Effect of Systane and Optive on Aqueous Tear Evaporation in Patients With Dry Eye Disease

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Objective: To compare the effect on aqueous tear (AT) evaporation rate of Systane and Optive at 30 min postinstillation in patients with dry eye.

Methods: In a crossover study of 20 patients with keratoconjunctivitis sicca, the evaporation rate of AT was measured. Evaporometry was used at two relative humidity (RH) ranges of 25% to 35% and 35% to 45%. The measurements were made at baseline (before the instillation of the study agent) and at 30 min after the instillation of 40 μL of either Systane or Optive per randomization assignment per visit with a 1-week interval between visits.

Results: No significant effects on AT evaporation rates at both RHs were found between study agents.

Conclusions: In our study, neither Systane nor Optive has a significant impact on AT evaporation at 30 min postinstillation in patients with dry eye.

Key Words: Dry eye—Eye drop—Systane—Optive—Tear evaporation—Tear film.

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Tear substitutes are the most common initial therapeutic option for dry eye disease. Recent technologic innovations have led to eye drops that resemble the tear film, increase retention time of the topical agent, and protect the ocular surface while stabilizing the tear film. They differ with respect to electrolyte composition, osmolarity, viscosity, and the presence or absence of compatible solutes and preservatives.[1] Many over-the-counter artificial tears are available. Systane Lubricant Eye Drops (Alcon Laboratories, Fort Worth, TX) is designed to mimic the mucin layer of the tear film by the addition of hydroxypropyl-guar (HP-Guar), which is believed to mimic the mucin layer of the tear film. It also contains the demulcents polyethylene glycol 400 (0.4%) and propylene glycol (0.3%) to provide protection to the ocular surface microenvironment and is preserved with POLYQUAD (0.001%).[2] On the other hand, Optive lubricant eye drops (Allergan, Irvine, CA) contain 0.5% carboxymethylcellulose sodium and 0.9% glycerin, which lubricate the ocular surface and also promote the growth of epithelial cells to provide osmoprotection. Optive includes a stabilized oxychloro complex as a preservative called Purite.[3,4] Clinical studies were conducted to evaluate the effect of these two artificial tears on the stability of the tear film by measuring tear film break up time (TBUT). Results showed a significantly increased TBUT using either Systane[5–7] or Optive.[4]

Application of tear substitutes increases the tear volume on the ocular surface. After a short period of time the tear volume returns to baseline as a result of drainage into the nasolacrimal duct and evaporation from the ocular surface.[8] The contribution of evaporation to aqueous tear (AT) volume loss has been reported to be in the range 20% to 60%.[9] When tear production is compromised, AT evaporation becomes increasingly important.[10] The rate of AT evaporation is influenced by environmental factors such as air flow, temperature, and humidity. The purpose of this study was to evaluate AT evaporation rate after the instillation of equal volumes of either Systane or Optive in patients with dry eye disease.

MATERIAL AND METHODS

Study Population

The study protocol, consent form, and data accumulation methods used in these studies were approved by the University of Texas Southwestern Medical Center Institutional Review Board before the initiation of these studies. The Health Insurance Portability and Accountability Act regulations were followed.

A total of 20 non–contact lens wearers with dry eye disease were enrolled in the study. By protocol design, only left eyes of all subjects were tested.

The eligibility criteria for enrollment of subjects in this study were that they should have symptoms consistent with dry eye disease, for example, foreign-body sensation or dryness combined with the signs of dry eye detected by slitlamp examination, pattern of Lissamine green vital dye staining,[11] and a Schirmer test value less than 7 mm. Subjects were excluded if they had a history of punctal plugs or punctal occlusions, keratorefractive surgery, ophthalmic disease, active systemic disease or if they took any eye drops or systemic medication that are known to influence AT production. Subjects with only one sighted eye or vision not correctable to 20/80 or better in both eyes were also excluded.

Study Agents

Two commercially available over-the-counter artificial tear solutions were instilled into the left eye of each patient:

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1. *Systane* consists of HP-Guar base with polyethylene glycol 400 (0.4%), propylene glycol (0.3%), and polyquaternium-1 as a preservative.
2. *Optive* consists of 0.5% carboxymethylcellulose sodium, 0.9% glycerin, and Purite (stabilized oxychloro complex as a preservative).

Study Design

The AT evaporation rate measurements of the left eye were taken on each patient with keratoconjunctivitis sicca at two visits. There was a 1-week interval between the first and second visits. The measurements were at baseline before the instillation of any study agent and at 30 min after the instillation of 40 μL of either Systane or Optive per randomization assignment per visit. The same testing was carried out on the second visit using the opposite study agent.

An evaporometer (Oxdata, Portland, OR) used a pump to direct room air through a drying tube into a form-fitting eye goggle that contained a sensor for humidity and temperature.[12] Dry air was pumped into the firm-fitting eye goggle to reduce relative humidity (RH) to 15%, at which time the pump was turned off. The RH within the goggle was allowed to rise. The increase in humidity because of evaporation from the skin and ocular surface was measured. The process was carried out first with the eyelids closed and then with eyelids open; the difference represented the AT evaporation rate at the ocular surface.

At the final step (open eyes), blink interval was controlled every 3 seconds with a metronome. Patient visual fixation and the fixation target were parallel to the floor and ceiling. The tests were performed by the same technician in a controlled temperature room of 25°C. Patients were allowed an interval of 30 min before running the test to adjust to room temperature.

Using the original formula published by Rolando and Refojo,[12] we calculated the evaporative rates under two different ranges of increasing RH, 25% to 35% and 35% to 45%. The area of the interpalpebral ocular surface was used to calculate AT evaporation per unit area; the image of the area was captured using a digital camera, and the area was calculated directly with the aid of computer software (Adobe Photoshop, version 6.0.1.2001; Adobe Systems, San Jose, CA). The results are expressed as $\mu L/cm^2/min$.

The artificial tear solutions were instilled with an adjustable micropipette with disposable tips.

Statistical Analysis

The analysis at different RHs, and time involving the two eye drops, was carried out using two-way analysis of variance test. Data presented in the table are expressed as mean ± SD. The Grubbs test was used for numerical consistency testing.[13]

Statistical analysis was carried out using SigmaStat 2.03 Software (Systat Software Inc, Richmond, CA).

RESULTS

The study group comprised 20 patients with keratoconjunctivitis sicca (5 men and 15 women) with a mean ± SD age of 50 ± 15 years (range: 21–75 years).

The mean rate of evaporation was higher at low RH regardless of which drop was tested. A decline in RH from 35–45% to 25–35% resulted in an average increase in evaporation rate of 37% in the Systane group and 35% in the Optive group.

Figure 1 and Table 1 show the evaporative rates for measurements at baseline and 30 min as mean and SDs for Systane and Optive at two RHs. No significant differences were detected among the groups ($P>0.05$).

DISCUSSION

The evaporation from the ocular surface increases at low RH.[14,15] The impact of low RH conditions on evaporation of AT has been reported in patients with and without dry eye.[16] Our data correlate with those in the previous study and confirm that lower RH conditions increase the evaporation from the AT.

In this study, neither Systane nor Optive showed a significant effect on AT evaporation rate after 30 min of their instillation in patients with dry eye disease. We are aware that the sample size was relatively small; thus, the statistical analysis could be underpowered.

In our previous study,[17] Systane showed a decrease in AT evaporation rate at 30 and 60 min postinstillation at RHs of 25% to 35% and 35% to 45%. The disparity with this study may be explained by the difference of preservative contained in the HP-Guar solution. The Systane solution tested in the previous study contained a nonclassic preservative: an ionic buffer system based on borate, aminomethyl propanol, sorbitol, and zinc.[17] The AT evaporation is most likely a function of many interacting variables, which suggest that any change in one of these variables might affect it. Toda et al.[18] found that evaporation rate increased for 30 min after 0.5% hydroxypropyl methylcellulose was instilled but not when 0.1% solution was applied. The effect on AT evaporation of other preservatives, such as benzalkonium chloride (BAK) and chlorobutanol (CHB), has been studied.[19] The authors did not observe any difference in tear evaporation rate after the instillation of artificial tears solutions preserved with BAK and CHB.[19] On the other hand, the application of a calcium-based ointment to the skin of the lower lid succeeded lowering AT evaporation rate.[20] The same result was

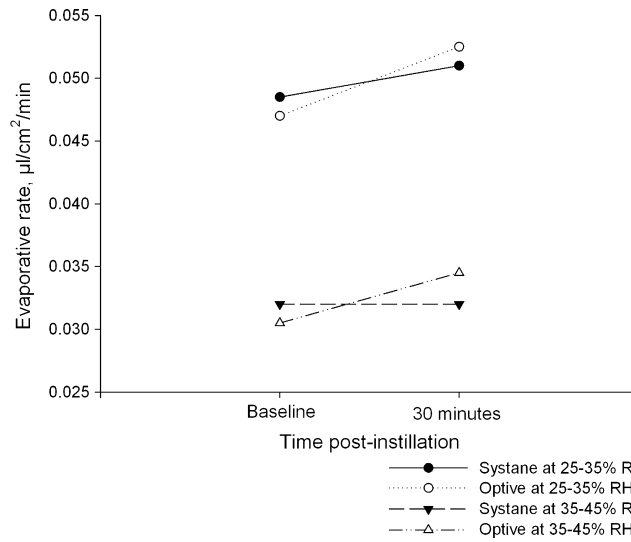

FIG. 1. A comparison of evaporative rates measured at two different relative humidity ranges for both artificial tears solutions. No statistically significant changes of evaporation were observed for either of the study agents ($P>0.05$).

TABLE 1. *Evaporative Rates After Applications of Two Artificial Tears Solutions Under Different RH Conditions*[a–d]

	Evaporative rate at 25% to 35% RH		Evaporative rate at 35% to 45% RH	
	Systane	Optive	Systane	Optive
Baseline	0.049 ± 0.023	0.047 ± 0.019	0.032 ± 0.016	0.031 ± 0.014
30 min	0.051 ± 0.025	0.052 ± 0.024	0.032 ± 0.014	0.034 ± 0.016

[a]RH, relative humidity.

[b]Values expressed as mean ± SD.

[c]Units: $\mu L/cm^2/min$.

[d]No significant differences were detected among the groups ($P>0.05$).

observed after 30 days of use of an oil-in water emulsion.[21] These findings suggest how the addition or combination of some agents may produce an effect on AT evaporation possibly by altering either the polar, nonpolar layers of the lipid layer of the tear film directly or by interaction with the aqueous mucin layer.

CONCLUSIONS

The results of this study show no statistical changes on AT evaporation rates between baseline and 30 min postinstillation of either Systane or Optive in patients with dry eyes. It is well known that evaporation from the ocular surface increased when a disturbance of the lipid layer is present. The absence of an effect of either of the study agents on AT evaporation rate might suggest that these eye drops do not adversely effect the tear film lipid layer.

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