Optical Quality and Tear Film Analysis after Various Lubricating Eye - Drops

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ABSTRACT

Purpose: To compare the optical quality and tear film analysis of normal and dry eye individuals after instilling various lubricating eye drops.

Materials and Methods: A total of 50 eyes of 25 normal individuals and 20 eyes of 10 dry eye patients were studied using LipiView Interferometer (TearScienceInc, Morrisville, North Carolina, USA) Optical Quality Analysis System (OQAS) and HD Analyzer (Visiometrics, Terrassa, Spain). These patients were subjected to randomized use of drop A (polyethylene glycol 400 NF 0.4%, propylene glycol 0.3%), drop B (sodium carboxymethyl cellulose (CMC) and glycerin 0.9%), and drop C (sodium CMC-5 mg). The optical quality and tear film were analyzed at the end of 10 min, 40 min and 1 week.

Results: The average interferometric units measured were 82.36, 74.28 and 71.4 with drops A, B and C, respectively. The average objective scatter index was 0.42 before using any drops and 0.48, 0.38 and 0.42 after drops A, B and C, respectively. The average modulation transfer function was 43.7 before drops and 39, 45.6 and 46 after usage of drops A, B, and C, respectively.

Conclusion: The lipiview analysis suggested that drop A had a beneficial effect on the lipid layer of the tear film. Metrics on OQAS revealed that drops B and C showed improvement in MTF and OSI in normal as well as dry eye patients.

KEY WORDS: Tear film, OQAS, Lipiview

INTRODUCTION

The tear film layer coats and protects the ocular surface. Various epithelial and glandular tissues (cornea, bulbar and palpebral conjunctiva, and lacrimal and accessory eyelid glands) of the ocular surface, contribute in the secretion of the tear film. Tear production is approximately 1.2 microliters per minute, with a total volume of 6 μl. A complete tear film is essential for normal functioning of the eye. Tear film thickness, as measured by interferometry, is 6.0 μm ± 2.4 μm in normal eyes. Tear film is the first limiting factor in preventing good quality of vision. [1]

Dry eye syndrome describes the multifactorial condition where the ocular system fails to produce good quality tears or a sufficient amount of tears to keep the eye moisturized. Human tears, composed of electrolytes, water, proteins (e.g., antibodies, lysozymes), and lipids, function to moisturize the ocular surface and minimize damage to the corneal epithelium. These components come together to form three distinct layers (Figure 1):

(1) The outermost lipid layer, (2) a middle aqueous layer, and (3) the epithelium-covering mucoid layer. Dysfunction in any of these layers can yield tear film instability and hyperosmolarity. External causes of such dysfunction are widespread including environmental factors, systemic diseases, and medications. [2,3]

Artificial tears are currently the mainstay of therapy of dry eyes. However, a large array of brands and
marketing strategies have made it a challenge for patients and clinicians to identify the product that best suit individual patients.[4]

This study aims at evaluating the optical quality in an individual based on the assessment of tear film, prior to and after using lubricating eye drops using Optical Quality Analysis System (OQAS) HD Analyzer (Visiometrics, Terrassa, Spain) and quantification of the lipid layer using Lipiview (TearScience Inc, Morrisville, North Carolina, USA) to categorize the lubricants on the basis of their actual functions.

MATERIALS AND METHODS

To provide the maximum utility for the patient and the clinician, commercially available artificial tears were identified and categorized based on the active ingredient. Active ingredients and preservatives were verified via package inserts for each product. Artificial tears were divided into groups based on active ingredients including polyvinyl alcohol and carboxymethyl cellulose (CMC), which are routinely prescribed at our set up.

Drop A: Polyethylene glycol 400 0.4%, propylene glycol 0.3%
Drop B: Sodium CMC and glycerin 0.9%
Drop C: CMC sodium 5 mg/mL

In this prospective non-randomized study 25 normal individuals (50 eyes) without any history of using ocular medication or lubricating eye drops for at least a week prior were included, along with 10 patients with diagnosed dry eye disease.

All the 3 drops were instilled in these individuals in random order and in turns. Tests were repeated after 10 min, 45 min and a week after using the drop A in the right eye and drop B in the left eye for a week, and then switched over to drop B in the right eye and drop C in the left eye for a week.

All patients were then subjected to Lipiview (Tear Science Inc, Morrisville, North Carolina, USA) and OQAS HD Analyzer (Visiometrics, Terrassa, Spain) before and after applying drops to measure the lipid layer thickness (LLT) and optical quality. The interferometry works by evaluating the spread of lipids through the tear film with blinking. Lipiview (Tear Science Inc, Morrisville, NC) is a commercially available interferometer that provides a quantitative values of the tear film LLT and this automated assessment of the LLT might be a suitable screening test for detecting meibomian gland dysfunction (MGD) (Figure 3).[5,6]

Tear film interferometry

When white light is projected over the cornea, a color interference pattern is produced due to specular reflection at the lipid-aqueous interface. An appropriately thick lipid layer spans the tear surface in a continuous manner, whereas a thin lipid layer degenerates into discontinuous patchy regions denoting an unstable tear film.

OQAS (OQAS II, Visiometrics SL, Spain)

Based on the principle of double pass, this HD analyzer provides a measure of the optical quality of patient’s visual system by assessing ocular scatter and the effect of higher-order aberrations on the light entering the eye. In addition, the HD analyzer can also be used to determine an eye’s depth of focus and to assess the optical quality of the tear film in 0.5 s intervals, which allows the physician to see real-time effects of tear film evaporation on optical quality. The area of the tear film was limited to that projected to the pupil area (in most cases, around a 7.0 mm
diameter central portion of the cornea), which allows the clinician to see the visual quality in between each blink, and is correlated with the potential visual acuity at each time point. This is ideal for analyzing patients who have fluctuating acuities due to dry eyes and correlating their symptoms. It gives confidence to the clinician in diagnosing and providing an explanation to the patient.[7]

RESULTS

Average interferometric units

![Graph of AVG ICU (Interferometric units)]

Average interferometric units were measured using the LipiView (TearScience Inc., Morrisville, NC) which gives the thickness of the lipid layer. Before the application of any lubricating eye drops the average interferometric units was 76.16 nm and the value increased to 82.36 nm with drop A and was 74.28 nm with drop B and 71.4 nm with drop C.

Objective scatter index (OSI)

![Graph of OSI] (OSI)

The OSI before usage of any drops was 0.426 and was 0.48, 0.38 and 0.42 with drop A, B and C subsequently.

Modulation transfer function (MTF)

![Graph of MTF](Modulation transfer function (MTF))

The MTF before application of drops was 43.7 and after drop A was 39, was 45.6 with drop B and 46 with drop C.

Mean OSI

![Graph of Mean OSI](Mean OSI)

The mean OSI was 0.69 before application of drops and 0.745, 0.761 and 0.741 after drop A, B and C.

DISCUSSION

The importance of dry eye disease and tear film analysis has increased a great deal in the past ten years. Understanding the impact a poor tear film has on patients’ vision is invaluable. The HD Analyzer is ideal for analyzing patients who have fluctuating acuities due to dry eyes and correlating their symptoms.[8]

Artificial tear formulations are buffered solutions that contain electrolytes, surfactants, and one or more viscous agents or lubricants, e.g., guar-based and cellulose based derivatives, including hydroxypropyl - guar, as well as glycerin, dextran, polyvinyl alcohol, polyethylene glycol 400, and propylene glycol. Although most artificial tear products contain similar ingredients, they differ in the types of lubricants used and in their mechanisms of action.
Despite the availability of various artificial tears, many of these products have been found to relieve the symptoms of the dry eye only temporarily, rather than healing the ocular surface or to treating the underlying cause of the disease.\(^9,10\)

CMC is a common demulcent that can be used to increase the viscosity of an ophthalmic formulation. The active agent in the line of artificial tears, CMC is found in 0.5% concentrations in the products designed for early stage dry eye sufferers, and it also works on the optical quality.

Polyethylene glycol 400, represents a new generation of artificial tear preparations. They work through a unique biphasic mechanism of action in which the product first binds to damaged hydrophobic areas of epithelial cells to add volume to the tear film, and then restructures the tear film by forming a protective gel matrix that provides long-lasting protection, which provides sustained lubrication to the eye and protects the ocular surface from further damage while the surface epithelial cells undergo repair and renewal.\(^10,11\)

There have been clinical studies which demonstrate that topical ocular instillation of drops containing polyethylene glycol 400, in patients with dry eye disease secondary to MGD substantially improve the tear film LLT and tear film stability.

The newer imaging modalities helped us assess the optical quality in all the individuals and helped us co-relate the symptoms of dry eye with the optics of the eye.

The drop containing polyethylene glycol 400 NF 0.4%, propylene glycol 0.3% provided optimal ocular surface protection and lubrication and also helped in regularizing the ocular surface as compared to the other drops. Using this drop in patients with MGD would be highly beneficial as it would help in stabilizing the lipid layer and then CMC group of drops can be used to improve the optical quality of the patient.

CONCLUSION

Current approaches to the management of dry eye disease reflect the multifactorial nature of this condition. Therapeutic strategies are designed to restore the natural tear film, protect the ocular surface, and improve the patient’s ocular comfort and quality of life. Artificial tears remain the mainstay of dry eye therapy. With the expansive amount of commercially available artificial tear options, specific recommendations are needed to help guide both the clinician and patient.

All the drops used in this study caused minimum blurring or haze upon instillation and provided prolonged ocular comfort and relief of dry eye symptoms.

REFERENCES