In-vivo heat retention comparison of eyelid warming masks

Article *in* Contact lens & anterior eye: the journal of the British Contact Lens Association · May 2016

DOI: 10.1016/j.clae.2016.04.002

CITATIONS
3

READS
167

3 authors, including:

Etty Bitton
Université de Montréal
61 PUBLICATIONS **125** CITATIONS

SEE PROFILE

Contact Lens and Anterior Eye xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Contact Lens and Anterior Eye

journal homepage: www.elsevier.com/locate/clae

In-vivo heat retention comparison of eyelid warming masks

Etty Bitton*, Zoé Lacroix, Stéphanie Léger

Ecole d'optométrie, Université de Montréal, Montreal, Quebec, Canada

ARTICLE INFO

Article history:
Received 3 December 2015
Received in revised form 12 March 2016
Accepted 11 April 2016

Keywords:
MGD
Warm compress
Eyelid temperature

ABSTRACT

Purpose: Meibomian gland dysfunction (MGD) is one of the most common causes of evaporative dry eye. Warm compresses (WC) are recommended as adjunct therapy to slowly transfer heat to the meibomian glands to melt or soften the stagnant meibum with targeted temperatures of 40−45° C. This clinical study evaluated the heat retention profiles of commercially available eyelid warming masks over a 12-min interval.

Methods: Five eyelid-warming masks (MGDRx Eyebag®, EyeDoctor®, Bruder®, Tranquileyes XR™, Thera°Pearl®) were heated following manufacturer's instructions and heat retention was assessed at 1-min intervals for 12 min. A facecloth warmed with hot tap water was used as comparison.

Results: Twelve (n = 12) subjects participated in the study (10F:2 M, ranging in age from 21 to 30 with an average of 23.2 ± 3.8 years). Each mask demonstrated a unique heat retention profile, reaching maximum temperature at different times and having a different final temperature at the end of the 12-min evaluation. After heating, all eyelid warming masks reached a temperature near 37° C within the first minute. The facecloth was significantly cooler than all other masks as of the 2-min mark ($p < 0.05$).

Conclusions: Reusability, availability and heat retention profiles should be considered when selecting an eyelid warming masks for adjunct WC therapy in the management of MGD. All masks tested, with the exception of the facecloth, demonstrated stable heat retention throughout the 12 min, bringing further awareness that patient education is required to discuss the shortcomings of the heat retention of the facecloth, if only heated once.

1. Introduction

Meibomian gland dysfunction (MGD) appears to be the most common cause of evaporative dry eye [1–3]. Regardless of the driving factor for MGD, ultimately it leads to an inadequate lipid layer, which increases the evaporation of the underlying tear film. Although management options vary for MGD treatment, warm compresses (WC) are regarded as a primary home-based therapy [2,4–6]. Warm compresses aiming to provide a thicker lipid layer by softening the stagnant meibum in the glands in order to facilitate it's expression upon blinking [2,7,8]. The challenge in heating the eyelid surface is to have the appropriate temperature reach the meibomian glands (MG). The heat must dissipate through the eyelid tissue to reach the meibomian glands, which are located deep within the inner surface of the eyelids.

Although WC are commonly recommended, there is no standardization with respect to duration or frequency [9–12]. While the exact temperature for WC therapy has not been determined, temperature ranges of 40 °C [8] to 45 °C [13] have been reported to effectively soften meibum over a 5–15 min session. Historically, the use of a warm moist facecloth has been widely adopted by eye care practitioners (ECP) as an accessible and affordable option for WC. However, the heat quickly dissipates, rendering it ineffective unless it is reheated every 2–4 min [13]. It has been demonstrated that WC therapy can improve dry eye symptoms, tear film stability, tear evaporation, tear film lipid layer thickness, and decrease MG orifice obstruction [8,14–19].

Several eyelid-warming masks have become commercially available and it would be of clinical interest to compare their heat retention profiles to the traditional facecloth. Lacroix et al. [20] recently published *ex-vivo* heat retention profiles of five eyelid-warming masks and a facecloth. The experiment was performed on a non-conductive surface to remove the variability of eyelid thickness, tissue heat retention and distribution. The heat retention profiles differed for each mask, with the facecloth maintaining the desired temperature of 40–45 ° C for 3 min quickly degrading in temperature after this time [20]. Three masks in that study (MGD Rx Eyebag®, The Eye Doctor®, and Thera°Pearl Eye-essential mask (Bausch + Lomb)) had a stable heat retention profile over the first 8 min of the12-min evaluation.

* Corresponding author.
E-mail address: etty.bitton@umontreal.ca (E. Bitton).

http://dx.doi.org/10.1016/j.clae.2016.04.002
1367-0484/

The objective of the present study was to evaluate the *in vivo* heat retention properties of commercially available eyelid-warming masks on human eyelids over a 12-min interval and compare them with the facecloth.

2. Materials and methods

Five eyelid-warming masks and a moist facecloth were used in this study to investigate their heat retention properties. The selected masks were the MGD Rx Eyebag®, The Eye Doctor®, Bruder® eye hydrating compress, Tranquileyes XR™ (Eyeeco), Thera°Pearl Eye-essential mask (Bausch + Lomb) and a moist facecloth. The description of each eye mask and facecloth, including the recommended heating instructions have been described elsewhere [20]. Each mask was heated using a microwave following the recommended times by the manufacturer. The facecloth was soaked with tap water that was heated in a microwave for 20 s. Once the facecloth was wrung out, it was folded three times to obtain a rectangular shape to cover both eyes [20]. Table 1 describes each eyelid-warming mask and the nature of the filler material.

Following approval from the University's ethics committee, consenting subjects 18–50 years of age were recruited. A higher degree of dry eye symptoms (as measured using the Ocular Surface Disease Index-OSDI [21], score >30/100), ocular surgery in the past 24 months, eyelid anomalies (including MGD) and damaged, broken or sensitive skin surrounding the eyelids were excluded from this study. Contact lenses, eye makeup, and creams were removed prior to the study.

The experiment was conducted in a closed space protected from drafts. The room temperature and skin temperature were monitored to ensure environmental stability. Each of the eyelid-warming masks was heated with the same microwave oven (Sharp Carousel 1100W) following manufacturer's recommended heating times. The order of the masks was randomized using a random Latin Square generator and the subjects had a 15-min pause between each warming mask, allowing the outer eyelid to return to ambient temperature. All six warming devices (5 masks plus the facecloth) were evaluated in a single session.

A digital thermometer probe with a resolution of 0.1° C (Fisher Scientific Traceable Total range) was secured to the right upper eyelid with surgical tape, such that only the probe end was underneath the mask or cloth as shown in Fig. 1. The subject was comfortably reclined in an examination chair to simulate an at-home scenario. The subject's skin temperature was measured prior to heating and served as a baseline measure. The eye mask was then placed on the subject's eyelids (t = 0) within 5–10 s of heating and the temperature was measured at one-minute intervals for 12 min (t = 1 to t = 12). The temperatures for each eyelid-warming masks were averaged across subjects and plotted for comparison.

The subjects were also asked to report the comfort level of each eye mask. After each of the tested masks, the subjects were asked to rate their comfort between 0 and 10, with higher numbers reflecting better comfort. In an attempt to control for possible order effects, the order of the masks, were randomized. At the end of the experiment, the subjects were asked to identify their favourite and least favourite masks.

Statistical analysis was performed using the non-parametric Mann-Whitney U-Test at an alpha level of 0.05 using SPSS (version 17.0 for Windows).

Table 1
Description of eyelid-warming masks.

Mask	Content
MGDRx EyeBag® The EyeBag Company	Flax seeds
The Eye Doctor® The Body Doctor	Mixed natural grains
Bruder Eye Hydrating Compress	MediBeads®
Tranquileyes XR™ goggles Eyeeco	Thermoeyes Beads
Thera°Pearl Eye-ssential mask Bausch & Lomb	Pearl Technology®
Warm face cloth	None

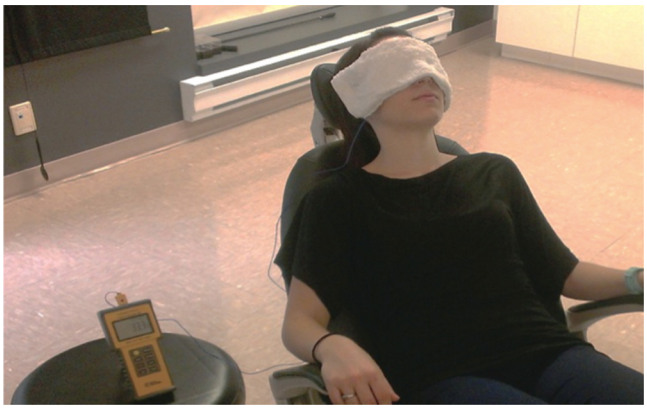

Fig. 1. Experimental set-up. The thermometer probe was secured to the lid with surgical tape such that the end of the probe was directly under the mask/cloth. The temperature could be read from an external digital reader.

3. Results

Twelve (n = 12) subjects participated in the study (10F:2 M, age 21–30 with an average of 23.2 ± 3.8 years). The average ambient temperature remained constant at 22.6 ± 0.9 °C, and the average eyelid skin temperature was 33.5 ± 0.9 °C prior to the experimentation. All masks were at room temperature prior to heating.

Each mask demonstrated a unique heat retention profile, reaching maximum temperature at different times and having a different final temperature at the end of the 12-min evaluation (Table 2). The MGD Rx Eyebag®, Bruder® and Tranquileyes XR™ all reached their maximum temperature at the 2 min mark. Of those, the Bruder® was the warmest at 40.1 °C. At the end of the 12-min evaluation, the warmest masks were the Bruder® and the Thera°Pearl at 37.9 °C, with the other masks (MGD Rx Eyebag®, The Eye Doctor®, Tranquileyes XR™) being within 1–2° C cooler. The facecloth recorded the coolest temperature at the end of the 12 min at 29.2 °C.

Table 2
Peak and final temperatures of eyelid-warming masks.

Mask	Peak Temperature (°C)	Time to reach peak temp (minutes)	Final Temperature (°C)
MGDRx EyeBag® The EyeBag Company	37.6	2	36.8
The Eye Doctor® The Body Doctor	38.4	4	37.8
Bruder Eye Hydrating Compress Bruder Healthcare	40.1	2	37.9
Tranquileyes XR™ goggles Eyeeco	38.7	2	36.1
Thera°Pearl Eye-ssential mask Bausch & Lomb	38.7	3	37.9
Warm face cloth	39.2	0	29.2

Please cite this article in press as: E. Bitton, et al., In-vivo heat retention comparison of eyelid warming masks, Contact Lens & Anterior Eye (2016), http://dx.doi.org/10.1016/j.clae.2016.04.002

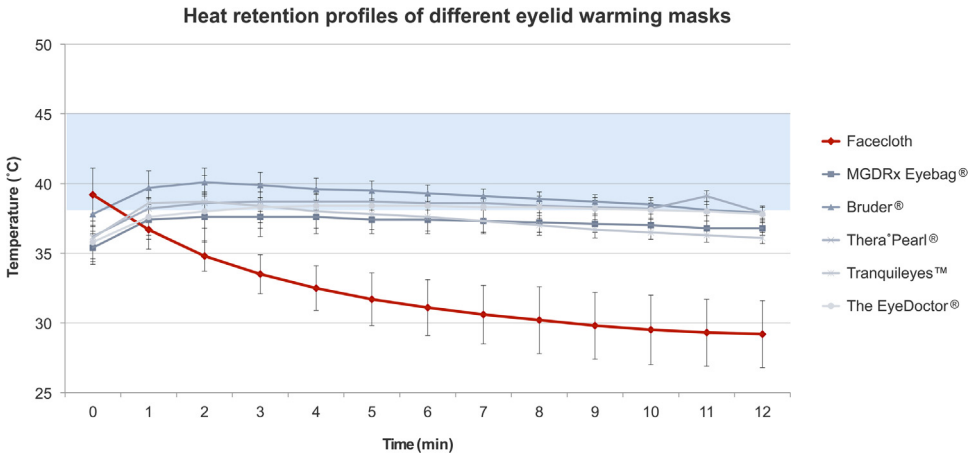

Fig. 2. Average temperature (°C) ± SEM reached for each eyelid-warming mask over 12 min. Time 0 (t = 0) reflects the time at which the mask was placed on the eyelid.

Overall, each eye mask had a stable heat profile between 37–41 °C over the 12 min, with the exception of the facecloth, which rapidly dropped below 37 °C after 1 min (Fig. 2). After heating, all eyelid-warming masks reached a temperature near 37 °C within the first min (t = 1). The facecloth was significantly cooler than all other masks as of the 2-min (t = 2) mark ($p < 0.05$).

The comfort level was reported following the use of each eyelid-warming mask on a level from 0 (poor comfort) to 10 (excellent comfort). The average level reported for all masks was relatively high (≥6/10). Although the facecloth received the lowest comfort score (6.8/10) and the Bruder® the highest (9.2/10), there was no statistically significant difference between the masks (Fig. 3).

Subjective overall preference (8 out of 12 subjects, 67%) leaned towards the Thera°Pearl as the preferred mask. Reasons included a good contact with the eyelids due to the elastic band and equally distributed warmth of the mask. The least favourite (8 out of 12, 67%) was the facecloth mainly due to the rapid cooling and the wet cloth on the skin. No adverse events were reported during the course of the study.

4. Discussion

ECPs typically advocate a 5–10 min WC therapy as one of the first recommendations for the management of MGD [4,12,22]. Commercially available eyelid-warming masks should aim to reach temperatures of 40–45 °C [8,13] for the entire treatment duration to remain effective. Each mask evaluated in this study increased in temperature subsequent to heating and exhibited individual heat retention profiles throughout the 12-min evaluation, reflecting properties of the individual fillers used.

This study provides additional support that the facecloth is poor at retaining the desired temperature for the required treatment period, and should be re-heated frequently. Studies have demonstrated that when the warm facecloth is appropriately administered, it improves dry eye symptoms, lipid layer thickness and tear film stability [8,13,15,23]. It should be noted that for patients who do not own a microwave, the facecloth remains a viable option for MGD management. However, education is key to reinforce the need for frequent reheating.

All the masks tested (MGD Rx Eyebag®, The Eye Doctor®, Bruder®, Tranquileyes XR™, Thera°Pearl), with the exception of the facecloth, demonstrated stable heat retention throughout the 12 min. This is clinically reassuring for ECPs who typically recommend at home WC therapy ranging from 5 to 10 min. Human behaviour typically underscores doctor's recommendations [24–27] and most patients will likely perform WC for less than the recommended time. This study supports that most commercially available eyelid-warming masks heat quickly (within the first minute) and have a stable temperature profile (between 37 and 41 °C) for the recommended 5–10 min. The

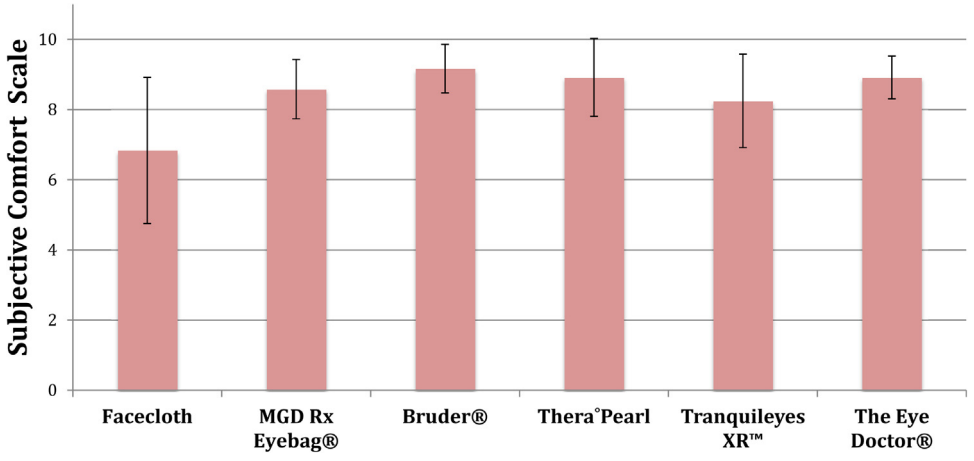

Fig. 3. Reported comfort level (average score ± SEM) of eyelid-warming masks on a scale from 0 (poor) to 10 (excellent).

Please cite this article in press as: E. Bitton, et al., In-vivo heat retention comparison of eyelid warming masks, Contact Lens & Anterior Eye (2016), http://dx.doi.org/10.1016/j.clae.2016.04.002

facecloth quickly dropped below the desired temperature 2 min after heating. This further corroborates the justification put forth by Olson et al. [8] who demonstrated that the lipid layer thickness was enhanced using a warm facecloth that was kept >38° C by reheating it every 2 min.

The *ex vivo* heat retention profile of eyelid-warming masks on a non-conductive surface, reported by Lacroix et al. [20] behaved differently than in the *in vivo* (eyelid skin) situation. Certain masks did not reach as high temperatures when used on eyelids, which could be explained by lid thickness, eyelid tissue composition and the ability of skin tissue to absorb and dissipate heat. All masks maintained a safe temperature profile throughout the 12-min interval with the highest temperature reaching 40.1 °C, well within the tolerable limits for eyelid skin, and sufficient to soften the meibum in the MG [8,13].

Microwave oven power and heating times must also be taken into consideration, as patients are not likely to change their appliance to comply with manufacturer's suggestions for an eyelid-warming mask. This may result in over- or under-heating of the mask. ECPs should remind patients to verify the temperature of the mask prior to placing it on their eyelids to prevent contact burns [28]. When removing the mask from the microwave, the sensory nerves of the hands would act as an early warning to alert the user if the mask was too hot and avoid potential for eyelid burns. Despite this, some patients may have different skin sensitivities, and should be reminded that their eyelid may react with the use of a WC [29]. It should be noted that temperatures nearing 49° C have the potential to scald human skin and result in a first-degree burn [30,31]. It has been recommended to set water heater temperature no more than 49° C (120 °F) to avoid potential scalding of the skin when using tap water, keeping in mind that a baby's skin is more sensitive than an adult's [32–35]. No skin sensitivity or other adverse events were reported in this study.

At the time of the study, the Eye Doctor® eyelid-warming mask used a combination of three different sized natural grains as filler. Since then, the filler has been changed to BodyBeads® [36,37], a proprietary material, which may have differing heat retention properties than those found in the first generation of the Eye Doctor® mask. As newer fillers are introduced in eyelid warming masks, it would be clinically valuable to assess their heat retention properties to insure a safe and stable temperature profile over the recommended treatment period. Ineffective heating of the eyelids can lead to the lack of improvement in symptoms, which can lead to non-compliance, discontinuation, patient frustration and lack of confidence in the ECP.

Some of the masks have a fabric cover (MGD Rx Eyebag®, The Eye Doctor®, Bruder®) while others (Thera°Pearl) have a plastic cover or a combination of fabric and plastic (Tranquileyes XR™). The fabric covers have the disadvantage of not being washable, except for The Eye Doctor® which has a removable fabric cover, while the plastic ones have the advantage of being wiped clean. These characteristics may be a consideration for heavy make-up users or people with very oily skin.

In the present study, the Bruder® eye mask received the highest comfort score, yet the Thera°Pearl was the overall preferred mask. One cannot derive any conclusions from this, as there was no significant difference between the comfort scores. A limited sample size (n = 12) may be the cause. A tapered fit due to the conformity of the fillers and/or elastic band as well as the uniformity of the heat distribution may have contributed to individual preferences [38,39]. Some may even prefer dry over wet/moist compresses [40], but this aspect goes beyond the scope of this study. Ultimately, ECPs can assist patients in selecting the most appropriate eye mask with the most desirable characteristics to fit their lifestyles, which can help enhance compliance with WC therapy.

Advantages of the facecloth are its availability, minimal cost and ease of washing. For patients who do not possess a microwave oven, the warm facecloth becomes the easiest therapy available. An added advantage is that the facecloth is compact and can easily be used during travel. Typically, the facecloth is simply heated directly using warm to hot tap water. In this study, the facecloth was soaked in tap water, heated for 20 s in a microwave, wrung out and then folded into 3 layers. The use of the microwave along with layering the facecloth may have enhanced the heat retention of the material. This can be further supported by the fact that it was the warmest (39.2 ± 1.9 °C) of all the masks at the start of the temperature recording (t = 0). Additionally, the range of temperatures (37.3–41.1 °C) at t = 0 for the facecloth can attest to the variability that tap water can give.

More recently, it has been reported that layering facecloth towels improves the heat retention of the WC and can enhance the therapeutic effectiveness of this method. The first towel is rolled in a cylinder and subsequent towels (up to 5–6) are wrapped around the previous one to create a thicker cylinder, referred to as the Bundle Method [40]. The cylinder is then heated in the microwave, and facecloths are pealed one at a time. At 1–2 min intervals, the external towel is removed and the smaller cylinder is placed back on the eye. The belief is that the internal towels retain heat longer than the ones on the outside due to contact with the external environment. The drawback of this method is that it still requires a microwave to heat the towels.

Strengths of the current study include the uninterrupted evaluation of the heat under the WC. The thermometer probe was secured under the WC and an external reader allowed for constant monitoring without disturbing the mask. Other studies [18,39,40] have measured the temperature of the lids but require temporary removal of the mask to obtain a thermal imaging, which may result in a slight underscoring of the temperature. The randomization of the masks also reduced possible order effects in the data.

A criticism of this study may include the limited time (i.e., 15 min) between the evaluations of each mask. All the masks were evaluated in one experimental session, for a total of 147 min or 2 h 45 min (6 masks $\times$ 12 min evaluation plus 5 $\times$ 15 min break in between). If we include instruction and heating of the masks it amounts to nearly 3 h for each participant. Anything over that commitment would have restricted recruitment for the study. That being said, it is to be noted that the therapeutic effect of the mask on the secretions of the MG was not under investigation. If that were the case, a longer interval would have been necessary in order to limit any serial effects of the heat on the meibum. The randomization of the masks also limited any bias with respect to the comfort scores.

Another potential limitation of this study was that subjects with MGD were not considered as part of the inclusion criteria. The purpose of the study was to establish the heat retention profiles of eyelid-warming masks to assess stability over the 12 min to be considered for the management of MGD, and not its therapeutic effect. McCulley and Shine [41] found that alterations in chemical composition of meibum in MGD require higher melting points. Furthermore, Pult et al. [14] demonstrated that meibum from MGD patients begin to melt at 35° C instead of 32° C for normals. All of the masks, except for the facecloth, maintained a temperature above 35° C for the entire 12 min. Altered meibum in MGD patients may require a longer time for the heat to dissipate through it to be therapeutically effective, however this was beyond the scope of this study. In addition, severe dry eye patients (OSDI scores >30/100) were not included and the results of this study may not necessarily translate to that population either. Further studies are needed to investigate the heat retention profiles on eyelids of severe dry eye patients.

Please cite this article in press as: E. Bitton, et al., In-vivo heat retention comparison of eyelid warming masks, Contact Lens & Anterior Eye (2016), http://dx.doi.org/10.1016/j.clae.2016.04.002

5. Conclusion

Different fillers of commercially available eyelid-warming masks have different heat retention properties. All masks tested in this study provided a safe and stable profile over a 12 min test period. This clinical study brings further awareness that the commonly recommended warm facecloth therapy is poor at retaining heat over a treatment period of 5–10 min, without frequent reheating. Ineffective therapy due to poor heat retention may lead to discouragement and discontinuation of treatment. ECPs should consider cost, reusability, availability and heat retention profiles of the mask when choosing an effective WC as adjunct therapy for MGD management.

Disclosures

This study was funded by the Canadian Optometric Education Trust Fund (COETF).

Ackowledgements

W. Wittich for statistical analysis and M. Gloin for assistance with graphics. Supported by the Canadian Optometric Education Trust Fund (COETF).

References

[1] The definition and classification of dry eye disease: report of the Definition and Classification Subcommittee of the International Dry Eye WorkShop, Ocular Surf. 5 (2) (2007) 75–92.
[2] A.J. Bron, J.M. Tiffany, The contribution of meibomian disease to dry eye, Ocular Surf. 2 (2) (2004) 149–164.
[3] G.N. Foulks, A.J. Bron, Meibomian gland dysfunction: a clinical scheme for description, diagnosis, classification, and grading, Ocular Surf. 1 (3) (2003) 107–126.
[4] G. Geerling, J. Tauber, C. Baudouin, E. Goto, Y. Matsumoto, T. O'Brien, et al: the international workshop on meibomian gland dysfunction: report of the subcommittee on management and treatment of meibomian gland dysfunction, Investig. Ophthalmol. Vis. Sci. 52 (4) (2011) 2050–2064.
[5] J. Kanski, B. Bowling, Eyelids. Clinical Ophthalmology: A Systemic Approach, 7 ed., Elesvier Saunders, Edinburgh, 2011, pp. 2–37.
[6] Blepharitis/Meibominitis, in: A.T. Gerstenblith, M.P. Rabinowitz (Eds.), The Wills Eye Manual: Office and Emergency Room Diagnosis and Treatment of Eye Disease, 6th ed., Wolters Kluwer, Lippincott Willaims & Wilkins, Philadelphia, 2012, pp. 125.
[7] O. Terada, K. Chiba, T. Senoo, Y. Obara, [Ocular surface temperature of meibomia gland dysfunction patients and the melting point of meibomian gland secretions], Nippon Ganka Gakkai Zasshi 108 (11) (2004) 690–693.
[8] M.C. Olson, D.R. Korb, J.V. Greiner, Increase in tear film lipid layer thickness following treatment with warm compresses in patients with meibomian gland dysfunction, Eye Contact Lens 29 (2) (2003) 96–99.
[9] J. Sugar, The eyelids, in: S. Podos, M. Yanoff (Eds.), Textbook of Ophthalmology: External Diseases: Cornea, Conjunctiva, Sclera, Eyelids, Lacrimal System, 8, Mosby, London, 1994 1.10–1.4.
[10] S. Patel, K.J. Blades, Treatment of Dry Eye. The Dry Eye: A Practical Approach, Butterworth-Heinemann, London, 2003, pp. 74–75.
[11] A.S. Bruce, M.S. Loughnan, Blepharitis-Posterior. Anterior Eye Disease and Therapeutics A-Z, Butterworth-Heinemann, Edinburgh, 2003, pp. 28–29.
[12] M. Rolando, M. Papadia, Diagnosis and management of lid and ocular surface disorders, in: P.A. Asbell, M.A. Lemp (Eds.), Dry Eye Disease: The Clinician's Guide to Diagnosis and Treatment, Thieme Medical Publishers, New York, 2006, pp. 63–83.
[13] C.A. Blackie, J.D. Solomon, J.V. Greiner, M. Holmes, D.R. Korb, Inner eyelid surface temperature as a function of warm compress methodology, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 85 (8) (2008) 675–683.
[14] H. Pult, B.H. Riede-Pult, C. Purslow, A comparison of an eyelid-warming device to traditional compress therapy, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 89 (7) (2012) E1035–41.
[15] E. Goto, K. Endo, A. Suzuki, Y. Fujikura, K. Tsubota, Improvement of tear stability following warm compression in patients with meibomian gland dysfunction, Adv. Exp. Med. Biol. 506 (Pt B) (2002) 1149–1152.
[16] Y. Matsumoto, M. Dogru, E. Goto, R. Ishida, T. Kojima, T. Onguchi, et al: efficacy of a new warm moist air device on tear functions of patients with simple meibomian gland dysfunction, Cornea 25 (6) (2006) 644–650.
[17] A. Mori, J. Shimazaki, S. Shimmura, H. Fujishima, Y. Oguchi, K. Tsubota, Disposable eyelid-warming device for the treatment of meibomian gland dysfunction, Jpn. J. Ophthalmol. 47 (6) (2003) 578–586.
[18] P.S. Bilkhu, S.A. Naroo, J.S. Wolffsohn, Effect of a commercially available warm compress on eyelid temperature and tear film in healthy eyes, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 91 (2) (2014) 163–170.
[19] H.S. Sim, A. Petznick, S. Barbier, J.H. Tan, U.R. Acharya, S. Yeo, et al., A randomized, controlled treatment trial of eyelid-Warming therapies in meibomian gland dysfunction, Ophthalmol. Ther. (2014).
[20] Z. Lacroix, S. Leger, E. Bitton, Ex vivo heat retention of different eyelid warming masks, Contact Lens Anterior Eye J. Br. Contact Lens Assoc. 38 (3) (2015) 152–156.
[21] R.M. Schiffman, M.D. Christianson, G. Jacobsen, J.D. Hirsch, B.L. Reis, Reliability and validity of the ocular surface disease index, Arch. Ophthalmol. 118 (5) (2000) 615–621.
[22] R.D. Cullom, B. Chang, Blepharitis/Meibomianitis. The Wills Eye Manual Office and Emergency Room Diagnosis and Treatment of Eye Disease, 2nd ed., J.B. Lippincott Company, Philadelphia, 1994, pp. 130.
[23] J.R. Paugh, L.L. Knapp, J.R. Martinson, M.M. Hom, Meibomian therapy in problematic contact lens wear, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 67 (11) (1990) 803–806.
[24] L.R. Martin, S.L. Williams, K.B. Haskard, M.R. Dimatteo, The challenge of patient adherence, Ther. Clin. Risk Manag. 1 (3) (2005) 189–199.
[25] D.M. Robertson, H.D. Cavanagh, Non-compliance with contact lens wear and care practices: a comparative analysis, Optom. Vis. Sci. 88 (12) (2011) 1402–1408.
[26] W. Townsend, Enhancing patient adherence to dry eye therapy. Part 1, Contact Lens Spectr. 28 (January) (2013) 22.
[27] M. Swanson, Compliance with and typical usage of artificial tears in dry eye conditions, J. Am. Optom. Assoc. 69 (10) (1998) 649–655.
[28] N.E. Alden, A. Rabbitts, R.W. Yurt, Contact burns: is further prevention necessary? J. Burn Care Res. Off. Publ. Am. Burn Assoc. 27 (4) (2006) 472–475.
[29] Y.J. Jones, D. Georgesuc, J.D. McCann, R.L. Anderson, Microwave warm compress burns, Ophthal. Plast. Reconstr. Surg. 26 (3) (2010) 219.
[30] Medicine UNLo. Burns [September 3, 2015]. Available from: https://www.nlm.nih.gov/medlineplus/burns.html.
[31] Institute B., Scald Burns [October 27, 2015]. Available from: http://www.burninstitute.org/wp-content/uploads/2013/03/ScaldBurns-factsheet.pdf.
[32] Foundation B., Scald Burns [September 3, 2015]. Available from: http://www.burnfoundation.org/programs/resource.cfm?c=1&a=3.
[33] Antiscald I., Exposure time to receive a severe burn [September 2, 2015]. Available from: http://www.antiscald.com/prevention/general_info/table.php.
[34] Canada Go. Water temperature and burns/scalds, [September 2, 2015]. Available from: http://healthycanadians.gc.ca/security-securite/home-maison/burns-brulures-eng.php.
[35] Inspectors A.B., Hot water and scalding graph [September 2, 2015]. Available from: http://www.accuratebuilding.com/services/legal/charts/hot_water_burn_scalding_graph.html.
[36] Doctor T.B., The Eye Doctor [September 3, 2015]. Available from: http://www.the-body-doctor.com/TheEyeDoctor.pdf.
[37] Doctor T.E., [November 11, 2015]. Available from: http://www.the-body-doctor.com/the-eye-doctor%AE?1.
[38] Hale M., Preferences for hot compress MGD treatments. Optician [Internet]. 2015 September 2, 2015. Available from: http://www.opticianonline.net/preferences-hot-compress-mgd-treatments/.
[39] M.T. Wang, Z. Jaitley, S.M. Lord, J.P. Craig, Comparison of self-applied heat therapy for meibomian gland dysfunction, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 92 (9) (2015) e321–6.
[40] D.K. Murakami, C.A. Blackie, D.R. Korb, All warm compresses are not equally efficacious, Optom. Vis. Sci. Off. Publ. Am. Acad. Optom. 92 (9) (2015) e327–33.
[41] J.P. McCulley, W.E. Shine, The lipid layer of tears: dependent on meibomian gland function, Exp. Eye Res. 78 (3) (2004) 361–365.

Please cite this article in press as: E. Bitton, et al., In-vivo heat retention comparison of eyelid warming masks, Contact Lens & Anterior Eye (2016), http://dx.doi.org/10.1016/j.clae.2016.04.002