

CE Credit - Topic Review

A clinical retrospective review of the effectiveness of treating meibomian gland dysfunction (MGD) with intense regulated pulse light on its own accord or with adding in a combined thermal treatment.

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Abstract: This review aims to analyze the efficacy of intense regulated pulse light (IRPL) and if an added effect occurs with thermal therapy on patients with meibomian gland dysfunction (MGD).

Participants: Patients with a diagnosis of (MGD) presenting to the optometry clinic at Port Coquitlam, British Columbia

Methods: This review is observational. One hundred and fifty-seven eyes received IRPL treatments on day 1, day 15, day 45 and day 75. Twenty-three patients had a final evaluation at day 75 before the fourth treatment was administered; the remaining fifty-six patients had a final evaluation within three months of the fourth IRPL session. Twenty six of the fifty-six received a thermal treatment, ilux at day 45. All patients at every treatment had a manual gland expression after the IRPL unless ilux was administered. Of the IRPL treatments sixty-one patients had the lower lid treated only (goggles- opaque glasses), and eighteen patients had upper and lower lids treated (shields- metal contact lens). One symptom questionnaire and thirteen signs were evaluated before and after all treatments were administered.

Results: Statistical improvements were observed in all fourteen parameters evaluated however clinically little change was noted in meibography. Combining IRPL with thermal treatment, an added clinical improvement was noted in meibomian gland expressibility but not statistically significant. No statistical difference was found between the goggles and shields group, three and four treatments or between males and females.

Conclusion: IRPL therapy with gland expression is an effective treatment statistically significant for treating MGD and thermal therapy aids in increasing gland expressibility, however not statistically significant.

INTRODUCTION

Dry eye is a multifactorial disease marked by tear film imbalance, ocular symptoms, and underlying inflammation, damage, or neurosensory dysfunction¹. Dry eye disease (DED) affects 5–50% of people, with prevalence based on clinical signs alone reaching up to 75% in some groups².

Meibomian gland dysfunction (MGD) is a subsection of DED and accounts for 70.3% of all DED³. The sebaceous meibomian glands are in the upper and lower eyelids. Humans have approximately 35-40 of these glands in each lid. The glands secrete lipid called meibum which acts as a protective seal for the underlining aqueous layer⁴. When the meibum is of poor quality or quantity the tear evaporates leading to increased tear hyperosmolarity, which damages the ocular surface both physically and by inflammation⁵. This leads to a vicious cycle. If left untreated, damage to epithelial cells can cause structural changes to the cornea, increasing ocular friction and worsening dry eye symptoms⁶. These symptoms may range from severe itching and redness to no noticeable symptoms at all⁷. Standard treatment has typically included ocular lubrication, omega-3 supplementation, warm compresses, and lid hygiene⁸. All have some merits but only provide partial relief of signs and symptoms and there are issues with compliance.

Intense pulse light (IPL) therapy first as a dermatological treatment is now also a potential treatment for MGD. Several IPL devices are currently available; the device used in this study was the E>Eye (E-Swin, Paris, France). It delivers a high intensity infrared light to the suborbital and zygomatic region of the face where the parasympathetic nerve passes⁹. This spectrum of light decreases superficial facial rosacea and stimulates the parasympathetic division of the trigeminal nerve, in theory decreasing inflammation on the ocular surface by improving meibomian gland function¹⁰. A few in-office thermal treatments are available, including LipiFlow, iLux, and TearCare. For this study,

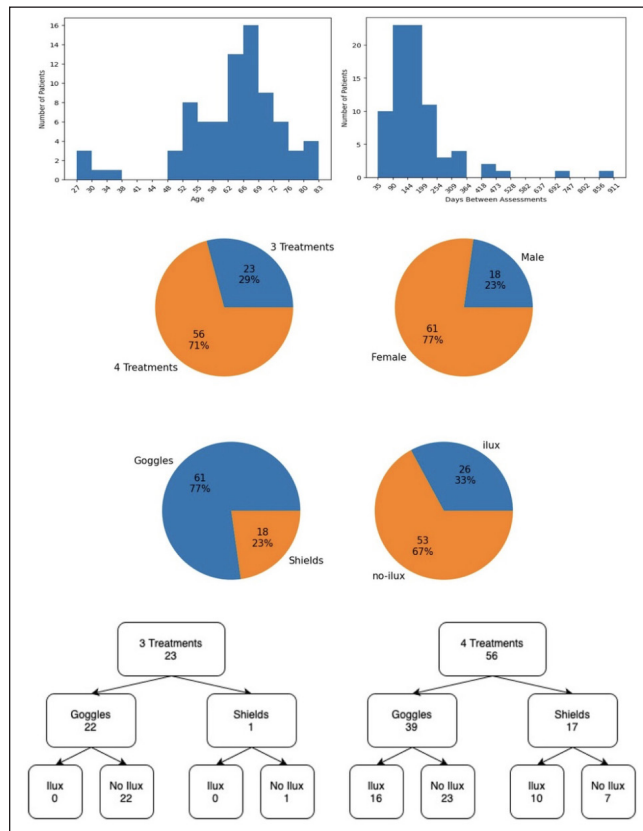
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the iLux system was used. iLux (Alcon, Canada) targets dysfunctional gland health using localized light-based heat followed by compression therapy¹¹. The overall objective with any dry eye treatment is to reduce patient's clinical signs and symptoms and improve quality of life. This study compared objective and subjective changes in symptoms and ocular surface changes after IRPL sessions and an ilux treatment.

Figure 1 Demographics of subjects and groups



MATERIALS AND METHODS

This review received ethical approval from the Research Ethics Board of Sterling Institutional Review Board (IRB) Ethics Committee in Atlanta, GA, USA, and adhered to the principles of the personal information protection and electronic document act (PIPEDA). All participants provided written consent to use their data in this review.

This observational review was conducted between Dec 2020 to Oct 2023 at a primary optometry private practice in British Columbia, Canada. Patients that participated in the review were selected from patients with dry eye signs or symptoms that were found in a routine eye exam. Of the 160 patients that returned for a dry eye assessment, 104 were confirmed to have MGD; seventy-nine patients records were reviewed. IRPL was the only treatment offered before Sept of 2022, then I-lux a thermal treatment was added in combination with the IRPL treatments. This study is a

review of clinical records of patients with confirmed MGD that consented to and had IRPL and or thermal treatments, with before and after dry eye assessments. Inclusion criteria were five positive clinical signs and subjective symptoms of MGD¹³, and participants were required to be 18 years of older. The eight parameters were OSDI ≥ 13 , osmolality ≥ 300 or difference of >8 between eyes, NIBUT <10 , TBUT <10 , telangectasis ≥ 1 , Meibography ≥ 1 (25% loss), meibum quality ≥ 1 , and meibum expressibility ≥ 1 . Each participant with five or more of the above was classified as confirmed MGD. Exclusion criteria were pure aqueous deficient dry eye, eyelid trauma, punctal plugs, skin pigmented lesions in the treatment area; pregnancy; ocular or dermatological surgery in the past three months and any uncontrolled ocular disease. Further exclusions were IRPL contraindications, including pacemaker, epilepsy, porphyria, allergy to sunlight, photosensitive medication or tanning supplements, eyeliner tattoo, sunburns in the past two weeks, and dark skin.

Seventy-nine patients (157 eyes) received four IRPL treatments using the E>Eye device (E-Swin, Paris, France), set to the meibomian gland treatment mode. Treatment intensity was adjusted based on Fitzpatrick skin type, ranging from 9.8 to 13 J/cm². The treatments were spaced over approximately 2.5 months, with the first two sessions scheduled two weeks apart and the remaining two at monthly intervals—approximately on day 1, day 15, day 45, and day 75.

Twenty-six patients (32.91%) also received iLux thermal treatment on day 45 (Figure 1). Prior to all treatments, eye and facial makeup was removed using Lid and Lash wipes. For the iLux procedure, proparacaine hydrochloride 0.5% was instilled in both eyes. The iLux tip was applied to the upper mid-lid and the lower lid (temporal and nasal regions), and in cases of stubborn gland blockage, additional passes were delivered within the same session.

Meibomian gland expression was performed after each IRPL treatment session, except when iLux was used. Prior to expression, proparacaine hydrochloride 0.5% was instilled. Tarse meibum expressor forceps were applied to both upper and lower lids, typically making two to four passes until clear meibum was expressed.

Figure 2, Patient prepped with gel, metal shields and stop plates, four flashes applied to upper eyelid.



Twenty-three patients (29.11%) had their final dry eye evaluation completed early, after three IRPL sessions, while the remaining 56 patients completed theirs within three months following the fourth IRPL session.

The IRPL treatment protocol included two subgroups based on the method of light delivery: goggles (77.22%) and shields (22.78%). Shields were used when upper lid meibomian gland loss reached grade 2 or higher ($\geq 50\%$ gland loss). Sixty-one patients wore goggles and received five to six light flashes applied to the upper cheek, nose, and temple areas. Eighteen patients used metal shields, receiving five to six flashes to the lower lid and an additional four flashes directed on the upper lid.

Ultrasound gel was applied to the skin prior to treatment. When treating the upper lids with shields, stop plates were used to protect the eyelashes and brows (Figure II). Proparacaine hydrochloride 0.5% was instilled before shield insertion. Following all treatments, a final round of proparacaine 0.5% was administered, along with ciprofloxacin 0.3% and brimonidine 0.025%.

Pretreatment and post treatment evaluation consisted of a questionnaire – Ocular surface disease index (OSDI), tear osmolarity (i-pen), Non-invasive break-up time (NIBUT)-, Fluorescein break -up time (TBUT), conjunctival staining (Efron), bulbar redness (Efron), meibography (0-4), blepharitis (Efron), strip meniscometry (SM)tube¹⁶, Tear meniscus height, MMP9 (Inflammadry)¹⁸, telangectasis (0-3), meibum quality (0-4) and meibum expressibility (0-3). Evaluations for NIBUT, TMH, telangectasis, blepharitis, bulbar redness and conjunctival staining were taken with the Medmont topographer. Due to supply chain issues during COVID 19, fourteen eyes did not have a complete before and after osmolarity reading, these eyes were excluded. The eyes included were matched for right or left.

Descriptive statistics (frequencies or means/SD/quantiles) were generated on the outcome variables with OD and OS listed separately when applicable, both in overall data, as well as stratified by each explanatory variable. Between-group comparisons were tested via exact chi-square test for binary outcome variables, or Wilcoxon rank-sum test for continuous outcome variables. Then univariate tests on changes in each continuous measure were performed, restricted to before values of "normal" and/or ranges where a change was possible. The Wilcoxon signed-rank tests were applied for continuous changes, and exact binomial test for the binary variable test specifically, MMP9.

Linear generalized estimating equations (GEE) models with exchangeable working correlation structure were fit, regressing each per-eye continuous outcome variable in data with two records (both eyes) per subject vs. each explanatory variable. Linear regression models fit by ordinary least squares (OLS) were fit on the subject-level continuous outcome variable OSDI vs. each explanatory variable. We

fit univariable models, as well as multivariable models with all four predictors (gender, ilux, modalities/goggles, number Tx) included, to assess independent effects. Models were fit on the "difference" outcomes (primary), outcomes assessed "after" (secondary), and outcomes assessed "before" (as a check on the quality of the randomization, wherein we expect few if any significant results). Model fit was assessed via normal quantile-quantile (Q-Q) plots of residuals. Linear generalized estimating equations (GEE) models with exchangeable working correlation structure were fit, regressing each multivariable models with all four predictors included, to assess independent effects. Models were fit on the "difference" outcomes (primary), outcomes assessed "after" (secondary), and outcomes assessed "before" (as a check on the quality of the randomization). Model fit was assessed via normal Q-Q plots of residuals. Binary logistic models were fit via maximum likelihood estimation (MLE), regressing the subject-level binary outcome MMP9-negative vs. each explanatory variable. We fit univariable models, as well as multivariable with all four predictors included, to assess independent effects. Models were fit on the "after" outcome (primary), and "before" outcome (as a check on the quality of the randomization). Model fit was assessed via the Hosmer and Lemeshow goodness of fit test¹². Analyses were performed using SAS version 9.4 (SAS Institute Inc., Canary, NC, USA).

Seaborn and Matplotlib were used to create pie plots and box plots.

Figure III Ocular Surface Disease Index

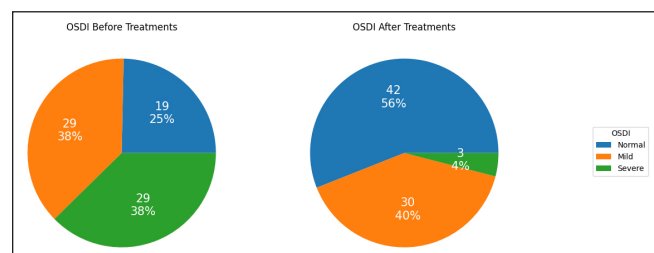


Table I: OSDI Normal

OSDI ≤ 12 Before	N = 19 Patients
36.9% Worse	7
36.9% Better	7
26.2% No change	5

Table II: Univariate tests on difference and averages of all groups with p-values

Variable	Count	Before	After	Difference	p-value
OSDI*	114	33.96	16.49	-17.47	< 0.001
OSMO*	113	321.88	310.68	-11.2	< 0.001
NIBUT*	128	3.6	5.33	1.73	< 0.001
TBUT*	153	3.68	6.25	2.56	< 0.001
Staining*	133	1.67	0.76	-0.91	< 0.001
Redness*	149	1.53	0.87	-0.67	< 0.001
Upper Meibo*	150	1.73	1.56	-0.16	< 0.001
Lower Meibo*	155	1.97	1.76	-0.21	< 0.001
Blepharitis*	109	1.18	0.27	-0.91	< 0.001
Telangiectasis*	145	1.51	0.75	-0.76	< 0.001
Meibum Quality*	153	2.04	0.68	-1.35	< 0.001
Meibum Expressability*	150	1.86	0.66	-1.2	< 0.001
SM Tube*	61	3.39	4.8	1.42	< 0.001
TMH* (Before > 0.4)	54	0.52	0.48	-0.05	0.008
TMH* (Before ≤ 0.2)	6	0.18	0.26	0.08	0.094

Table II Univariate tests on difference in data. * Difference: Where Staining, Redness, Upper Meibography, Lower Meibography, Blepharitis, Telangiectasis, Meibum Quality, Meibum Expressibility > 0 before treatments. OSDI > 12 before treatments, OSMO > 300 before treatments, NIBUT < 10 before treatments, TBUT < 10 before treatments, SM-Tube < 5 before treatments, TMH > 0.46 before treatments, and TMH ≤ 0.21 before treatments

Table III: Univariate tests on MMP9

MMP9	Frequency (%)
Negative	60 (60.0)
Positive	40 (40.0)
Proportion Negative	0.6000
95% Lower Exact Limit	0.0472
95% Upper Exact Limit	0.6967
95% Upper Conf Limit	0.4972
Two-sided Exact p-value	<0.0001
Sample Size	100

Table III Univariate tests on MMP9, only including patients with MMP9 positive before treatment.

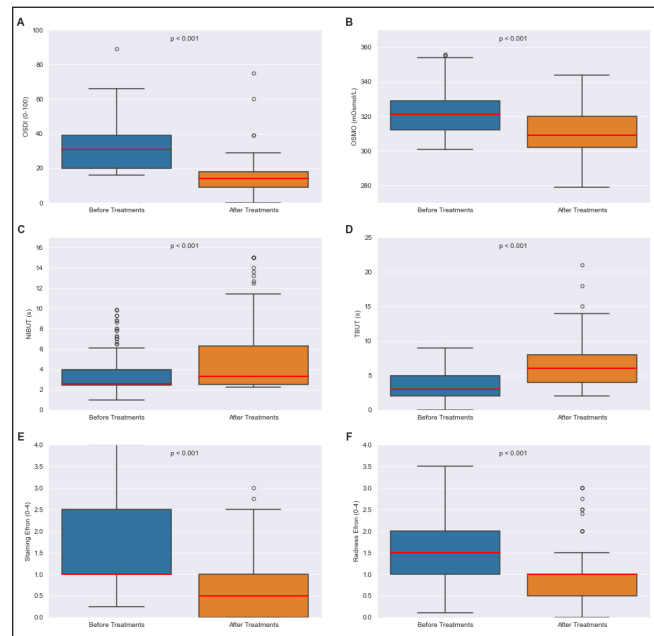


Figure IV: Boxplot analysis of A) OSDI > 12 before treatment (114 eyes), B) OSMO > 300 before treatment (113 eyes), C) NIBUT < 10 before treatment (128 eyes), D) TBUT < 10 before treatment (153 eyes), E) Staining > 0 before treatment (133 eyes), and F) Redness > 0 before treatment (149 eyes). Box plots show the distribution of data using the median (red line), interquartile range (box), and whiskers (data within 1.5*IQR from quartiles). Circles represent outliers beyond this range.

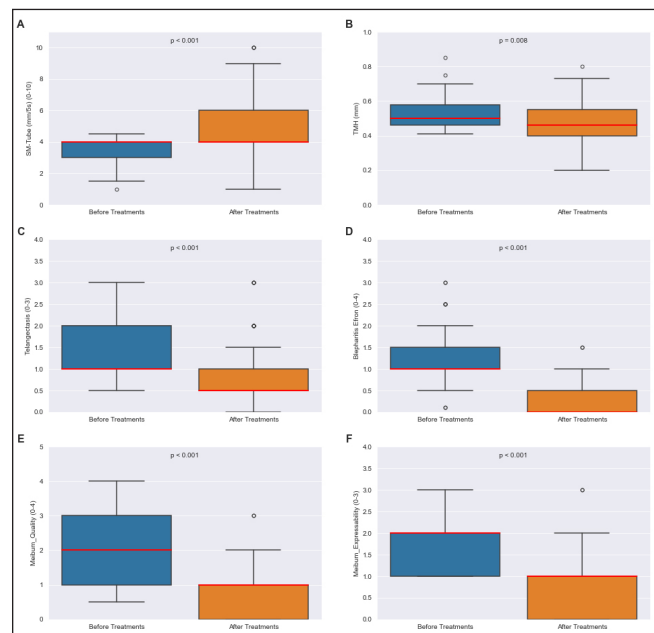


Figure V: Boxplot analysis of A) SM-Tube < 5 before treatment (61 eyes), B) TMH > 0.4 before treatment (56 eyes), C) Telangiectasis > 0 before treatment (145 eyes), D) Blepharitis > 0 before treatment (109 eyes), E) Meibum Quality > 0 before treatment (153 eyes), and F) Meibum Expressability > 0 before treatment (150 eyes). Box plots show the distribution of data using the median (red line), interquartile range (box), and whiskers (data within 1.5*IQR from quartiles). Circles represent outliers beyond this range.

Table IV: Model statistical analysis on variables before, after and difference after treatment between i-lux and IRPL only.

Variable	Count		Before		After		Difference	
	Ilux	No Ilux*	Ilux	No Ilux*	Ilux	No Ilux*	Ilux	No Ilux*
OSDI	52	100	26.77	27.72	14.58	14.54	-12.19	-13.18
OSMO	50	88	316.02	317.06	310.36	307.88	-5.66	-9.18
NIBUT	51	92	3.89	4.78	5.18	5.88	1.29	1.1
TBUT	52	105	3.6	3.97	5.74	6.62	2.15	2.66
Staining	52	105	0.95	1.64	0.39	0.8	-0.56	-0.84
Redness	51	105	1.16	1.61	0.62	0.93	-0.54	-0.68
Upper_Meibo	52	101	1.65	1.71	1.58	1.51	-0.07	-0.2
Lower_Meibo	52	103	1.8	2.05	1.72	1.78	-0.09	-0.27
Blepharitis	52	105	0.87	0.79	0.26	0.16	-0.61	-0.64
Telangiectasis	52	105	1.38	1.4	0.83	0.63	-0.56	-0.77
Meibum_Quality	52	105	1.65	2.15	0.52	0.74	-1.13	-1.41
Meibum_Expressability	52	105	1.88	1.73	0.45	0.72	-1.43	-1.0
SM_Tube	48	103	4.6	5.45	5.02	5.7	0.42	0.25
TMH	52	103	0.37	0.39	0.39	0.4	0.02	0.01

*No ilux = IRPL only

RESULTS

Sixty-one patients were female and eighteen were male. The youngest patient treated was twenty-seven and the oldest was eighty-three years old, the average age of the patients treated were 63 years old, demographic characteristics and treatment groups are reported in figure I. Fourteen dry eye parameters were evaluated before and after treatments when using univariate tests on changes in each continuous measure, restricted to before values of "normal" and/or ranges where a change was possible, all tests were highly significant, p-value <0.001 demonstrated in Table II, III, and Figure IV and V except TMH p-value was <0.008. Between all groups no statistically significant difference was found, Appendix A. Clinically, changes were found in expressibility in the i-lux group Table V.

Compared to baseline, symptoms measured with the OSDI questionnaire demonstrated an 18-point decrease, 57% of the patients went from mild to normal symptoms and 33% went from severe to normal, depicted in Figure III. OSDI difference analyzed in data with OSDI before >12 included was 114 eyes¹⁹⁻²⁶.

Objective measures showed notable improvements across several key dry eye parameters. Osmolarity decreased by an average of 11 mOsm/L in eyes with baseline values >300 mOsm/L, analyzed in 113 eyes^{19,23}. Non-invasive tear break-up time (NIBUT) improved by 1.7 seconds on average in 128 eyes with baseline NIBUT <10 seconds^{19,23}. Similarly, standard TBUT increased by 2.5 seconds in 153 eyes with TBUT <10 seconds at baseline.

For this study, tear meniscus height (TMH) was considered normal between >0.2 mm and <0.4 mm, while aqueous deficiency was defined as TMH ≤0.2 mm³⁷. TMH changes were analyzed in two groups: those with TMH ≤0.20 mm and those with TMH >0.40 mm. Of the 62 eyes with elevated baseline TMH, a significant improvement was observed, with values approaching normal by an average of 0.1 mm (p = 0.008), as shown in Figure VI and Table II. The smaller group with TMH ≤0.20 mm, consisting of 6 eyes, showed no significant change.

Schirmer (SM) Tube test results in 61 eyes with baseline values <5 mm improved by an average of 1.4 lines. Conjunctival staining with sodium fluorescein decreased by 1 point on the Efron scale among 133 eyes with baseline staining >0, as demonstrated in Figure IX. Ocular redness also improved, with a reduction of 0.6 on the Efron scale in 149 eyes with baseline scores >0, shown in Figure VII⁷.

In terms of lid margin disease, blepharitis severity decreased by 1 point on the Efron scale in 109 eyes with baseline scores >0, illustrated in Figure VIII³³. Telangiectasia, indicative of ocular rosacea, showed a reduction of 0.8 points on the Efron scale in 145 eyes with baseline telangiectasia >0, also depicted in Figure VIII.

Improvements were also seen in meibum quality and expressibility. Meibum quality (scored 0–4) improved by 1.35 points in 153 eyes, while expressibility (scored 0–3) improved by 1.2 points in 150 eyes. Notably, the iLux group showed a greater increase in expressibility—0.4 points more than other groups (Table IV). Meibography changes were also observed: the lower lid improved by 0.2 points in 155 eyes, and the upper lid by 0.16 points in 150 eyes, on a 0–4 scale (Figure X).

Regarding MMP-9, a marker of ocular surface inflammation, 60% of 100 initially positive patients converted to MMP-9 negative following treatment²⁵ (Table III). Importantly, across all parameters measured, there were no statistically significant differences between treatment groups, as detailed in Appendix A.

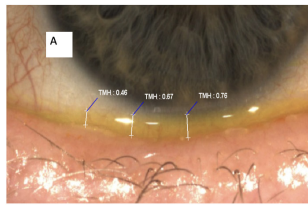


Figure VI A: Enlarged tear meniscus height 0.63 mm before treatment.

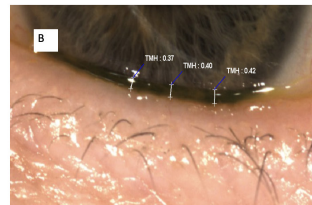


Figure VI B: a decreased tear meniscus height 0.39 mm, reduced by 0.24mm after four IRPL treatments.

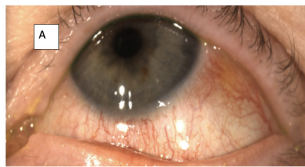


Figure VII A: Redness Efron grade 2.5 before treatment



Figure VII B: Redness Efron grade 1 after three IRPL treatments, 1.5 grade reduction.

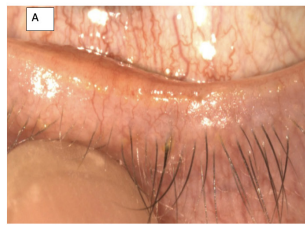


Figure VIII A: Telovascular grade 2, blepharitis grade 1 before treatment

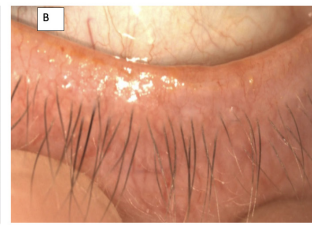


Figure VIII B: Telovascular grade 1; blepharitis grade 0 after 3 IRPL's

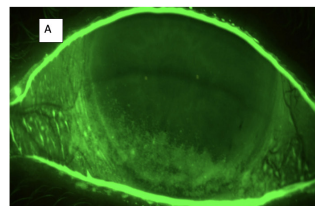


Figure IX A: Corneal staining Efron grade 2 before treatment

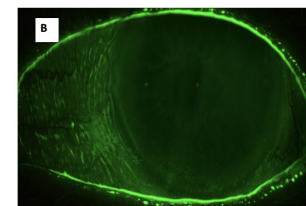


Figure IX B: Corneal staining Efron grade 0 after 4 IRPL treatments

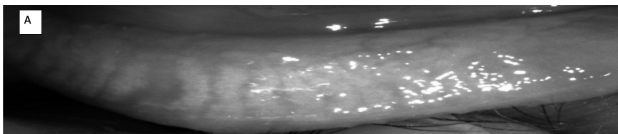


Figure X A: lower lid Meibography baseline.

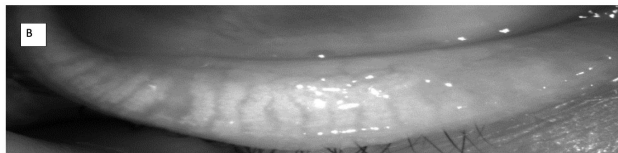


Figure X B: lower lid Meibography 2 months after four IRPL treatments.

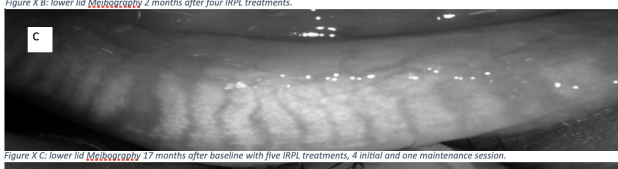


Figure X C: lower lid Meibography 17 months after baseline with five IRPL treatments, 4 initial and one maintenance session.

DISCUSSION

Dry eye is a multifactorial disease, and symptoms of ocular surface disease can vary from severe itching, redness, eye fatigue, and fluctuating vision to no symptoms at all⁷. These symptoms can significantly impair daily activities, quality of life, social interactions, and overall productivity¹³⁻¹⁴. The efficacy of palliative treatment for MGD remains limited due to transient relief and poor patient compliance. Presently, there is no known cure for dry eye.

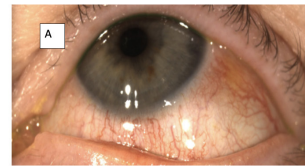


Figure VII A: Redness Efron grade 2.5 before treatment

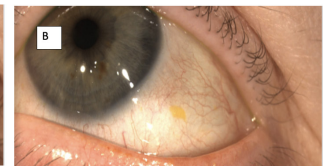


Figure VII B: Redness Efron grade 1 after three IRPL treatments, 1.5 grade reduction.

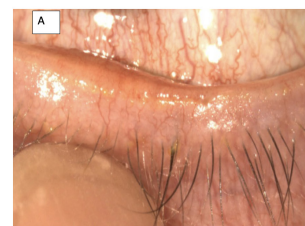


Figure VIII A: Telovascular grade 2, blepharitis grade 1 before treatment



Figure VIII B: Telovascular grade 1; blepharitis grade 0 after 3 IRPL's

Since 2011, several therapeutic devices have become available in Canada for the treatment of MGD, including LipiFlow (Johnson & Johnson Vision) in 2011, iLux (Alcon) in 2019, E>Eye (E-Swin, France) in 2020, TearCare in 2021, OptiLight (Lumenis) in 2021, and Lumecca (InMode) in 2022^{11,19,34,38-40}. The E>Eye and iLux devices were selected based on demonstrated clinical effectiveness, patient comfort, affordability, compact design, and overall market availability^{11,31}.

iLux was chosen specifically for its portability, cost-efficiency, and small clinical footprint, making it well-suited for integration into a busy primary care setting. It was also reported to perform comparably to the gold standard LipiFlow, but with more flexibility in delivery and lower operating costs¹¹.

E>Eye was selected over other IPL devices based on several key advantages. In 2020, it was the only device approved by Health Canada specifically for the treatment of MGD. E>Eye uses IRPL technology, which delivers controlled, multi-sub pulse energy bursts, making each flash more efficient and targeted than conventional IPL³¹. As a result, it requires only 5-10 flashes per eye per session, compared to 8-16 with other systems, leading to shorter treatment times, greater patient comfort, and no reported treatment pain. The E>Eye was purpose-built for MGD rather than adapted from dermatologic systems, and it is a dedicated, standalone device, RF or cosmetic modules cannot be added, unlike the modular platforms offered by InMode and Lumenis. This made it an ideal fit for an optometric focused clinic aiming to treat ocular surface disease exclusively.

The results of this objective study demonstrated the efficacy of IPL therapy in patients with MGD. IPL combined with thermal therapy provided an additive improvement in meibum expressibility.

Symptoms measured by the OSDI questionnaire showed an average decrease of 18 points, SD 13.7, in patients with abnormal baseline scores. When OSDI scores were within the normal range, however, little to no improvement was observed, as shown in Figure III and Table I. As expected, patients without symptoms did not report changes, though clinicians still noted improvements in clinical signs. Osmolarity decreased by 11 mOsm/L, SD 15.5, in patients with baseline readings of 300 or greater, which is consistent with findings from Dr. Luca Vigo's study³¹ but contrasts with other studies that reported no change^{19,20,23}. Improved lipid layer quality and meibum expressibility likely enhanced aqueous retention in patients with mild mixed mechanism dry eye²⁹. This may explain the 1.4-line improvement in SM Tube scores among those with baseline values under 5. Most of these patients had borderline aqueous deficiency with a score of 4, and 60% of them improved to above 5 following treatments.

For tear meniscus height (TMH), no meaningful change was observed in eyes with values ≤ 0.20 mm. In contrast, those with TMH > 0.40 mm showed a reduction in excessive tearing by 0.12 mm³⁰. This supports the idea that treatment did not directly target low aqueous production, but rather improved oil layer function, which reduced reflex tearing¹⁵. It is worth noting that only six eyes were in the low aqueous group. Meibography scores changed by only 0.2 on a 0–4 scale over the 188-day period between assessments. While this reflects a modest 4% increase in gland visibility, the absence of further gland loss is still clinically relevant. However, this degree of change is likely too small to be meaningful over the short term. Figure 10 illustrates more significant gland growth over two years of IRPL therapy, which aligns with Dr. Korb's observations of gland regeneration with annual probing¹⁷. Please note that this study did not look at meibography over time, this is only a clinical observation found.

Tear film stability, measured through NIBUT and TBUT, improved by an average of two seconds in patients with baseline times under 10 seconds. Some studies have shown similar results, while others reported no significant change^{19,22,24,32}. Inflammation, as indicated by MMP-9, decreased by 60%. Telangiectasia, corneal staining, and blepharitis each decreased by 25%, while conjunctival redness reduced by 15%, consistent with findings from other research^{32,33}. Meibum quality improved by 34%, and expressibility increased by 40%^{9,20}. The combination group receiving both iLux and IRPL had a 47% improvement in expressibility, although this was not statistically different from the IRPL-only group. Since thermal therapy enhances meibum flow, a higher expressibility outcome is expected³⁴.

Interestingly, patients who received four treatment sessions did not show greater improvement than those who received three. Outcomes between the groups were essentially the same, although many patients reported feeling they needed the fourth session. It is possible that this additional treatment might extend the duration of therapeutic effect, but further studies are needed to determine whether three or four sessions are optimal. When comparing delivery methods, patients who used shields were expected to show less improvement due to more advanced meibomian gland loss. However, both the shield and goggle groups improved to a similar degree. One possible explanation is that the shields allowed IPL to be delivered in closer proximity to the eyelids, with an increased number of flashes, which may have compensated for baseline differences in gland function and resulted in comparable outcomes.

The limitation with this study includes biased patient selection to more advanced stages of MGD, no control group, not testing iLux on its own, subgroups size and a lack of follow up meibography at six, twelve and twenty-four months and comparing IRPL's with and without gland expression. Osmolarity readings were limited to testing one eye or not at all due to lack of product caused by supply chain issues during Covid 19.

CONCLUSION

Meibomian gland dysfunction (MGD) is a subsection of DED and accounts for 70.3% of all DED³. Having a treatment to offer suffering patients other than symptomatic pharmaceuticals is a relief. This study has demonstrated that IRPL therapy with gland expression and with the combination of thermal therapy has its merits of reducing signs and symptoms of MGD. The most impressive change occurred in meibum expressibility when the two treatments were combined.

This study also demonstrated that patients with a low OSDI score will notice little improvement in their symptoms, these patients still have MGD and require intervention prior to refractive, eyelid and cataract surgeries²⁷. As clinicians demonstrating signs to asymptomatic patients will hopefully increase treatment compliance. This is analogous to the compliance problem in managing glaucoma patients³⁶.

These treatments do offer patients relief from MGD; however, they are not a cure, and their effects will wear off. Further studies are needed on maintenance protocol.

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APPENDIX A:

Model statistical analysis on change after treatment between groups; each model is adjusted for gender, with or without i-lux, modality and number of treatments

model	outcome	parm	coef	coef_low	coef_up	pvalue
Linear OLS models	OSDI_difference	genderf	-2.48	-10.50	5.55	0.540
		ilux	0.97	-7.06	9.01	0.810
		modalitys	4.23	-4.19	12.65	0.320
		numtx4	-2.28	-10.97	6.40	0.602
Linear GEE models with exchangeable working correlation	OSMO_difference	genderf	-6.26	-14.43	1.90	0.133
		ilux	0.46	-6.64	7.56	0.899
		modalitys	0.10	-7.06	7.25	0.979
		numtx4	8.83	-0.33	17.98	0.059
	NIBUT_difference	genderf	1.03	-1.31	3.37	0.389
		ilux	0.12	-1.71	1.96	0.895
		modalitys	0.08	-1.68	1.84	0.929
		numtx4	0.18	-1.93	2.30	0.864
	TBUT_difference	genderf	-0.63	-2.06	-0.80	0.387
		ilux	-0.81	-2.11	0.49	0.221
		modalitys	-0.53	-1.73	0.66	0.379
		numtx4	0.98	-0.39	2.36	0.161
	Staining_difference	genderf	-0.09	-0.46	0.27	0.618
		ilux	0.19	-0.25	0.63	0.392
		modalitys	0.10	-0.34	0.54	0.663
		numtx4	0.16	-0.24	0.56	0.423
	Redness_difference	genderf	-0.11	-0.40	0.18	0.441
		ilux	0.20	-0.11	0.51	0.199
		modalitys	-0.07	-0.41	0.27	0.686
		numtx4	-0.09	-0.39	0.21	0.565

	Upper_Meibo_difference	genderf	-0.05	-0.14	0.05	0.336
		ilux	0.18	0.06	0.30	0.004
		modalitys	-0.11	-0.24	0.03	0.117
		numtx4	-0.06	-0.19	0.07	0.394
	Lower_Meibo_difference	genderf	-0.06	-0.19	0.08	0.432
		ilux	0.21	0.05	0.37	0.010
		modalitys	-0.09	-0.26	0.08	0.295
		numtx4	-0.01	-0.20	0.17	0.880
	TMH_difference	genderf	0.05	-0.01	0.10	0.111
		ilux	0.02	-0.03	0.08	0.392
		modalitys	0.02	-0.05	0.09	0.502
		numtx4	-0.05	-0.11	0.01	0.116
	Blepharitis_difference	genderf	0.05	-0.29	0.38	0.788
		ilux	0.06	-0.22	0.34	0.688
		modalitys	-0.16	-0.47	0.15	0.301
		numtx4	0.03	-0.34	0.41	0.861
	SM_Tube_difference	genderf	-0.54	-1.48	0.39	0.253
		ilux	-0.01	-0.93	0.91	0.989
		modalitys	-0.72	-1.58	0.13	0.097
		numtx4	0.78	-0.37	1.92	0.184
	Telangiectasis_difference	genderf	0.22	-0.06	0.50	0.116
		ilux	0.25	-0.01	0.52	0.063
		modalitys	0.03	-0.24	0.30	0.823
		numtx4	-0.10	-0.40	0.19	0.493
	Meibum_Quality_difference	genderf	0.04	-0.34	0.42	0.826
		ilux	0.32	0.00	0.65	0.053
		modalitys	-0.04	-0.43	0.36	0.858
		numtx4	-0.09	-0.53	0.35	0.678
	Meibum_Expressability_difference	genderf	0.22	-0.21	0.66	0.311
		ilux	-0.32	-0.72	0.09	0.128
		modalitys	-0.06	-0.49	0.36	0.765
		numtx4	-0.22	-0.63	0.18	0.280
	outcome	parm	or	or_low	or_up	Value
Binary Logistic MLE models	MMP9negative_after	genderf	1.34	0.43	4.20	0.615
		ilux	0.98	0.29	3.28	0.974
		modalitys	1.44	0.39	5.32	0.588
		numtx4	1.08	0.32	3.71	0.899
	MMP9negative_before	genderf	0.87	0.27	2.82	0.815
		ilux	0.37	0.10	1.28	0.116
		modalitys	1.49	0.43	5.15	0.533
		numtx4	0.62	0.19	1.99	0.419