Change in Corneal Biomechanics with Warm Compression for Treatment of Meibomian Gland Dysfunction

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Background: *Meibomian gland dysfunction (MGD) is a common eye problem. Eyelid hygiene for MGD consists of warm compression, lid massage and lid scrubs. There have been reports of visual acuity changes after warm compression.*
Objective: *To compare visual acuity, corneal curvature, corneal astigmatism and refraction before and after MGD treatment with warm compression and lid scrubs.*
Material and Method: *The subjects, who were MGD patients at Rajavithi Hospital, were asked to do lid scrubs and warm compression using a gel pad at a controlled temperature of 35℃ to 40℃ for 10 minutes once daily. Visual acuity, corneal curvature, corneal astigmatism and refraction were measured before treatment, and at 4-week and 8-week visits.*
Results: *The data of 76 eyes from 38 patients were analyzed. Mean best corrected VA were 0.13±0.13, 0.14±0.12, 0.15±0.13 logMAR, at baseline, 4-week and 8-week visits, respectively. Mean flattest and steepest curvatures were 44.20±1.70, 45.09±1.72 at baseline, 44.11±1.63, 45.07±1.73 at 4-week visit, and 44.15±1.63, 45.04±1.67 diopters at 8-week visit. Mean astigmatism was -0.89±0.59 at baseline, -0.96±0.74 at 4-week visit and -0.89±0.69 diopters at 8-week visit. Spherical equivalence was 0.52±1.75, 0.60±1.83, 0.62±1.83 diopters at baseline, 4-week and 8-week visit, respectively. There were no statistically significant differences in visual acuity, corneal curvature, corneal astigmatism or refraction parameters at each visit. All patients reported no worsening in their vision, and some stated that they had better vision than before treatment.*
Conclusion: *There were no statistically significant changes in visual acuity, corneal curvature, corneal astigmatism or refraction following warm compression in subjects presenting with MGD.*

Keywords: *Corneal biomechanics, Warm compression, Meibomian gland dysfunction, Corneal curvature, Heat*

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In 2011, the International Workshop on Meibomian Gland Dysfunction provided the most current definitions of Meibomian gland dysfunction (MGD), stating that it is a chronic, diffuse abnormality of the meibomian glands, commonly characterized by terminal duct obstruction and/or qualitative/ quantitative changes in the glandular secretion[1]. The prevalence of MGD varies from 3.5%[2] to almost 70.0%[3]. In Bangkok, Thailand the prevalence of MGD in people aged 40 years or more is 46.2% and symptoms tend to be more common in women[4]. MGD can lead to eye irritation, inflammation and ocular surface disease, the severity of which varies can affect patients' quality of life. There are several treatment options for MGD including warm compression, lid massage, lid scrubs, topical medication, systemic medication, and adjunctive treatment such as lubrication[5]. Practitioners' treatment patterns for each option also vary greatly depending on their own preference, and patients should be advised about the chronic nature of this condition, which has no known cure; however, recommendations for the performance of lid warm compression, lid massage and lid scrubs are commonly made. A report in 2007 found that warm compress application for 30 minutes induced transient visual degradation in all 13 experimental eyes, with 9 eyes exhibiting a VA decrease of at least 2 lines of the Snellen chart, correlating positively with Fischer-Schweitzer polygonal reflex[6]. McMonnies CW found that susceptibility to corneal deformation was possibly associated with elevated corneal temperature[7]; therefore, the treatment involving warm compresses combined with lid massage could induce corneal deformation from elevated corneal temperatures and rubbing-related deformation leading to visual deterioration in MGD patients.

The purpose of this study was to investigate changes in visual acuity, corneal curvature, corneal

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astigmatism and refraction following warm compression of eyelids in subjects presenting with MGD.

Material and Method

The protocol of this research was reviewed and approved by the ethics committee of Rajavithi Hospital (No. 131/2559). Patients were recruited from the Ophthalmology Department, Rajavithi Hospital, Bangkok, Thailand. Study enrollment consisted of consecutive patients who had none of the exclusion criteria and satisfied the following inclusion criteria: current diagnosis of MGD in both eyes; able to do warm compression and lid scrubs as described in the study protocol; and able to read, understand, and sign an informed consent form. Exclusion criteria were anterior segment pathology besides dry eyes; glaucoma; recent intraocular surgery; or any disease which could affect the obtained parameters.

The trial was conducted as a prospective, quasi-experimental study. The protocol was fully explained to the enrolled subjects, who were instructed and coached to perform 2 steps of lid hygiene consisting of warm compression of eyelids followed by lid scrubs. The warm compression step was done using warm gel pad compresses (35°C to 40°C) gently applied to the skin of the closed eyelids for 10 minutes once daily at home. A 200-gram hospital-made gel pad was heated using a microwave set at 600 watts for 1 minute or soaked with hot water for 1 minute to the desired temperature determined by a mercury thermometer before each application. Lid scrubs were then performed by diluting infant shampoo or commercial lid scrubs (OcuSOFT, Inc., Rosenberg, TX, USA), and all subjects were informed not to do lid massage/compression. On their initial visit, subjects were monitored throughout the procedure, ensuring that each step was done correctly. Those patients who were receiving topical or systemic medications for dry eyes were instructed to continue using prior medications. Subjects were followed-up approximately 4 and 8 weeks after their initial visit, and best corrected visual acuity (BCVA) by Snellen chart, corneal curvature (flattest curvature, steepest curvature, average curvature), and refraction by autorefractor were recorded. Subjects were asked about visual deterioration or improvement after treatment on each visit.

Statistical analysis

Refraction and BCVA data were both converted to a form more appropriate for statistical analysis. Refraction was converted to spherical equivalent (SE) [SE = sphere + (cylinder/2)]. BCVA was converted to logMAR. Corneal curvature data at baseline and each visit were analyzed using paired t-test and ANOVA. Differences were considered statistically significant when the *p*-value was less than 0.05.

Results

One hundred and thirty eyes of 65 patients with MGD were enrolled in the prtesent study. Twenty-seven subjects were considered lost to follow-up while the other thirty-eight completed all the treatment protocol and follow-up sessions and formed the statistical database for this article. Baseline characteristics are detailed in Table 1. Female patients predominated, accounting for 78.9% (30/38 patients), with males at 21.1% (8/38 patients). The mean age of the subjects was 64$\pm$11.6 years, with an age range of 29 to 87 years.

The mean measurements and standard deviation of all parameters are shown in Table 2. The flattest curvature and steepest curvature change was very minimal on each visit (44.20$\pm$1.70, 45.09$\pm$1.72 diopters at baseline, 44.11$\pm$1.63, 45.07$\pm$1.73 diopters at the 4-week visit and 44.15$\pm$1.63, 45.04$\pm$1.67 diopters at the 8-week visit. The astigmatism at the 4-week visit (-0.96$\pm$0.74 diopters) was a little higher than at the baseline (-0.89$\pm$0.59 diopters), but decreased closer to the baseline on the 8-week visit (-0.89$\pm$0.69 diopters). Spherical equivalence was 0.52$\pm$1.75, 0.60$\pm$1.83, 0.62$\pm$1.83 diopters at baseline, 4-week and 8-week visits respectively. BCVA increased from 0.13$\pm$0.13 to 0.14$\pm$0.12 at 4-week visit and to 0.15$\pm$0.13 logMAR after 8-weeks. No subjects reported visual deterioration at any point in time. Thirty-six subjects had subjective visual improvement, and no improvement was reported by the other 2 patients.

There were no statistically significant differences in corneal curvature, astigmatism, BCVA or spherical equivalence at any visit compared to the baseline (Table 3).

Discussion

MGD has been classified, based on meibomian gland secretion, into low-delivery and high-delivery states. Low-delivery states are further classified as hyposecretory or obstructive. Obstructive MGD describes the condition of decreased meibum delivery due to terminal duct obstruction[1]. Some studies have found that meibum delivery and secretion out of the glandular ducts could be enhanced by raising the

Table 1. Demographics of the study population

	No. of participants (%)	No. of eyes	Age (years)
Total	38	76	64.00±11.60
Men	8 (21.1)	16	70.40±11.00
Women	30 (78.9)	60	62.30±11.30

Values are represented as mean ± SD

Table 2. Mean measurement (± standard deviation) at baseline, 4-week visit and 8-week visit

	Baseline	At 4-week	At 8-week
Central corneal curvature (diopters)			
Flattest curvature	44.20±1.70	44.11±1.63	44.15±1.63
Steepest curvature	45.09±1.72	45.07±1.73	45.04±1.67
Astigmatism (diopters)	-0.89±0.59	-0.96±0.74	-0.89±0.69
Best corrected visual acuity (logMAR)	0.13±0.13	0.14±0.12	0.15±0.13
Spherical equivalence (diopters)	0.52±1.75	0.60±1.83	0.62±1.83

Values are represented as mean ± SD

Table 3. Pairwise comparisons between baseline, 4-week visit and 8-week visit

	Baseline vs. 4-week visit		Baseline vs. 8-week visit		4-week visit vs. 8-week visit	
	MD	*p*-value	MD	*p*-value	MD	*p*-value
Central corneal curvature (diopters)						
Flattest curvature	0.092	0.287	0.049	0.855	-0.043	0.819
Steepest curvature	0.022	1.000	0.051	0.241	0.030	0.943
Astigmatism (diopters)	0.070	0.739	0.002	1.000	0.072	0.333
Best corrected visual acuity (logMAR)	-0.014	0.481	-0.017	0.434	-0.003	1.000
Spherical equivalence (diopters)	-0.074	0.682	-0.092	0.806	-0.018	1.000

Values are represented as mean difference (MD) and *significant at *p*-value <0.05

temperature of the eyelids[8], effectively reducing the conjunctival tear evaporation rate[9] and inducing symptom improvements in MGD patients[10]. McCulley JP found that meibomian secretions from normal subjects began to melt at 32°C and 35°C in patients with obstructive MGD[11] even though the temperature and duration of warming therapy still varies greatly depending on practitioner preference[11,12]. Moreover, lid warming can be achieved in a number of ways (e.g., hot shower, warm towel compress, infrared source or electric warming devices[13-15]). The authors' protocol, which used a gel pad at 35°C to 40°C for 10 minutes for lid warming, would be effective in meibum enhancement.

It is known that direct application of heat to the cornea can alter the configuration of collagen fibers, and that changes in corneal shape occur in conductive keratoplasty treatment[16,17]. Corneal parameters (surface asymmetry index (SAI), and surface regularity index (SRI) measured by corneal topography have been found to change after treatment with hard-boiled eggs at temperatures between 40°C and 50°C covered with a wet cloth gently touching the eyelid without rubbing for 5 minutes[18]. Some subjects have reported transient blurred vision after treatment, but there has been no information on visual acuity[18]. Solomon JD reported

transient visual degradation, with 69.2% of eyes (9/13 eyes) exhibiting a VA decrease of at least 2 lines of the Snellen chart, correlating positively with Fischer-Schweitzer polygonal reflex[6].

The demographic characteristics of the present study showed that subjects were predominately female, and that the mean age was 64 years which is similar to the previous reports of MGD prevalence in Bangkok, Thailand[4]. There were no significant differences in corneal curvature, astigmatism, visual acuity or refraction after treatment with warm compression for 4 and 8 weeks. In previous reports, visual deterioration and corneal changes were transient, and in the present study, we were unable to detect changes at the follow-up visits because values returned to their baseline before the data was collected. Most subjects reported visual improvement, and this might have been because of the increased lipid tear component from warm compression, but unfortunately, we lacked data about tear film or a questionnaire about the patients' symptoms.

Lid rubbing or massage can also elevate the corneal temperature, and alterations in corneal deformation have been described in conditions such as normal eye[19], keratoconus[20,21], and chalazion[22]. A combination of lid warming with any method of lid massage may induce more corneal deformation in MGD patients. Patient selection for lid massage is recommended, especially for patient who are at risk e.g., those with keratoconus or allergies. The present study instructed patients not to do lid massage because we wanted to know the effect of warm compression alone without possible cofactors.

With regard to clinical application, the present study showed that a warm compression protocol, as in the present study, could be performed in patients who had MGD and planned to undergo cataract surgery or refractive surgery without alteration of corneal curvature or refraction data which are important in IOL/treatment plan calculations. Using the 200-gram hospital-made gel pad heated as instructed is more convenient and less speculative than putting a washcloth into hot water to get the desired temperature. This may improve compliance from patients with this chronic disease.

There were limitations to the present study. Warm compress therapy of 35°C to 40°C was applied for 10 minutes once daily, and we do not know what the effect would have been on the cornea after a longer treatment period or at a higher temperature. There was also a lack of information regarding other corneal parameters such as aberration changes, SAI, SRI from corneal topography. Another drawback of the study was that there was no monitoring of MGD signs and symptoms after treatment. Further studies including those data would be useful.

Conclusion

There were no statistically significant changes in visual acuity, corneal curvature, corneal astigmatism or refraction following warm compression using a gel pad at a controlled temperature of 35°C to 40°C for 10 minutes once daily in subjects presenting with MGD.

What is already known on this topic?

Eyelid hygiene treatment for MGD consists of warm compression, lid massage and lid scrubs. There have been reports of visual acuity change after warm compression.

What this study adds?

No change was noted in visual acuity, corneal curvature, corneal astigmatism or refraction after a 10-minute application of a warm compress at a controlled temperature of 35°C to 40°C once daily for 8 weeks for MGD treatment.

This warm compression protocol can be performed in MGD patients who plan to undergo cataract surgery or refractive surgery without alteration of corneal curvature or refraction data which are important in IOL/treatment plan calculations.

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Potential conflicts of interest

None.

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