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Randomised trial of the clinical utility of an eyelid massage device for the management of meibomian gland dysfunction

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ABSTRACT

Purpose: To compare the single application and two week treatment effects of device-applied (Eyepeace) and manually-applied eyelid massage techniques, as an adjunct to warm compress therapy, on ocular surface and tear film parameters.

Methods: Twenty participants (11 females, 9 males; mean age, 27 ± 11 years) with dry eye symptoms were recruited in a two week, investigator-masked, randomised, contralateral-eye trial. Following 10 min of warm compress therapy application (MGDRx EyeBag®) on both eyes, eyelid massage therapy was applied to one eye (randomised) by device, and to the fellow eye by manual eyelid massage, once daily for 14 days. Ocular surface and tear film measurements were conducted at baseline, and 15 min post-application by a clinician, then again after 14 days of self-administered daily treatment at home.

Results: Baseline clinical measurements did not differ between the treatment groups (all $p > 0.05$). Following two weeks of treatment, tear film lipid layer grade improved significantly with device massage ($p = 0.008$), and was marginally greater than manual massage by less than 1 grade ($p = 0.03$). Although immediate post-treatment improvements in tear film stability were observed in both groups (both $p < 0.05$), no significant long-term cumulative effects or inter-treatment differences in stability measures were detected (all $p > 0.05$). Visual acuity, tear meniscus height, conjunctival hyperaemia, ocular surface staining, and meibomian gland dropout did not change during the treatment period (all $p > 0.05$).

Conclusions: Two weeks of treatment with the eyelid massage device, as an adjunct to warm compress therapy, effected marginally greater improvements in tear film lipid layer thickness than the conventional manual technique, which were statistically but not clinically significant. Future parallel group trials with longer treatment periods and a greater range of disease severity are required.

1. Introduction

Evaporative disease considered the more prevalent dry eye aetiological subtype, and is commonly caused by meibomian gland dysfunction (MGD) [1,2]. In MGD, the increased melting points of the meibomian gland secretions and viscosity can contribute towards blockage and inflammation of the ductal system, diminishing the quantity and quality of lipids delivered to the tear film [2–4]. The compromised integrity of the surface lipid layer of the tear film can then lead to hyper-evaporation, and perpetuate a vicious cycle of tear film instability, hyperosmolarity, and ocular surface inflammation [2,3,5–8].

Physical expression of the meibomian gland secretions, through the use of warm compress therapy and eyelid massage techniques, is typically recommended for the management of MGD [9–15]. The restoration of natural meibum to the lipid layer has previously been demonstrated to improve tear film quality, and provide symptomatic relief from dry eye disease [9–11,13,16,17]. Recently, an eyelid massage device (Eyepeace, UK, Fig. 1) has become commercially available, and is marketed to enhance meibum expression as an adjunct to warm compress therapy. The flexible hand-held device is manufactured from silicone, and exerts controlled, vertical pressure over closed eyelids. However, the relative efficacy of the device compared to manual eyelid massage techniques has not yet been established. The purpose of this randomised contralateral-eye study was therefore to compare the effects of the device and manual eyelid massage techniques, as an adjunct to warm compress therapy, on ocular surface and tear film measurements, after single application by a clinician and following a two-week

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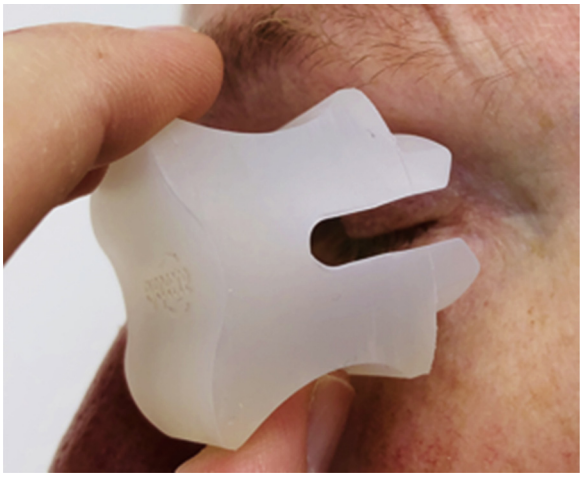

Fig. 1. The Eyepeace eyelid massage device exerts controlled, vertical pressure over closed eyelids.

period of self-administered daily treatment at home.

2. Methods

2.1. Subjects

This prospective, two-week, investigator-masked, randomised, contralateral-eye study adhered to the tenets of the Declaration of Helsinki, and was approved by the University of Auckland Human Participants Ethics Committee. Subjects were required to be 16 years or older, with symptomatic dry eye, no major ocular or systemic diseases (other than dry eye disease, anterior blepharitis, or meibomian gland dysfunction), no previous ocular surgery, no contact lens wear, and no use of topical or systemic medications known to affect the ocular surface. Symptomatic dry eye was defined by an Ocular Surface Disease Index (OSDI) score of 13 or more [18]. Eligible participants were enrolled after providing written consent, and were required to attend three visits: an enrolment visit, an in-office clinical demonstration and training session, and a post-follow up visit after a home treatment period of 14 days.

A total of 20 participants were recruited, satisfying sample size requirements calculated using PASS 2002. The designated primary outcome measure for determining sample size was meibomian gland function, as determined by tear film lipid layer thickness grade. Multiplicity and non-parametric adjusted power calculations were made with tear film lipid layer as the designated outcome and showed that 15 subjects were required to detect a clinically significant difference of a change of one lipid layer grade, with 80% power ($\beta = 0.2$), and a two-sided statistical significance level of 5% ($\alpha = 0.05$). The SD of normal values was estimated to be 1 lipid layer grade [17].

2.2. Treatments

Participants were randomised to the device eyelid massage technique (Eyepeace, Belfast, UK) on one eye, and a conventional manual eyelid massage technique on the fellow eye, as adjuncts to warm compress therapy (MGDRx EyeBag®, EyeBag® Company, UK), for self-administered, once daily evening application at home, for a period of 14 days. Randomisation was conducted by computer-generated random number allocation, and applied to sequentially enrolled participants. The randomisation schedule was pre-determined prior to participant recruitment, such that the investigator involved in baseline participant assessment had no involvement in treatment allocation. During the in-office clinical demonstration session, participants received training on the application of the warm compress therapy, device and manual eyelid massage techniques, and detailed written instructions were provided. Participants were instructed to heat the warm compress in a microwave at full power for 30 s, before application to the closed eyelids of both eyes simultaneously for a period of 10 min, according to manufacturer's instructions. This was followed immediately by 10 gentle squeezes of the eyelid massage device on one eye, and 10 gentle eyelid massaging movements using the index and middle fingers on the fellow eye [9,10].

2.3. Measurements

Study investigators conducting clinical assessments were masked to the pre-determined treatment randomisation schedule and had no involvement in treatment allocation. The eligibility and enrolment visit occurred 48 h before the in-office clinical demonstration session, due to the invasive nature of the ocular surface staining and infrared meibography assessments conducted. During the in-office clinical demonstration session, measurements were conducted on both eyes of each participant by a masked investigator at baseline, before warming and expression ('treatment') had been applied by an unmasked clinician according to the predetermined randomisation schedule. Measurements were repeated 15 min post-treatment by the masked investigator, followed by an in-office clinical demonstration for participant training purposes. After the home treatment period of 14 days with participants self-applying treatment daily, post-follow up measurements were assessed as close as possible to the same time of day as the in-office clinical demonstration session. All participants were assessed at the same location, with a mean ± SD room temperature of 20.5 ± 1.2 °C, and a mean ± SD relative humidity of 51.5 ± 4.6%. To minimise the impact on tear film physiology for subsequent tests, measurements were performed in ascending order of invasiveness, always starting with the

Table 1
Order of clinical measurements conducted at the enrolment visit, in-office clinical demonstration session, the post-follow up visit after a home treatment period of 14 days.

Eligibility and enrolment visit	In-office clinical demonstration session (48 hours following enrolment visit)		Post-follow up visit (14 days following in-office session)
	Pre-treatment	15 minutes post-treatment	
OSDI questionnaire	Best corrected visual acuity	Best corrected visual acuity	Best corrected visual acuity
Sodium fluorescein staining	Tear meniscus height	Tear meniscus height	Tear meniscus height
Lissamine green staining score	Non-invasive tear film breakup time	Non-invasive tear film breakup time	Tear film lipid layer grade
Superior lid wiper epitheliopathy	Tear film lipid layer grade	Tear film lipid layer grade	Non-invasive tear film breakup time
Inferior lid wiper epitheliopathy	Bulbar conjunctival hyperaemia	Bulbar conjunctival hyperaemia	Bulbar conjunctival hyperaemia
Superior eyelid meibography			Sodium fluorescein staining
Inferior eyelid meibography			Lissamine green staining score
			Superior lid wiper epitheliopathy
			Inferior lid wiper epitheliopathy
			Superior eyelid meibography
			Inferior eyelid meibography

right eye (Table 1) [18]. The primary outcome measure was tear film lipid layer thickness grading.

Sodium fluorescein and lissamine green dyes were applied at the lateral canthus in order to evaluate localised corneal and conjunctival areas of epithelial desiccation. Staining was recorded using the modified Oxford grading scheme, [19] and superior and inferior lid wiper epitheliopathy evaluated relative to the Korb grading scheme [20]. Infrared meibography was performed with the Oculus Keratograph 5 M, with the superior and inferior eyelids everted in turn. From the captured image, the proportion of meibomian glands visible within the tarsal area were graded according to the five-point Meiboscale [21].

The best spectacle-corrected visual acuity was assessed with a standard logMAR chart. The tear meniscus height, non-invasive tear film breakup time, tear film lipid layer grade, and bulbar conjunctival hyperaemia were assessed using the Keratograph 5 M. The lower tear meniscus height was assessed from high magnification infrared images using the software's pre-calibrated digital callipers, and three measurements near the centre of the lower meniscus were averaged. Non-invasive tear film breakup time was measured using automated detection of first break-up, while the subject maintained fixation and was requested to refrain from blinking. First breakup time readings were conducted in triplicate and averaged in each case [18,22,23]. The tear film lipid layer was graded according to the modified Guillon-Keeler system: grade 1, open meshwork; grade 2, closed meshwork; grade 3, wave or flow; grade 4, amorphous; grade 5, coloured fringes; grade 0, non-continuous layer (non-visible or abnormal coloured fringes) [24,25]. Bulbar conjunctival hyperaemia was assessed by automated objective evaluation of high magnification digital imaging on the proprietary JENVIS 0 to 4 grading scale [26].

Finally, on day 14, participants were asked to confirm whether the device and manual eyelid massage techniques had been applied as instructed during the treatment period.

2.4. Statistics

Statistical analysis was performed with Graph Pad Prism version 6.02 (California, USA) and IBM SPSS version 23 (New York, USA). The significance of overall treatment, time, and treatment by time interaction effects were assessed using repeated measures two-way analysis of variance (ANOVA) for continuous variables with normal distributions confirmed by Kolmogorov-Smirnov testing ($p > 0.05$). Non-normally distributed continuous measurements (non-invasive break-up time) and ordinal data were converted to rank-values prior to undergoing analysis. Post-hoc multiplicity-adjusted Sidak's tests were conducted to examine the significance of treatment effects at each time point, and intra-group comparisons over the treatment period. All tests were two tailed, and $p < 0.05$ was considered significant. Data are presented as mean ± SD, or median (IQR) unless otherwise stated.

3. Results

The mean ± SD age of the 20 enrolled participants (11 females, 9 males) was 27 ± 11 years, and the mean ± SD OSDI score was 30 ± 12. Summary statistics of clinical measurements at baseline, 15 min (post-treatment), and day 14 (post-follow up) are presented in Tables 2 and 3. Clinical measurements did not differ significantly between the two treatment groups at baseline (all $p > 0.05$). On day 14, all participants reported applying the device and manual eyelid techniques as instructed during the treatment period.

Lipid layer grading for the two treatment groups is illustrated in Fig. Fig. 2. Repeated measures analysis of variance demonstrated significant treatment and time effects for tear film lipid layer grading (both $p < 0.05$), although treatment by time interaction effect was non-significant ($p = 0.63$). Multiplicity adjusted post-hoc analysis demonstrated that the median lipid layer grade rose significantly by day 14 in the device massage group ($p = 0.008$), and was marginally greater than that of the manual massage group by less than 1 grade ($p = 0.03$). There were no significant differences in any other intra-group and inter-treatment comparisons (all $p > 0.05$).

Table 2
Repeated measures analysis of variance of clinical measurements for treatment, time and interaction (treatment by time) effects. Ordinal data were converted to rank-values prior to assessment. Data are presented as p values. Asterisks denote statistically significant values ($p < 0.05$).

Parameter	Treatment	Time	Interaction
Refractive error			
Best correct visual acuity (logMAR)	0.99	0.81	> 0.99
Tear film quality			
Tear meniscus height (mm)	0.91	0.44	0.96
Tear film lipid layer grade (out of 5)	0.03*	0.02*	0.63
Non-invasive tear film breakup time (s)	0.41	0.03*	0.16
Ocular surface characteristics			
Bulbar conjunctival hyperaemia (out of 4)	0.14	0.11	0.63
Sodium fluorescein staining score (out of 55)	0.81	0.42	0.27
Lissamine green staining score (out of 55)	0.75	0.29	0.43
Superior lid wiper epitheliopathy grade (out of 3)	0.31	0.69	0.48
Inferior lid wiper epitheliopathy grade (out of 3)	0.83	0.42	0.18
Superior eyelid meibography grade (out of 4)	0.55	0.44	0.79
Inferior eyelid meibography grade (out of 4)	0.92	0.59	0.34

Non-invasive tear film stability distributions of the two treatment groups are illustrated in Fig. 3. A significant time effect was detected for non-invasive tear film breakup time ($p = 0.03$), although treatment and interaction effects were both non-significant (both $p > 0.05$). Post-hoc analysis showed that tear film stability was greater immediately post-treatment at 15 min than at baseline or day 14 in both treatment groups (all $p < 0.05$). Breakup times did not differ significantly between baseline and day 14, or between treatments at all three time points ($p > 0.05$).

No significant treatment, time, or interaction effects were detected for visual acuity, tear meniscus height, conjunctival hyperaemia, ocular surface staining, or meibomian gland dropout (all $p > 0.05$). No adverse events were reported during the study.

4. Discussion

The results of the current study show that following two weeks of participant-applied treatment, eyes randomised to the device massage group exhibited marginally greater improvements in tear film lipid layer thickness than those in the manual massage group. However, the difference between the two groups was less than 1 lipid layer grade, and therefore statistically but not clinically significant. It cannot be reliably determined whether these trends indicate a difference in clinical efficacy of the eyelid massage device in the expression of meibum as an adjunct to warm compress therapy, or reflect poorer participant adherence to the manual eyelid massage technique, or represent a combination of both factors. However, the lack of significant inter-group difference in lipid layer quality immediately post-treatment at 15 min may potentially add greater weight to the final hypothesis. Long term efficacy of in-office meibum expression techniques conducted by clinicians has been demonstrated to improve tear film lipid layer thickness [13]. While this might provide further indirect evidence that poorer participant adherence to the manual technique may have contributed towards the trends reported in the current study, it is acknowledged that the pressure exerted during in-office therapeutic expression techniques is greater and can be associated with considerable eyelid discomfort [15]. Such a high level of pressure would neither be expected to be tolerated nor reliably replicated by participants during daily self-administration of manual massage at home, while a controlled amount of exerted pressure might be expected to be achieved with the eyelid massage device. It is therefore conceivable for the device to be

Table 3
Clinical measurements of the eyes of subjects randomised to device and manual eyelid massage techniques at baseline, 15 min post-treatment, and day 14 post-follow up. Data are presented as mean ± SD or median (IQR). Asterisks denote statistically significant values ($p < 0.05$).

Parameter	Day	Device massage (n = 20)	Manual massage (n = 20)	p
Refractive error				
Best corrected visual acuity (logMAR)	Baseline	−0.13 ± 0.11	−0.13 ± 0.11	> 0.99
	15 minutes	−0.14 ± 0.11	−0.14 ± 0.10	0.99
	Day 14	−0.14 ± 0.08	−0.14 ± 0.09	0.99
	p	0.84	0.81	
Tear film parameters				
Tear meniscus height (mm)	Baseline	0.26 ± 0.10	0.27 ± 0.09	0.80
	15 minutes	0.28 ± 0.11	0.28 ± 0.10	> 0.99
	Day 14	0.26 ± 0.09	0.25 ± 0.09	0.86
	p	0.64	0.58	
Tear film lipid layer grade (out of 5)	Baseline	2 (2-3)	2 (2-3)	0.46
	15 minutes	3 (2-3)	2.5[a] (2-3)	0.63
	Day 14	3 (2-3)	2.5[a] (2-3)	0.03*
	p	0.008*	0.22	
Non-invasive tear film breakup time (s)	Baseline	13.2 (9.5-19.2)	14.7 (8.7-20.9)	> 0.99
	15 minutes	17.0 (10.6-22.7)	19.6 (9.7-30.2)	0.44
	Day 14	12.5 (8.9-17.5)	13.7 (8.2-18.0)	0.31
	p	0.02*	0.005*	
Ocular surface characteristics				
Bulbar conjunctival hyperaemia (out of 4)	Baseline	0.8 ± 0.3	0.7 ± 0.2	0.52
	15 minutes	0.9 ± 0.3	0.9 ± 0.3	0.75
	Day 14	0.8 ± 0.2	0.7 ± 0.2	0.14
	p	0.40	0.19	
Sodium fluorescein staining score (out of 55)	Baseline	0 (0-0)	0 (0-1)	0.54
	Day 14	0 (0-0)	0 (0-1)	0.34
	p	0.32	0.97	
Lissamine green staining score (out of 55)	Baseline	0 (0-0)	0 (0-0)	0.43
	Day 14	0 (0-0)	0 (0-0)	0.74
	p	0.98	0.36	
Superior lid wiper epitheliopathy grade (out of 3)	Baseline	0 (0-1)	0 (0-0)	0.29
	Day 14	0 (0-0)	0 (0-0)	0.83
	p	0.69	0.97	
Inferior lid wiper epitheliopathy grade (out of 3)	Baseline	0 (0-2)	0 (0-1)	0.38
	Day 14	0 (0-2)	0 (0-2)	0.46
	p	0.84	0.75	
Superior eyelid meibography grade (out of 4)	Baseline	1 (0-1)	1 (0-2)	0.81
	Day 14	1 (0-2)	1 (0-2)	0.55
	p	0.72	0.92	
Inferior eyelid meibography grade (out of 4)	Baseline	0 (0-2)	0 (0-1)	0.51
	Day 14	0 (0-1)	0 (0-1)	0.94
	p	0.45	0.55	

[a] Tear film lipid layer grade is an ordinal measurement, and the median value of 2.5 was derived from the arithmetic mean of the two mid-range data points of the even sample size group (n = 20), where the lipid layer grades of the 10th and 11th ranked participants were 2 and 3, respectively.

perceived as being more convenient and consistent than a manual massage technique.

Despite immediate post-treatment improvements in non-invasive tear film breakup time in both treatment groups at 15 min, no significant cumulative effects were detected post-follow up on day 14. The immediate post-treatment changes in breakup time are consistent with earlier studies which report that the expression of natural meibum can be associated with improvements in tear film stability through fortifying the integrity of the surface lipid layer [11,16], with a continuous lipid layer being necessary for inhibiting aqueous tear evaporation [6]. However, it is difficult to determine whether the lack of significant long term effects detected in the current study might be due to the transient nature of improvements in tear film stability, which is recognised to be a highly variable measurement [18], suboptimal treatment adherence, or whether the follow up time of two weeks was insufficient to allow significant cumulative effects to develop. Furthermore, it is noted that

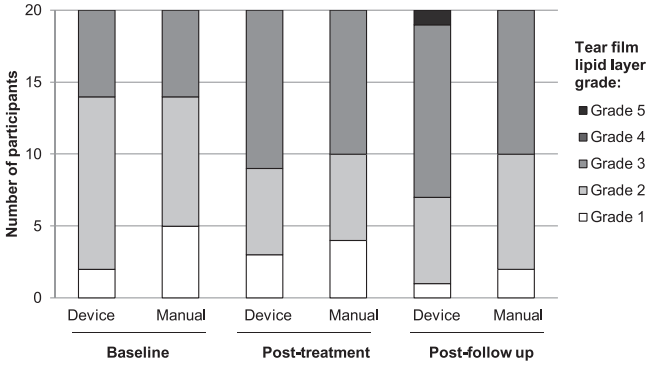

Fig. 2. Tear film lipid layer grade distribution of the eyes of subjects randomised to device and manual eyelid massage techniques at baseline, 15 min post-treatment, and day 14 post-follow up. Bars represent the number of participants within each lipid layer grade. The density of shading corresponds to the lipid layer grade.

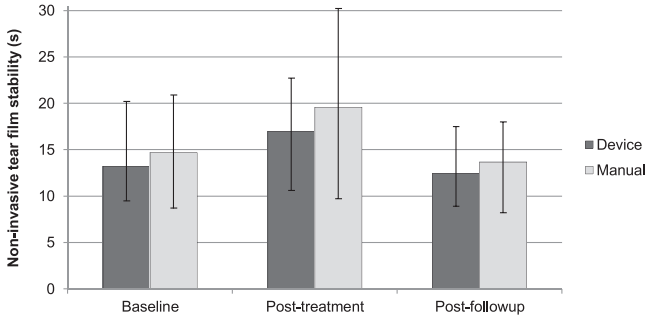

Fig. 3. Non-invasive tear film breakup time of the eyes of subjects randomised to device and manual eyelid massage techniques at baseline, 15 min post-treatment, and day 14 post-follow up. Each bar represents the median breakup time. Error bars represent the interquartile range.

median non-invasive breakup time at baseline exceeded 10 s in both treatment groups, which would confirm that the participants recruited in the current study exhibited symptomatic dry eye on the mild-to-moderate spectrum of disease severity [18]. It is not known whether the higher baseline breakup times might have also contributed to the lack of long term cumulative effects observed.

Following two weeks of self-administered treatment with warm compress therapy and both eyelid massage techniques, no changes were observed in visual acuity, tear meniscus height, conjunctival hyperaemia, ocular surface staining, or meibomian gland dropout, and no adverse events were reported by participants during the study. Overall, these results support the clinical tolerability and safety profile of the eyelid massage device, although it is acknowledged that this may have been influenced by participant treatment adherence levels.

This study is not without limitations. The contralateral-eye study design can introduce subject bias, and precluded masked assessment of symptomology changes. In addition, the monitoring of percentage treatment adherence, assessment of subjective treatment preference, and a longer follow up period is required in future studies.

In conclusion, the results demonstrated that two weeks of self-administered treatment with the eyelid massage device, as an adjunct to warm compress therapy, effected marginally greater improvements in tear film lipid layer thickness than conventional manual lid massage. Future research conducted using a parallel group design, larger sample size, over a longer follow up period, with a greater range of disease severity is required to confirm the clinical benefits of the eyelid massage device.

Declaration of Competing Interest

None.

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References

[1] J.P. Craig, K.K. Nichols, E.K. Akpek, B. Caffery, H.S. Dua, C.K. Joo, et al., TFOS DEWS II definition and classification report, Ocul Surf 15 (3) (2017) 276–283.
[2] E. Knop, N. Knop, T. Millar, H. Obata, D.A. Sullivan, The international workshop on meibomian gland dysfunction: report of the subcommittee on anatomy, physiology, and pathophysiology of the meibomian gland, Invest Ophthalmol Vis Sci 52 (4) (2011) 1938–1978.
[3] A.J. Bron, C.S. de Paiva, S.K. Chauhan, S. Bonini, E.E. Gabison, S. Jain, et al., TFOS DEWS II pathophysiology report, Ocul Surf 15 (3) (2017) 438–510.
[4] J.P. McCulley, W.E. Shine, The lipid layer of tears: dependent on meibomian gland function, Exp Eye Res 78 (3) (2004) 361–365.
[5] G.N. Foulks, The correlation between the tear film lipid layer and dry eye disease, Surv Ophthalmol 52 (4) (2007) 369–374.
[6] J.P. Craig, A. Tomlinson, Importance of the lipid layer in human tear film stability and evaporation, Optom Vis Sci 74 (1) (1997) 8–13.
[7] E. Goto, K. Endo, A. Suzuki, Y. Fujikura, Y. Matsumoto, K. Tsubota, Tear evaporation dynamics in normal subjects and subjects with obstructive meibomian gland dysfunction, Invest Ophthalmol Vis Sci 44 (2) (2003) 533–539.
[8] C. Baudouin, E.M. Messmer, P. Aragona, Revisiting the vicious circle of dry eye disease: a focus on the pathophysiology of meibomian gland dysfunction, Br J Ophthalmol 100 (3) (2016) 300–306.
[9] L. Jones, L.E. Downie, D. Korb, J.M. Benitez-Del-Castillo, R. Dana, S.X. Deng, et al., TFOS DEWS II management and therapy report, Ocul Surf 15 (3) (2017) 575–628.
[10] 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, Invest Ophthalmol Vis Sci 52 (4) (2011) 2050–2064.
[11] 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.
[12] M.T. Wang, A. Gokul, J.P. Craig, Temperature profiles of patient-applied eyelid warming therapies, Cont Lens Anterior Eye 38 (6) (2015) 430–434.
[13] D.R. Korb, J.V. Greiner, Increase in tear film lipid layer thickness following treatment of meibomian gland dysfunction, Adv Exp Med Biol 350 (1994) 293–298.
[14] M.M. Hom, M.W. Silverman, Displacement technique and meibomian gland expression, J Am Optom Assoc 58 (3) (1987) 223–226.
[15] D.R. Korb, C.A. Blackie, Meibomian gland therapeutic expression: quantifying the applied pressure and the limitation of resulting pain, Eye Contact Lens 37 (5) (2011) 298–301.
[16] J.P. Craig, K. Blades, S. Patel, Tear lipid layer structure and stability following expression of the meibomian glands, Ophthalmic Physiol Opt 15 (6) (1995) 569–574.
[17] M.T. Wang, Z. Jaitley, S.M. Lord, J.P. Craig, Comparison of self-applied heat therapy for meibomian gland dysfunction, Optom Vis Sci 92 (9) (2015) e321–6.
[18] J.S. Wolffsohn, R. Arita, R. Chalmers, A. Djalilian, M. Dogru, K. Dumbleton, et al., TFOS DEWS II diagnostic methodology report, Ocul Surf 15 (3) (2017) 539–574.
[19] A.J. Bron, V.E. Evans, J.A. Smith, Grading of corneal and conjunctival staining in the context of other dry eye tests, Cornea 22 (7) (2003) 640–650.
[20] D.R. Korb, J.P. Herman, J.V. Greiner, R.C. Scaffidi, V.M. Finnemore, J.M. Exford, et al., Lid wiper epitheliopathy and dry eye symptoms, Eye Contact Lens 31 (1) (2005) 2–8.
[21] H. Pult, B. Riede-Pult, Comparison of subjective grading and objective assessment in meibography, Cont Lens Anterior Eye 36 (1) (2013) 22–27.
[22] J.K. Mooi, M.T.M. Wang, J. Lim, A. Muller, J.P. Craig, Minimising instilled volume reduces the impact of fluorescein on clinical measurements of tear film stability, Cont Lens Anterior Eye 40 (3) (2017) 170–174.
[23] J.P. Craig, J. Lim, A. Han, L. Tien, A.L. Xue, M.T.M. Wang, Ethnic differences between the Asian and Caucasian ocular surface: a co-located adult migrant population cohort study, Ocul Surf (2018).
[24] J.P. Guillon, Use of the Tearscope Plus and attachments in the routine examination of the marginal dry eye contact lens patient, Adv Exp Med Biol 438 (1998) 859–867.
[25] J.P. Craig, M.T. Wang, D. Kim, J.M. Lee, Exploring the predisposition of the asian eye to development of dry eye, Ocul Surf 14 (3) (2016) 385–392.
[26] J. Sung, M.T.M. Wang, S.H. Lee, I.M.Y. Cheung, S. Ismail, T. Sherwin, et al., Randomized double-masked trial of eyelid cleansing treatments for blepharitis, Ocul Surf 16 (1) (2018) 77–83.