INCREASE IN TEAR FILM LIPID LAYER THICKNESS FOLLOWING TREATMENT OF MEIBOMIAN GLAND DYSFUNCTION

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INTRODUCTION

Meibomian gland lipid secretions contribute to the formation of a stable tear film. Meibomian gland dysfunction may result in dry eye symptoms, keratoconjunctivitis (Keith, 1967; McCulley and Sciallis, 1977) and contact lens intolerance (Henriquez and Korb, 1981), presumably due to an inadequate tear film lipid layer secondary to the meibomian gland dysfunction (MGD) itself. The presence of dysfunctional meibomian glands can often be indicated by serrated and inflamed eyelid margins, although in some instances, signs of inflammation may be lacking. In contrast to normal meibomian glands whose orifices open easily and secrete transparent sebum upon gentle expression, the dysfunctional meibomian gland requires forceful digital pressure to elicit expression of sebum, which is generally cloudy in appearance. Frequently, sebum may not be released from dysfunctional meibomian glands even with forceful digital pressure. The present prospective study evaluated whether a program of manual expression of the meibomian glands of patients with a diagnosis of MGD could increase tear film lipid layer thickness by relieving meibomian gland obstruction.

MATERIALS AND METHODS

Subject Selection

Subjects ranging in age from 25-35 years (n=10) were selected on the basis of fulfilling criteria of (1) a lipid layer thickness (LLT) of 60 nm or less as judged by specular reflection techniques described below, (2) obstructed meibomian glands as evidenced by the appearance of the lid margin (Fig. 1) and the lack of visible secretion upon application of moderate digital pressure, (3) dry eye symptoms including discomfort and/or sandy, gritty, foreign body sensations, (4) no evidence of other acute internal or external hordeola or other ophthalmic conditions, and (5) no current contact lens use.

Lacrimal Gland, Tear Film, and Dry Eye Syndromes
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Figure 1. Comparison of the lower eyelid margin of (a) normal and (b,c) dysfunctional meibomian glands. (a) Obvious meibomian gland orifices (arrow). (b) Note dilated blood vessels indicative of acute inflammation, and serrated eyelid margin. (c) Note serrated eyelid margin and absence of dilated blood vessels, indicating chronic inflammation. Meibomian gland orifices are not readily apparent (b,c).

Meibomian Gland Treatment

A six-month treatment program was established that included four meibomian gland expressions performed as office procedures at six week intervals and daily self-administered meibomian gland treatment. Meibomian gland expressions in the office setting were performed under 16x magnification in order to allow observation of the discharge from the meibomian gland orifices. Two drops of topical anesthetic (0.5% proparacaine hydrochloride ophthalmic solution) were instilled into the conjunctival sac. The eyelid margins were scrubbed with a sterile cotton-tipped applicator soaked in the same anesthetic solution in order to remove surface debris. With the eye directed in upgaze, the lower eyelid was gently drawn away from the globe in order to accommodate a sterile cotton-tipped applicator soaked with the proparacaine solution. The applicator was positioned in the lower conjunctival sac of the right eye, against the lower tarsal conjunctiva adjacent to a meibomian gland and its orifice. Meibomian gland expression was achieved by simultaneous digital pressure on the skin and applicator pressure on the palpebral conjunctiva so as to compress the gland without trauma to the globe. The expressed sebum was removed with the cotton-tipped applicator during the procedure. Each meibomian gland along the lower eyelid was expressed and drained in a similar manner. The characteristics of the expressed sebum, or the lack of it, were noted. The meibomian glands of the upper eyelid were similarly expressed after directing the eye in downgaze and positioning the cotton-tipped applicator against the upper tarsal conjunctiva, adjacent to a meibomian gland and its orifice on the eyelid margin. The entire procedure was then repeated for the left eye. At the conclusion of the procedure the eyelid margins were scrubbed with cotton-tipped applicators soaked with fresh anesthetic in order to remove loose surface cells and any remaining inspissated sebum. Subjects were then instructed to perform a daily treatment regimen that included (1) application of warm compresses to the lower eyelid for two minutes and (2) the use of an eyelid scrubbing solution consisting of baby shampoo.

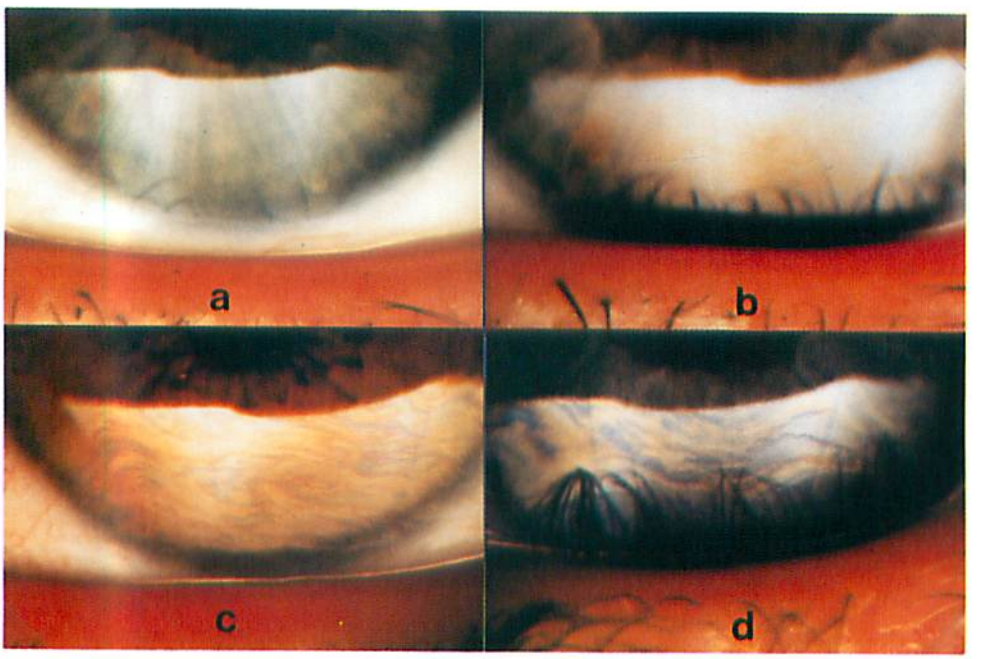

Figure 2. Color patterns of various tear films and their corresponding lipid layer thickness (LLT) values as listed in Table 1. (a) No colors or waves visible in zone of specular reflection. The gray or gray (white) appearance indicates a lipid layer thickness of 60 nm or less. (b) A dominant color of yellow is present on the lower portion of the cornea approaching the meniscus (centrally), representing a lipid layer thickness of 90 nm. (c) An irregular wave pattern with a dominant brown color (135 nm), and secondary colors of brown (yellow) (120 nm) and blue (180 nm). (d) The dominant color of blue (165-180 nm) is seen in the form of a more regular wave pattern, with secondary colors of brown and yellow indicating thinner regions.

Measurement of Tear Film Lipid Layer

A custom-designed specular reflection microscope system allowed quantification of the tear film LLT based on the interference colors of the lipid layer (Korb et al., 1993). This system included a hemicylindrical broad spectrum illumination source with heat absorbing filters, a binocular microscope with a Zeiss beam-splitter providing 70% light to a high resolution video camera, a VHS recorder, and a high resolution 20-inch color monitor. Following calibration with Eastman Kodak color reference standards (Wratten filters), the static and dynamic appearance of the lipid layer was observed before and after blinking. During this observation period, the subject was instructed to blink naturally while gazing at a fixation target. For purposes of quantitation and standardization, a specific region of the tear film was designated for analysis. This area encompassed a zone approximately one mm above the lower meniscus to slightly below the inferior pupillary margin, averaging 5 mm wide by 2.5 mm in height. The dominant color within this designated area was used as the basis for assigning LLT values. Thickness values were assigned to specific colors on the basis of prior work on tear film lipid layer interference colors (McDonald, 1969; Norn, 1979; Guillon, 1982; Hamano et al., 1982) and are summarized in Table 1. To confirm the LLT values assigned to each subject's tear film, video tape recordings were independently graded by two observers masked as to subject identity. Examples of tear films and their corresponding LLT values are shown in Figure 2 (colorplate). Statistical analysis was performed using Student's t-test.

Experimental Sequence

Baseline lipid layer thickness values were established for each subject at the time of initial examination and again two weeks later. Following these two baseline measurements, subjects began the six-month treatment protocol which included four meibomian gland expressions performed as office procedures at six week intervals and daily self-administered meibomian gland treatment. Six months after the initial meibomian gland expression, subjects were evaluated for lipid layer thickness (Measurement 1). The subject then continued daily self-treatment for an additional two weeks at which time a

Table 1. Quantification of lipid layer thickness (LLT) according to dominant color of interference pattern. Parentheticals indicate prominent, but less dominant color.

COLOR		LLT(nm)
White	=	30
Gray (White)	=	45
Gray	=	60
Gray (Yellow)	=	75
Yellow	=	90
Yellow (Brown)	=	105
Brown (Yellow)	=	120
Brown	=	135
Brown (Blue)	=	150
Blue (Brown)	=	165
Blue	=	180

second post-treatment measurement of lipid layer thickness was determined (Measurement 2).

RESULTS

In contrast to the clear sebum expressed from normal meibomian glands (Fig. 3a), manual expression of dysfunctional meibomian glands often yielded a thickened, cloudy discharge (Fig. 3b). Occasionally, this cloudy discharge was copious in nature (Fig. 3c). Frequently, meibomian material appeared to have undergone solidification and was expressed from the glands in the form of a small, firm mass (Fig. 3d). A paste-like, filamentous material was expressed in some instances (Fig. 3e). Frequently, there was a minimal yield, or no yield, of sebum despite maximum digital pressure. The consistency and morphology of the expressed material varied among meibomian glands within a given individual. Over the course of the six-month treatment period, there was some indication of improved meibomian gland function in all subjects, as evidenced by the increased number of glands from which sebum could be expressed. Concurrently, there was a decrease in the number of glands exhibiting solidified meibomian material.

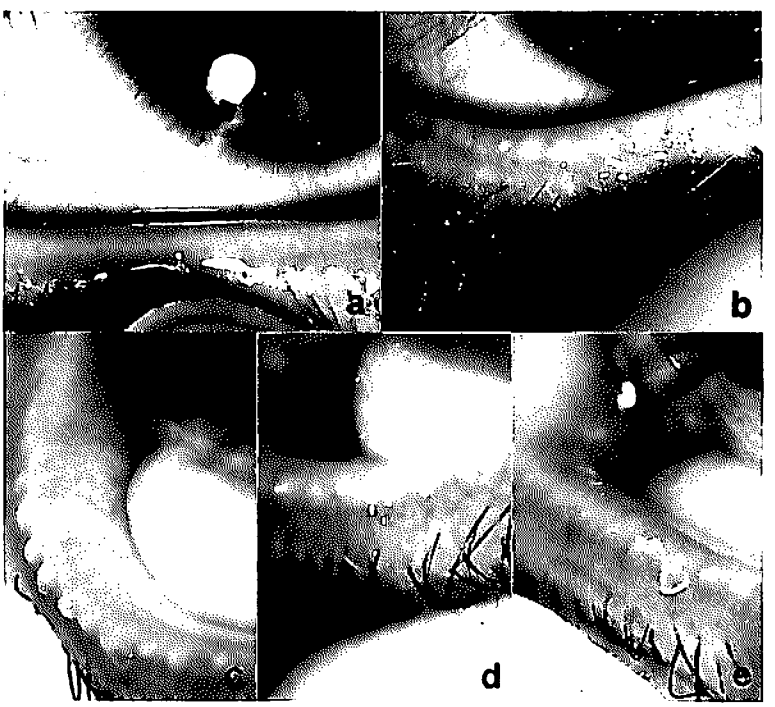

Figure 3. Meibomian gland expression of (a) normal and (b,c,d,e) dysfunctional meibomian glands. (a) Clear sebum. (b) Cloudy discharge. (c) Copious cloudy discharge. (d) Minimal discharge of firm mass. (e) filamentous, paste-like extrusion.

Baseline LLT measurements did not significantly vary at the two time points studied prior to beginning the treatment program, remaining 60 nm or less in all cases. Following the six-month program, tear film LLT values increased in all ten subjects (Table 2). The LLT increased from a value of 60 nm or less to a mean of 111 nm. This difference between pre- and post-treatment values was highly significant ($p < 0.001$). Additionally, all subjects reported symptomatic relief following the treatment program, as characterized by increased comfort and/or decreased dry eye symptoms.

Table 2. Tear film lipid layer thickness following six-month treatment program.

Subject #	Measurement 1	Measurement 2	Average
1	90	90	90
2	105	135	120
3	90	120	105
4	90	90	90
5	75	75	75
6	180	120	150
7	135	75	105
8	135	135	135
9	75	75	75
10	180	150	165

Pre-treatment values for all subjects were 60 nm or less.
Measurements 1 and 2 determined at a two week interval after the six-month program.
All data expressed as nm.

DISCUSSION

The present study examined the changes in tear film lipid layer thickness following a six-month treatment program designed to improve meibomian gland function. At the onset of the study, subjects displayed tear film LLT values of 60 nm or less, and the overt appearance of expressed sebum was consistent with that reported by Korb and Henriquez (1980) for patients demonstrating contact lens intolerance. Following treatment, subjects revealed a trend toward less solidified forms of sebum and reported symptomatic relief. These results were accompanied by a significant increase in tear film lipid layer thickness, which may result in a more stable tear film. This treatment regimen may thus be beneficial in cases of keratoconjunctivitis, dry eye, contact lens intolerance, and other syndromes where underlying meibomian gland obstruction may be a significant component in the etiology of the disorder.

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