extractos lipídicos de las LC de los participantes con o sin DGM reflejaron un incremento no significativo de la presión de superficie a medida que disminuía el área; sin embargo, los extractos procedentes de los dos diferentes materiales reflejaron isotermos distintos.
Conclusiones: Las secreciones de las LC de los participantes, con o sin DGM, mostraron diferencias en cuanto a tipo, cantidad y patrón de los depósitos de las lentes. Los lípidos procedentes de los participantes con DGM se depositaron de modo irregular, mientras que los de los participantes sin DGM reflejaron más uniformidad.

Introduction

The human ocular surface is covered by a complex tear film that is made up of many components including water, enzymes, proteins, mucins, lipids, and immunoglobulins.[1–6] The tear film is highly structured and is arranged into several indistinct layers.[1,7–9] The outermost layer is made up of lipids produced by the meibomian glands that reside within the upper and lower tarsal plates.[1,9–11] This lipid layer is further divided into non-polar and polar lipid layers.[4,5,7,9,12,13] The outermost non-polar lipid layer functions to control the rate of evaporation of the aqueous layer, whereas the underlying polar lipid layer functions to stabilize and support the non-polar layer.[1,4,5,7,12–14] A stable lipid layer is essential for maintaining ocular surface health and visual acuity and disruption in any of the many tear film components can cause ocular discomfort and dry eye.[1,15–17] Dry eye syndrome is one of the most common ocular disorders and has two main manifestations: aqueous tear deficiency and evaporative deficiency.[18] Aqueous tear deficiency is the most common and is a result of a decrease in lacrimal gland secretion.[18] Since the non-polar lipid layer functions to prevent the evaporation of aqueous tears, evaporative dry eye is often caused by a deficiency within the lipid layer, often a result of a condition known as meibomian gland dysfunction or MGD.[9,18,19] Some common ocular symptoms of MGD