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CLINICAL REPORT

# All Warm Compresses Are Not Equally Efficacious

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## ABSTRACT

***Purpose.*** To investigate which warm compress (WC) methods used in a small case series are the most effective in providing heat to the inner eyelids for the supplemental treatment of meibomian gland dysfunction.

***Methods.*** Inclusion criteria included the following: 18 years or older and willingness to participate in the study, no current ocular inflammation/disease, and no ocular surgery within the last 6 months. Five patients were fully consented and enrolled. Various forms of contact and noncontact WC heating methods (dry, wet/moist, and chemically activated dry heat) were tested. A paired contralateral design was used; each subject had a heated test eye and an unheated control eye. For both test and control eyes, the temperature of the external upper, external lower, and internal lower lids was measured at baseline and every 2 minutes for 10 minutes during application. Each participant underwent each of the eight treatments under study. Microwaved compresses were heated to 47 ± 1.0°C; two compresses were self-heating and thus not under investigator control.

***Results.*** The mean (±SD) age of the patients was 42.2 (±20.3) years. Out of the eight methods tested, the bundled wet/moist towel method was the only compress that elevated the temperature of all three lid surfaces (external upper, external lower, and internal lower lids) to 40°C or higher. The chemically activated EyeGiene, MGDRx EyeBag, and MediBeads compresses resulted in the lowest temperature increase at the inner palpebral surface.

***Conclusions.*** The Bundle method, although the most labor intensive, increased lid temperatures above therapeutic levels, as reported in the literature, for all measured sections during the WC application. As such, this method of WC application can be recommended for supplemental at-home therapy for meibomian gland dysfunction and any condition requiring that therapeutic heat of 40°C be administered to the meibomian glands.

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Key Words: meibomian gland dysfunction, warm compress, eyelid temperature

The International Workshop on Meibomian Gland Dysfunction concluded that meibomian gland dysfunction (MGD) may be the leading cause of dry eye disease throughout the world.[1] The Dry Eye Workshop in 2007 reported that nearly five million people in the United States have dry eye, with millions more likely to be experiencing milder symptoms.[2] Unsurprisingly, large epidemiological studies have found anywhere between 5 and 30% of subjects 50 years or older have dry eye, with as much as two-thirds of all cases caused by MGD.[2–4] Individual studies from China, Japan, and Taiwan reported greater than 60% prevalence of MGD in their respective populations.[1]

Warm compresses (WCs) are routinely recommended and, provided compliance is good, they are generally considered to be good supplemental therapy for MGD.[5–10] The heat from the compress is understood to soften the secretions in obstructed glands, temporarily increasing the lipid layer thickness and stabilizing the tear film, thus preventing excessive evaporation of the aqueous layer and evaporative dry eye.[5,7,11,12] There is no single melting point for meibomian secretion because the chemistry and viscosity of the secretion itself are variable, and these physical properties impact the temperature at which the secretion becomes mostly liquid.[5,6,9] Secretions from severely obstructed glands have been found to have considerably higher melting points than the secretions from apparently normal, unobstructed glands.[6,9] Although the precise temperature for optimal WC therapy is not known, it is understood that higher temperatures, preferably higher than or equal to 40°C, provided safety is maintained, are superior for more severely obstructed glands.[5,6,9]

A review of the literature reveals many methods of heat application to the eyelids for the treatment of MGD.[5,10,13,14] Despite recent studies and a number of Web sites dedicated to WC instructions, there is no standard method or consistent recommendation for the selection of and application method for WCs.[1,10] To illustrate this point, some examples of WCs include heated tea bags,

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bags of rice, hardboiled eggs, lamps held near the lids, and even baked potatoes.[15,16] Results from using a WC can vary significantly when one considers the variety of methods available for heating a compress, how long the compress is applied, and whether the compress remains hot enough for the duration of the application. Variation in the compress efficacy, in combination with poor compliance, can lead to waning enthusiasm for the home therapy, which only further diminishes the likelihood of successful treatment.[5,7,10,17] The goal of this case series evaluation was to investigate which of the selected method(s) were most effective in providing heat to the meibomian glands, measured at the inner eyelid surface, for the treatment of MGD.

## METHODS

All tenets of the Declaration of Helsinki for the protection of human subjects in medical research were strictly observed and the approved informed consent was obtained from all subjects before enrollment. An independent ethics committee approved the study. A total of five subjects were recruited from a single practice in Massachusetts in December 2013. Inclusion criteria included the following: 18 years or older and willingness to participate in the study, no current ocular inflammation/disease, and no ocular surgery within the last 6 months.

### The Compresses

A total of eight different compress and heated devices were used for this study (Table 1). Four WC systems used dry heat (required no water) and were heated by a microwave, which included the MediBeads (*Bruder Eye Hydrating Compress*), Eye-ssential, rice bag, and MGDRx EyeBag WCs. Each has its own set of heating time requirements and instructions. Two compress methods were heated in the microwave and delivered moist heat, which included the Bundle method and Tranquileyes XR compresses. The Blephasteam was heated electrically with an attached plug for a 10-minute controlled treatment and the EyeGiene produced heat from a chemical reaction within a packaged unit. All compresses heated in the microwave were given to subjects when they reached 47°C (±1°C). As per the instructions, they were only heated once. The EyeGiene compress and Blephasteam heated independently and therefore no microwave was used. Table 1 lists the various compresses used and specific descriptions regarding the design and method in the delivery of heat each compress uses.

Unlike the other methods used in this case series evaluation, the Bundle method was not well known. A brief description of this method, as summarized in Table 1, is as follows: The microfiber towels were dampened (5 to 6) in room-temperature water and excess water was squeezed out. The towels were then folded (long rectangles to ~12 × 6 cm each). The first towel was rolled into a tight cylinder. The remaining towels were wrapped around the first towel until a large bundle was created. The bundled towels were placed in a container, covered with lid, and microwaved. The bundle was heated for about 1.5 minutes and the temperature was then tested. In this study, the compress was used when the outer towel reached 47°C (±1°C). The outermost towel was applied first according to standard WC instructions (keep the remaining towels in a covered dish). A new towel was removed from the heated bundle at each 2-minute temperature measurement interval.

### Methods for Temperature Measurement on Subjects

The methods for gathering temperature data from the lid surfaces have been published elsewhere.[10] Briefly, temperatures measured on the subjects were taken at baseline/time zero and every 2 minutes over a 10-minute period using an infrared pyrometer (Model OS-611, Omega, Stamford, CT), on the external upper eyelid, external lower eyelid, and internal lower eyelid surfaces. When measuring the eyelid surface temperature, the infrared pyrometer was held according to the manufacturer's instructions, close to the eyelid surface without making contact. The internal temperature measurements were focused exclusively on the lower lids to minimize heat loss during the measurement process. This is attributed to the relative ease with which the lower lid, in contrast with the upper lid, can be everted and returned to its natural position.

Patients were instructed to look down first to measure external upper lid temperatures and then asked to look up for external and internal lower lid temperatures. The lower lid was carefully and quickly everted to expose the palpebral conjunctiva for inner lower lid temperature readings. The control eye was repeated in the same fashion. All measurements were taken in the central section of each lid surface.

Each subject had each of the eight different treatments. For each subject, consecutive heating trials were conducted a minimum of 5 hours after the prior heating trial to ensure lid temperatures returned to normal baseline temperatures before each trial. Insufficient time between compresses would potentially provide baselines that were artificially elevated. Compresses were only applied to one eye, randomly chosen as the test eye, with the contralateral eye used as the control. The same test eye was used for each method, except the Blephasteam in which both eyes served as test eyes. (It was not possible to have a contralateral control eye because of the device design.) Further, the Blephasteam-treated eye could not be measured every 2 minutes because of the design of the heating device. For compresses that require a patient holding them on their face, subjects were instructed to place compresses with close apposition to both upper and lower lids without exerting additional pressure to the globe through closed lids. The ambient temperature of the room all trials were conducted in remained between 20 and 22°C (between 68 and 72°F), and the same investigator conducted each WC application and measured lid temperatures for each section for every subject to minimize variability in technique and the gathering of data.

### Statistical Analysis

Descriptive statistics are reported as means ± SD. Significance was determined at the level $\alpha = 0.05$. Repeated-measures analysis of variance with Bonferroni correction and F tests for multiple means were used as appropriate. A *post hoc* power analysis was performed to ensure sufficient sample size to ensure 95% power to avoid a type II statistical error. Although a sample size of 5 is modest, there was limited variability in the baseline temperatures between these subjects and a high discrepancy between the heated compress and the baseline temperatures. Ideally, the *post hoc*

**TABLE 1.**
Description of WCs

| WC | Type of compress and method of heating | Description and materials | Company information |
|---|---|---|---|
| EyeGiene | Dry—chemical | • 15 cm × 5.5 cm Inactivated unit comprises two sealed foil compartments<br>• Activation requires squeezing one side and combining the contents together<br>• Instructions recommend wearing the mask for 8 to 10 min | Eyedetec Medical, Inc, Danville, CA<br>www.eyedetec.com |
| MediBeads | Dry—microwave | • 21 cm × 8.5 cm<br>• Cloth mask enclosed with patented ''MediBeads''<br>• Heating instructions—20 s in a microwave, with an additional 10 s if necessary, without exceeding 30 s total<br>• Recommended treatment: 3 to 5 min | Bruder Healthcare Company, Alpharetta, GA<br>www.bruder.com |
| Eye-ssential | Dry—microwave | • 17 cm × 6.5 cm<br>• BPA and phthalate-free latex; elastic head strap; filled with blue ''pearls'' (5 mm, absorbent polymer)<br>• Suggested heating times for the mask depend on microwave wattage capabilities | Thera°Pearl, LLC, Jessup, MD<br>www.therapearl.com |
| Rice bag | Dry—microwave | • 10 cm × 21 cm<br>• ~1 cup of rice | |
| MGDRx EyeBag | Dry—microwave | • 26 cm × 11 cm<br>• Flaxseeds<br>• Silver silk material on one side and 100% brushed black cotton on the other | The EyeBag Company, LTD, West Yorkshire, UK<br>www.eyebagcompany.co.uk |
| Bundle method | Wet—microwave | • Dampen and squeeze out 5–6, 50 × 50 cm microfiber cloths. Fold each cloth to measure 12.5 × 6 cm; roll up the layers as indicated in the figure. Soak and then heat in the microwave for ~1.5 min | |
| Tranquileyes XR | Wet—microwave | • 6 × 8 cm (bead packs); goggles<br>• Unique combination of dry and wet compress characteristics in a moisture goggle | Eye Eco Inc, Temecula, CA<br>www.eyeeco.com |
| Blephasteam | Heated goggle—electronic | • 10-min automatic treatment<br>• Plastic goggle with adjustable strap—connected to control box and electric plug<br>• Blephasteam rings moistened by saline placed in each goggle chamber | Laboratoires Théa, Clermont-Ferrand, France<br>www.blephasteam.com/home.htm |

power analysis would be performed with the SD of a much larger sample including male and female subjects, rendering the analysis more powerful.[10] All statistical analysis was performed using GraphPad Prism (La Jolla, CA).

## RESULTS

The age range of the subjects was 23 to 70 years (mean [±SD] age, 42.2 [±20.3] years; 5 women, 0 men). A *post hoc* power analysis revealed that the sample size was sufficient to offer 95% power to avoid a type II statistical error.

### Baseline Eyelid Temperatures

Table 2 shows the mean baseline temperatures of test and control eyes for each WC trial. There were no significant differences between test and control lid surface temperature eyes at baseline in each group ($p = 0.4$). However, as expected, and as has

**TABLE 2.**
Baseline temperatures

| | External upper lid, °C | External lower lid, °C | Internal lower lid, °C |
|---|---|---|---|
| EyeGiene | 35.6 ± 0.5 | 35.4 ± 0.5 | 35.6 ± 0.5 |
| Eye-ssential | 35.6 ± 0.5 | 35.6 ± 0.5 | 36.4 ± 0.5 |
| MediBeads | 35.4 ± 0.5 | 35.4 ± 0.5 | 36.2 ± 0.4 |
| Bundle method | 35.6 ± 0.5 | 35.6 ± 0.5 | 36.6 ± 0.5 |
| Rice bag | 35.0 ± 0.0 | 35.5 ± 0.0 | 35.8 ± 0.4 |
| Tranquileyes | 35.2 ± 0.4 | 35.2 ± 0.8 | 36.2 ± 0.8 |
| Blephasteam | 35.1 ± 0.3 | 35.3 ± 0.7 | 35.8 ± 0.6 |
| MGDRx EyeBag | 35.0 ± 0.0 | 35.0 ± 0.0 | 35.8 ± 0.4 |

**TABLE 4.**
Final temperatures

| | External upper lid, °C | External lower lid, °C | Internal lower lid, °C |
|---|---|---|---|
| EyeGiene | 37.2 ± 2.0 | 36.6 ± 2.1 | 37.0 ± 1.9 |
| Eye-ssential | 39.0 ± 1.2 | 38.4 ± 1.1 | 38.0 ± 1.4 |
| MediBeads | 39.4 ± 1.3 | 38.4 ± 1.3 | 37.4 ± 1.3 |
| Bundle method | 41.0 ± 1.2 | 40.0 ± 1.0 | 40.0 ± 1.0 |
| Rice bag | 41.0 ± 1.0 | 39.4 ± 1.1 | 38.2 ± 0.8 |
| Tranquileyes | 38.2 ± 1.6 | 37.8 ± 1.1 | 38.2 ± 1.5 |
| Blephasteam | 40.0 ± 1.5 | 38.4 ± 1.7 | 38.2 ± 0.9 |
| MGDRx EyeBag | 39.2 ± 1.2 | 38.2 ± 0.8 | 37.6 ± 0.9 |

been previously documented, the outer lid surface temperature was consistently cooler than the inner lid surface temperature.[10,18] The difference, although small, is significant ($p = 0.03$).

## Maximum Eyelid Temperatures

Table 3 shows maximum temperatures achieved in each lid section and the corresponding time that temperature was recorded. The bundle WC heating of the inner lower lid palpebral surface reached the highest maximum temperature when compared with that of the other WC methods. The heating from the bundle WC was only statistically significantly higher than that from the EyeGiene, the MGDRx, and the MediBeads ($p < 0.05$).

## Final Temperatures

Table 4 shows final temperatures measured for each lid section measured once 10 minutes of heating was complete. The only method that increased the inner lower lid temperatures above 40°C was the Bundle method.

Figs. 1 to 3 show the temperature measurements and heating curves for all compresses, with the exception of the Blephasteam, over the 10-minute period. There were no significant differences in the lower lid internal temperatures until 4 minutes had passed. At 4 minutes, the bundle WC resulted in internal lower lid heating (39.8 ± 0.8°C) that was significantly greater than that of the EyeGiene (37.4 ± 1.3°C, $p < 0.05$) and the MGDRx (37.6 ± 0.5°C, $p < 0.05$). This significant difference was maintained throughout the heating period. At 8 minutes, the internal lid heating from the bundle WC was also significantly warmer that that of the MediBeads (37.6 ± 1.5°C, $p < 0.05$). After 10 minutes of heating, the bundle WC resulted in internal lower lid heating (40.0 ± 1.0°C) that was significantly greater than that of the EyeGiene (37.0 ± 1.3°C, $p < 0.05$), the MGDRx (37.6 ± 0.9°C, $p < 0.05$), and the MediBeads (37.4 ± 1.3°C, $p < 0.05$). The external lid temperatures shown in Figs. 1 and 2 show significant variability.

The Tranquileyes XR compress evidenced a sharp decline in external upper lid temperatures after minute 4. Lower lid surfaces never reached 40°C, and by the end, all lid surfaces were near 38°C. The Blephasteam heated the external upper lids to 40°C, with both lower lid surfaces reaching just above 38°C. The humid environment provided within each chamber was immediately felt and sustained during the entire treatment by each subject.

## DISCUSSION

Meibomian gland dysfunction is understood to be the leading cause of dry eye, and thus, MGD poses a significant public health concern.[1,19] Although removal of obstruction is critical to the success of comprehensive MGD therapy, supplemental at-home heating of glands has long been considered to be of benefit to patients with MGD.[20] Despite the challenges posed by lack of compliance, WCs continue to play an important supplementary role in the treatment of MGD. The full range of WC methods extends beyond the scope of this case series investigation. However, the eight methods investigated in this study encompass the variety of commonly used forms of WC that patients are likely to encounter, either through a recommendation by their clinician or from their own research.

Most of the methods were able to increase outer upper lid surface temperatures above 40°C within the first minute. However, only the heated moist cloths used in the Bundle method elevated internal

**TABLE 3.**
Maximum temperatures

| | External upper lid | | External lower lid | | Internal lower lid | |
|---|---|---|---|---|---|---|
| | Temperature, °C | Time | Temperature, °C | Time | Temperature, °C | Time |
| EyeGiene | 39.6 ± 1.5 | Minute 2 | 38.6 ± 1.3 | Minute 2 | 37.4 ± 1.3 | Minutes 4–8 |
| Eye-ssential | 40.6 ± 1.5 | Minutes 2–4 | 39.8 ± 1.5 | Minute 2 | 39.0 ± 0.7 | Minute 4 |
| MediBeads | 40.2 ± 1.6 | Minutes 2–4 | 39.4 ± 1.3 | Minute 6 | 38.0 ± 1.4 | Minutes 4–6 |
| Bundle method | 41.4 ± 1.5 | Minute 6 | 40.4 ± 1.3 | Minute 4 | 40.0 ± 0.8 | Minute 10 |
| Rice bag | 42.0 ± 0.7 | Minute 2 | 39.6 ± 1.3 | Minute 4 | 38.6 ± 0.5 | Minute 6 |
| Tranquileyes | 40.8 ± 1.9 | Minutes 2–4 | 39.2 ± 0.8 | Minutes 2–4 | 38.8 ± 1.1 | Minute 6 |
| Blephasteam | | | | | | |
| MGDRx EyeBag | 40.4 ± 0.9 | Minute 4 | 38.2 ± 0.8 | Minute 4 | 37.8 ± 0.8 | Minute 6 |

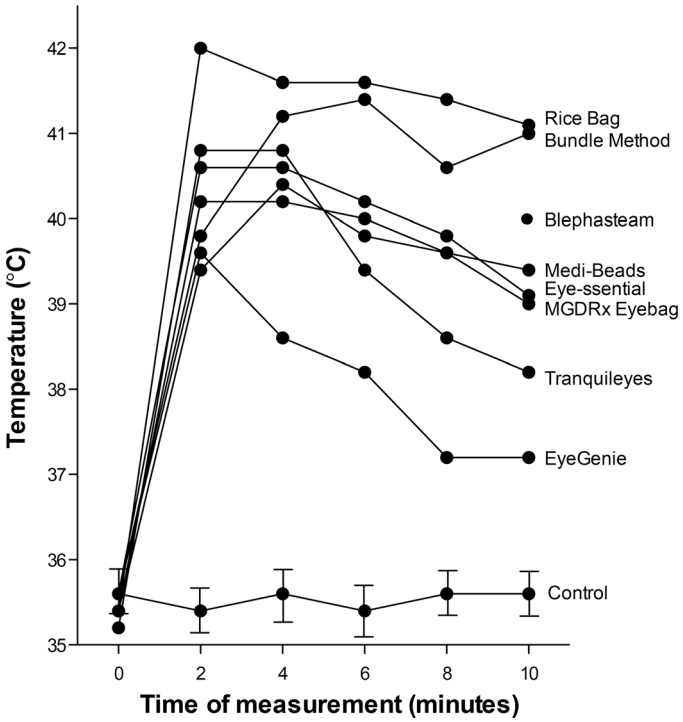


**FIGURE 1.**

Mean external upper lid temperature measurements for all subjects (n = 5) with all compress methods (n = 8). Standard deviations are large and overlapping, rendering the figures overly busy and thus have not been included. Contralateral unheated control data ± SDs are also included (n = 5).

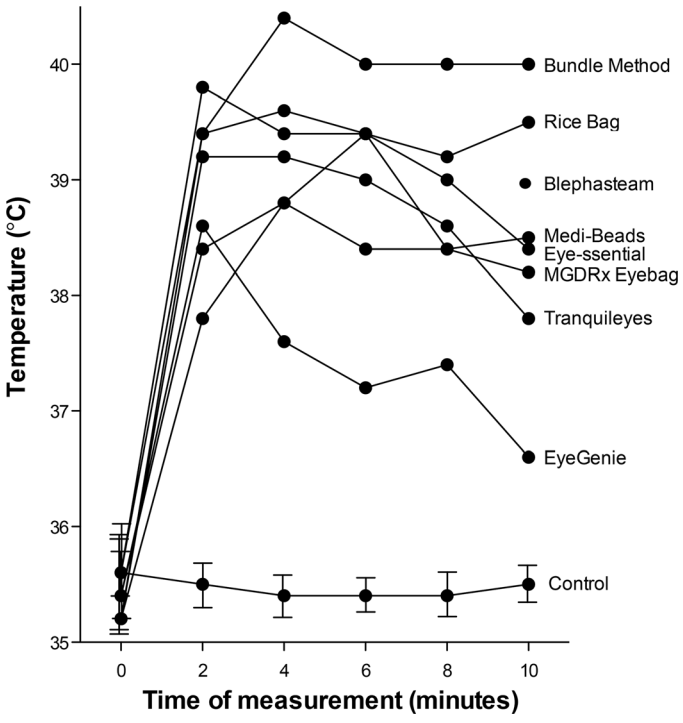


**FIGURE 2.**

Mean external lower lid temperature measurements for all subjects (n = 5) with all compress methods (n = 8). Standard deviations are large and overlapping, rendering the figures overly busy and thus have not been included. Contralateral unheated control data ± SDs are also included (n = 5).

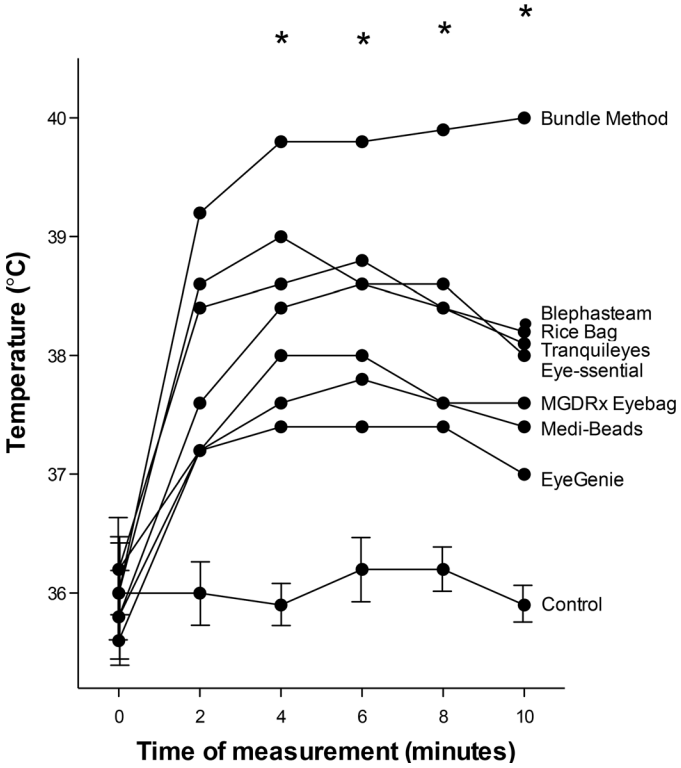


**FIGURE 3.**

Mean internal lower lid temperature measurements for all subjects (n = 5) with all compress methods (n = 8). Standard deviations are large and overlapping, rendering the figures overly busy and thus have not been included. Contralateral unheated control data ± SDs are also included (n = 5). *The bundle WC resulted in internal lower lid heating that was significantly ($p < 0.05$) greater than that of the EyeGiene and the MGDRx. This significant difference was maintained throughout the heating period. At 8 and 10 minutes, the bundle WC was also significantly warmer that that of the MediBeads ($p < 0.05$).

lower lid surfaces higher than or equal to 40°C after 10 minutes. A compress that is not able to elevate lid temperatures beyond a therapeutic level will be limited in its efficacy. One could argue that an advantage to many of the beaded masks or rice bag as compresses from a patient's perspective is their ease of use. Instructions generally advised a single heating of 40 seconds or less, and as previously reported, a limitation to using a wet towel is the labor-intensive need to reheat the towel so as to maintain consistent temperature. Consistent temperature is necessary to produce a sustained elevated lid temperature.[10] With an improved system of wrapping damp towels as performed in the Bundle method, a single heating can now be applied to a wet compress that incorporates easy handling and a method that is proven to elevate lid temperatures more effectively. The Bundle method helps standardize a technique that, if done correctly, can outperform other compress types. A noncooling or self-heating compress would serve to generate an even more reliable effect of elevating the internal lid temperature/meibomian glands to higher than or equal to 40°C. The reasonable constraint in generating a commercially available self-heating compress is that safety concerns drive the temperature of the marketable device down where the need for therapeutic efficacy demands higher temperatures. With a method such as the bundle method described here, the onus is on the clinician to teach this method and its goals correctly and on the patient to administer and use the compress effectively, both of which can be barriers for successful treatment to heating the eyelids for MGD.

Comparing the efficacy of heat retention and heat transference to lid structures among this group produced a range of results and confirms that not all WCs are equally effective. The difference in the way heat is delivered to the lid surfaces plays a crucial role, with wet heat having more success in these experiments. The benefit of a heated wet compress over a compress using dry heat may be a result of the different physical attributes in transference of heat.[21,22] Conversely, Arita et al.[12] concluded that "warm-moist" type of devices were less effective in improving tear film condition and meibomian gland functioning compared with nonmoist warm devices. Although no explanation was provided, one could speculate that rapid evaporative cooling after wet heating plays a role.

While conducting this investigation, many subjects reported momentary and mild visual blur immediately after a WC. Transient visual degradation was an expected side effect and has been previously associated with WCs.[23] The transient phenomenon is known as the Polygonal reflex of Fischer-Schweitzer.[24,25] Heated application by a compress has been shown to increase lid and corneal temperatures significantly and the pressure placed upon the globe through closed lids can result in temporary changes to the structure of the corneal epithelium.[23,26] Significant corneal deformation or corneal ectasia has also been reported, addressing the potential long-term risks from WCs if improperly used or if patients exercised lid massage with their compress.[27]

This study did not measure any signs of MGD, whether the compresses decreased symptoms and improved meibomian gland function and also used a female-only sample. The main goal was to see which compresses could adequately elevate lid temperatures higher than or equal to 40°C, which was not reliant on whether subjects experienced dry eye symptoms or had MGD. A possible study beyond this investigation would incorporate the heated measurements of these compresses and correlate those data with any possible signs of improvement in gland functioning and symptoms. For now, we have to infer that a compress that efficiently elevates all lid surfaces sufficiently is more likely to be a better supplementary method to treat obstruction in MGD based on our understanding of the melting range for meibum secretions and the importance for thick lipid layer thickness and stable tear film. Another limitation of this case series evaluation was the measuring of lid temperatures every 2 minutes. Without maintaining constant contact with the compress, heat will naturally escape whenever a compress is not being applied. This was certainly the case in this study. However, compresses were never away from lid surfaces for more than a few seconds, limiting the amount of heat loss that would ultimately affect final lid temperatures.

Regardless of any limitations of WC use, any compress applying heat, if applied safely, will likely still be a better option than not using a compress at all. The growing awareness of the far-reaching implications of untreated MGD is paralleled by the need for similar expansion and growth in our approach to educating our patients as to the benefits and limitations of supplemental at-home therapy for MGD.

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