Review Article - Narrative Review

Taiwan J Ophthalmol 2025;15:505-515

Access this article online

Quick Response Code:

Website: http://journals.lww.com/TJOP

DOI: 10.4103/tjo.TJO-D-25-00103

Current practices and considerations in intense pulsed light therapy for meibomian gland dysfunction

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Abstract:

Intense pulsed light (IPL) therapy has emerged as a promising modality for the treatment of meibomian gland dysfunction (MGD), a leading cause of evaporative dry eye disease. However, its clinical application varies significantly across studies, with notable procedural heterogeneity in device selection, treatment intervals, anatomical coverage, and adjunctive strategies. This comprehensive review synthesizes 110 clinical studies to delineate prevailing procedural trends and identify evidence-based components of IPL protocols for MGD. Using structured data extraction, we examined key treatment variables including IPL device type, pulse energy, number and frequency of sessions, anatomical treatment regions, filter types, light guide configurations, and adjunctive interventions such as meibomian gland expression, low-level light therapy, and pharmacologic agents. While substantial variability exists, several consistent procedural patterns were identified that may inform clinical standardization. This review provides a practical framework for optimizing IPL therapy in MGD and underscores the need for further comparative investigations to refine protocol design.

Keywords:

Dry eye disease, intense pulsed light, meibomian gland dysfunction, review, treatment protocol

Introduction

Dry eye disease (DED) is a multifactorial condition of the ocular surface. Meibomian gland dysfunction (MGD) is one of its most prevalent subtypes, particularly in patients with evaporative DED.[1] MGD involves obstruction or dysfunction of the meibomian glands, resulting in reduced quality and quantity of meibum. These changes destabilize the tear film and increase evaporative loss.[2] These changes result in ocular discomfort, visual disturbance, and a decline in quality of life.

Intense pulsed light (IPL) therapy has recently gained attention as a therapeutic option for MGD. Originally developed for dermatologic purposes, IPL delivers polychromatic light in the 500–1200 nm range. Its mechanisms of action include photocoagulation of telangiectasia, thermal liquefaction of meibum, reduction of inflammatory cytokines such as interleukin (IL)-6 and IL-17A, and eradication of Demodex mites.[3-6]

Numerous randomized controlled trials have shown that IPL treatment can improve subjective symptom scores, lipid layer thickness [LLT], and tear film stability.[7-9] Consistent improvements in LLT and subjective symptom scores have also been reported when IPL was compared with placebo or no treatment.[10,11] However, clinical studies vary considerably in their protocols. Differences include device type, pulse energy, session frequency, and anatomical treatment areas.[12-14] Adjunctive procedures such as meibomian gland expression (MGX) and low-level light therapy (LLLT) also remain under consideration.

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Submission: 21-06-2025
Accepted: 25-10-2025
Published: 22-12-2025

How to cite this article: Ahn H, Jun I, Kim TI, Seo KY. Current practices and considerations in intense pulsed light therapy for meibomian gland dysfunction. Taiwan J Ophthalmol 2025;15:505-15.

This variability has made it difficult to standardize IPL therapy and limits the generalizability of its outcomes. To address this gap, the present review analyzes 110 clinical studies on IPL treatment for MGD, focusing on procedural parameters, anatomical application strategies, and the use of adjunctive treatments. By synthesizing available evidence, this review aims to inform the development of evidence-based and clinically applicable IPL protocols for patients with MGD.

Methods

Literature search strategy

A comprehensive search was conducted in PubMed in June 2025 using the following terms: intense pulsed light AND dry eye and intense pulsed light AND meibomian gland dysfunction. The search identified 379 articles.

Study selection

After the removal of 151 duplicates, 228 unique records remained. These articles were screened based on titles and abstracts. Studies were excluded if they were not related to the clinical application of IPL for DED or MGD (n = 12), were published in non-English languages (n = 16), or were nonoriginal research articles such as reviews (n = 50), case reports (n = 5), letters, surveys, or study protocols (n = 13). In addition, one animal study was excluded. After this screening process, 131 full-text articles were assessed for eligibility. Of these, 21 were excluded based on insufficient procedural detail or irrelevance to the research question. As a result, 110 clinical studies were included in the final analysis. The overall selection process is illustrated in Figure 1, following the PRISMA flow diagram.

Eligibility criteria

Eligible studies were defined as original human clinical investigations assessing the use of IPL in the treatment of either MGD or DED. Both prospective and retrospective study designs were included, with no restrictions on publication date or journal source.

Data extraction

For each included study, detailed procedural parameters were extracted. These included the type of IPL device used, the number of treatment sessions, the energy settings, and the interval between sessions. The anatomical areas treated – such as the lower eyelid alone versus both upper and lower eyelids – were noted, along with technical aspects such as filter type, light guide configuration, and pulse delivery strategy. In addition to these parameters, data were collected regarding the use of adjunctive therapies, including MGX, LLLT, and pharmacologic agents. Studies that reported direct comparisons of different procedural approaches or specific modifications intended to enhance therapeutic outcomes were also identified.

Structure of narrative synthesis

This review was designed to describe and synthesize procedural features of IPL protocols rather than to assess their clinical efficacy *per SE* the primary aim was to comprehensively describe procedural variations in IPL application across published clinical studies and to discuss their potential implications for protocol optimization in the management of MGD and DED. The review was designed as a narrative synthesis of procedural characteristics. Among the 110 studies included, four lacked sufficient detail regarding core IPL procedural parameters. As a result, while all 110 studies were considered in the overall review, only 106 were included in the analysis of IPL components except adjunctive therapies [Supplementary Table 1].

Clinical Evidence and Procediral Considerations

Intense pulsed light devices

Among the 106 included studies, the most frequently used IPL device was M22 (Lumenis, Israel), reported in 56 studies (53.3%). This was followed by E-Eye (E-Swin, France) in 12 studies (11.4%) and Eye-light (Espansione, Italy) in 9 studies (8.6%). Other devices such as Thermaeye Plus (MDS Medical Technologies, Spain), Tearstim (ESW Vision, France), Solari (Lutronic, Korea), Eyesis (Shanxi Chengal Technology, China), Aqua Cel (Jeysis, Korea), and BroadBand Light (Sciton, USA), were reported in one to three studies.

Several studies conducted direct comparisons of IPL platforms. A randomized trial comparing Eyesis with E-Eye demonstrated similar improvements in ocular surface disease index (OSDI) and tear break-up time (TBUT), although Eyesis was associated with better symptom and tear film stability.[15] Another study comparing M22 and E-Eye reported that both devices were effective, but M22 showed superior improvement in lower eyelid meibomian gland parameters and TBUT.[16] A separate trial comparing M22 and OPL-I found both systems effective in improving TBUT, meibomian gland secretion score, and corneal staining.[17] A comparison of M22 and Aqua CEL reported that both devices improved SPEED score, noninvasive TBUT (NIBUT), and lid margin abnormalities.[18] Finally, a three-arm study compared Eye-Light with LLLT, E-Eye, and Thermaeye Plus. While all groups experienced OSDI reduction, only Eye-Light with LLLT groups showed consistent improvement in LLT. However, it remains unclear whether the observed effect was attributable to differences in device characteristics or to the additional effect of adjunctive LLLT.[19]

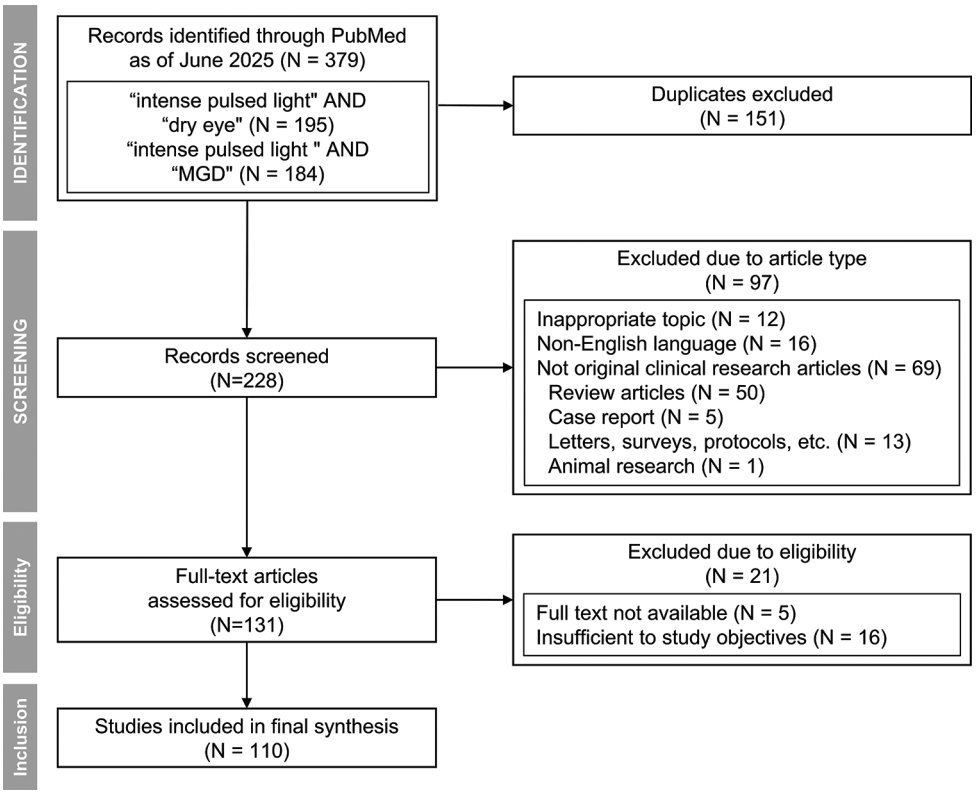

Figure 1: Review flow chart

Overall, current evidence does not support the notion that device type is the primary determinant of clinical outcome.

Number of sessions and interval strategy

The number of IPL treatment sessions varied considerably. The most common protocol consisted of three sessions, reported in 50 studies (47.2%). Four sessions were applied in 38 studies (35.8%), while two or fewer sessions were used in 7 studies (6.6%). A small number of studies adopted flexible or individualized schedules. Treatment intervals also showed substantial variation. The most frequently reported interval was every 3 weeks (24 studies, 22.6%), followed by every 2 weeks (21 studies, 19.8%) and every 4 weeks (11 studies, 10.4%). Several studies used exact day-based protocols (e.g., Day 0, 15, and 45). Other interval schemes included weekly application, monthly sessions, or hybrid protocols depending on device or group assignment.

In addition to descriptive trends, several studies directly investigated the impact of varying session numbers or treatment intervals on clinical outcomes. One retrospective cohort study involving 90 MGD patients who received between one and five IPL-MGX sessions found that while objective signs such as meibomian gland expressibility (MGE) and TBUT improved even after a single session, subjective symptom relief was only statistically significant in patients who received three or more sessions.[20] This suggests that longer treatment courses may be required for perceptible symptom improvement, whereas meibomian gland function and tear stability may respond more rapidly. Another multicenter study compared three versus five sessions of IPL in patients with moderate-to-severe MGD and found no significant difference in the magnitude of improvement in objective clinical indices (e.g., OSDI, TBUT, and meibum quality [MQ]). However, the response rate, defined as a one-stage improvement in MGD grading, was higher in the five-session group (70.0%) compared to the three-session group (63.3%).[21] Additional sessions may improve the likelihood of achieving a clinical response, even if the degree of improvement remains similar. Finally, a prospective study evaluated temporal changes in tear film parameters over three IPL sessions spaced over 75 days. Significant improvements in NIBUT and subjective discomfort scores were seen progressively across sessions. However, tear quantity measures remained unchanged.[22]

Three to four IPL sessions spaced at 2–4-week intervals represent a frequently adopted approach in the current literature. Additional sessions may be considered in refractory cases or when patient-reported outcomes lag behind objective signs. However, further studies are warranted to determine the optimal number and timing of sessions based on disease severity and treatment response.

Treatment areas

IPL treatment was applied to the lower eyelid, which remains the standard anatomical target. In contrast, only 29 studies (27.4%) reported treating the upper eyelid, often under modified conditions such as reduced energy levels or with ocular shielding in place. The preauricular region was included in approximately 83% of protocols, whereas the forehead was rarely targeted, with only four studies reporting its inclusion, appearing in only 4 studies.

Two comparative studies directly examined the clinical implications of anatomical treatment variations. In a paired-eye study comparing combined upper and lower eyelid treatment with lower eyelid treatment alone, both groups demonstrated improvements in OSDI, TBUT, and MQ.[23] However, the group receiving upper eyelid treatment showed greater reductions in MMP-9 positivity and telangiectasia, suggesting a potential anti-inflammatory advantage. A separate three-arm study evaluated three treatment configurations: lower eyelid only, upper and lower eyelid, and lower eyelid combined with the lateral canthal region.[24] All groups showed improvements in lid margin abnormality score (LAS), MGE, MQ, TBUT, and OSDI. Notably, LAS improvement was significantly greater in the groups that included either the upper eyelid or the preauricular area, although there was no difference between those two groups. These findings suggest that including the preauricular area may be an effective and possibly safer alternative to upper eyelid treatment, particularly when upper eyelid comfort or safety is a concern.

While lower eyelid treatment remains the most common and safest approach, the addition of upper eyelid or preauricular irradiation may offer an additive clinical benefit. However, it should be noted that treating broader areas, as well as narrower regions such as the upper eyelid, may transiently increase patient discomfort due to treatment-related adverse effects.

Filter type and light guide

Several studies have investigated the influence of filter type and light guide configuration on the performance and tolerability of IPL therapy.

All identified filter comparisons were conducted using the M22 platform under otherwise standardized conditions. A randomized paired-eye study by Jang *et al*. compared acne and 590-nm filters in 30 patients with moderate-to-severe MGD.[25] A subsequent prospective study by Lee *et al*. using the same filters found similar efficacy across ocular parameters but emphasized differential pain profiles and treatment tolerability.[26] Kim and Min later evaluated a vascular dual-band filter (530–650 nm and 900–1200 nm) against the standard 590-nm cutoff. Both groups improved in OSDI, TBUT, MGE, and MQ, but the vascular filter group reported significantly higher pain scores.[27]

In terms of light guide configuration, two studies compared tip geometries in the M22 system. Min *et al*. retrospectively analyzed outcomes in 170 eyes treated using either a 6-mm cylindrical tip or a conventional 8 mm × 15-mm rectangular guide. Both designs achieved comparable clinical improvements, but the smaller tip was associated with lower pain scores, indicating improved tolerability without compromising efficacy.[28] Zhu *et al*. subsequently demonstrated that the 6-mm tip allowed safe and effective IPL application directly to the eyelid in patients with chalazion, indirectly supporting its utility in periorbital delivery.[29] Arita and Fukuoka also reported the clinical feasibility of anatomically matched applicators in the Aqua Cel system, although direct comparisons were not performed.[30]

While current data suggest that filter and light guide choices may influence specific aspects of tolerability or inflammatory outcomes, their impact on core therapeutic efficacy appears to be limited. These parameters may offer procedural flexibility and enhance patient comfort, particularly in anatomically sensitive areas, but they are not currently considered essential determinants of treatment success.

Energy, number of shots, and double pass

The energy settings used in IPL therapy for MGD vary widely depending on the device platform and patient characteristics. Most studies employed energy fluence levels within the manufacturer-recommended range, typically adjusted according to Fitzpatrick skin type and treatment area. Nearly all studies applying IPL within these ranges reported clinical improvement in tear film stability and meibomian gland function, but no clinical trials to date have directly compared different energy levels or pulse durations under controlled conditions.

In addition to energy, procedural variables such as the number of IPL flashes and the use of repeated irradiation (double pass) were extracted. While all 106 studies reported the total number of IPL shots per session, the values varied substantially, ranging from as few as 8 to over 50 flashes for both eyes. This variability often reflected differences in treatment area (e.g., inclusion of upper eyelid or lateral canthus) and light guide size rather than evidence-based standardization.

Approximately half of the studies (n = 58) explicitly described the use of a double pass technique, in which IPL is applied twice over the same anatomical area within a single session. This method was originally adopted in the Toyos protocol, which first introduced IPL as a treatment

for MGD.[31] Although the approach is presumed to enhance energy delivery to the meibomian glands, there is currently no controlled evidence demonstrating its superiority over single-pass protocols. None of the included studies evaluated clinical outcomes with and without duplication in a comparative framework.

While energy settings vary within manufacturer-recommended ranges based on dermatological applications, therapeutic effects have been consistently observed within these parameters. In contrast, the number of shots and the use of double pass techniques lack standardization and remain underexplored in terms of clinical significance. These procedural elements may influence treatment intensity and the risk of adverse effects, but their precise contribution is unclear. Further randomized controlled trials are needed to compare these technical variables and establish evidence-based guidelines.

Combination therapy

Meibomian gland expression

MGX is the most commonly used procedure combined with IPL. Among the 106 studies reviewed, 31 (29.2%) incorporated MGX immediately following each IPL session.

Two comparative studies directly evaluated the additional benefit of MGX when combined with IPL therapy. Two controlled studies have directly compared IPL monotherapy with IPL combined with MGX. A randomized crossover trial by Shin *et al*. found that the addition of MGX led to a significantly greater improvement in TBUT (mean difference: 2.7 s; $P = 0.003$), although no significant differences were observed in OSDI, MGE, or MQ scores.[32] A second prospective trial by Chen *et al*. compared three groups – MGX alone, IPL alone, and IPL combined with MGX. The combination group showed significantly superior outcomes in corneal staining, TBUT, and MQ, with effects sustained for at least 3 months.[33]

MGX provides a synergistic benefit when combined with IPL, particularly in improving tear film stability and MQ. While it is unclear to enhance symptom relief in all patients, MGX may be especially useful in moderate-to-severe MGD with high meibum viscosity or obstruction.

Low-level light therapy

LLLT has been explored as a treatment for MGD, particularly in European protocols. It utilizes low-intensity red or near-infrared light to stimulate mitochondrial activity, enhance tissue regeneration, and exert anti-inflammatory effects. Among the 106 reviewed studies, 10 (9.4%) incorporated LLLT in combination with IPL.

A prospective observational study by Marques *et al*. compared IPL monotherapy with IPL combined with LLLT in patients with MGD. While both groups showed improvement in LLT and OSDI scores after 3 weeks, the addition of LLLT did not demonstrate clear superiority.[34] In contrast, a longer-term study by Castro *et al*. reported that the IPL–LLLT group sustained improvements in LLT and OSDI over a 6-month period, whereas outcomes in the IPL-only group declined over time. Notably, the combination group also showed increased basal tear secretion, although a paradoxical rise in tear osmolarity was observed at 6 months.[19]

These findings suggest that while LLLT may offer an additive benefit in maintaining long-term outcomes, its role remains uncertain. The use of LLLT as an adjunct to IPL may be selectively considered in refractory cases or patients requiring prolonged maintenance, but further prospective validation is needed.

Heated eye mask

Heated eye masks (HEMs) have been used as a preconditioning method before IPL treatment, with the rationale that thermal softening of meibum may enhance IPL-mediated clearance of the glands. Among the reviewed studies, four incorporated HEM as an adjunct to IPL and evaluated its additive benefit.

In a randomized controlled trial by Li *et al*., patients receiving IPL combined with HEM showed significantly greater improvements in LLT, NIBUT, MGE, MQ, and OSDI scores compared to IPL monotherapy.[11] Wu *et al*. extended this approach by comparing IPL with 0.1% hyaluronic acid (HA) with and without HEM in patients with post-LASIK dry eye.[35] The HEM group demonstrated superior improvement in all measured parameters, including NIBUT, LLT, MGE, MQ, and OSDI, at 4 weeks. In a case series by Vigo *et al*., use of the Activa® thermo-vibrating mask (42°C, 20 Hz, 15 min) led to immediate posttreatment increases in NIBUT and LLT, even after a single session.[36] Similarly, Pac *et al*. reported that combining HEM with IPL accelerated the rise in LLT and led to faster symptom relief compared to IPL alone.[37]

These studies suggest that HEM may enhance the early therapeutic response of IPL. However, most available data are short-term, and further research is needed to determine the durability of this effect and its utility in long-term strategies.

Intraductal meibomian gland probing

Intraductal meibomian gland probing (MGP) is an invasive technique designed to mechanically open obstructed gland orifices and relieve intraductal pressure. In a randomized controlled trial, Huang *et al*. enrolled

45 patients with refractory obstructive MGD into three groups: IPL alone, MGP alone, and MGP followed by IPL (IPL-MGP).[38] The combination group received a single MGP session followed by three IPL sessions at 3-week intervals. Compared to either monotherapy, the combination group showed significantly superior outcomes across multiple parameters, including TBUT, MQ, and the SPEED symptom score. Furthermore, no patients in the IPL-MGP group required retreatment, whereas 35.7% and 20% of those in the IPL-alone and MGP-alone groups, respectively, did. In severe MGD, where the glands are nonexpressible, it has been suggested that a single IPL session may reduce inflammation but is unlikely to resolve mechanical obstruction. Although these findings suggest that MGP may have a synergistic effect, the current evidence is limited to a single trial, and the technique itself is relatively invasive. As such, its use should be approached with caution and reserved for selected cases until further validation is available through well-designed studies.

Pharmacologic adjuncts

Over half of the studies reviewed (approximately 56.6%) reported concurrent pharmacologic use, either maintained from baseline or introduced shortly after treatment. Commonly used agents included 0.1% fluorometholone (FML), 0.5% loteprednol, and 0.05% topical cyclosporine A (CsA), usually prescribed for 1–2 weeks following each IPL session.

Two studies investigated the impact of pharmacologic adjuncts in combination with IPL. Huo *et al*. compared IPL combined with 0.05% CsA versus IPL with 0.1% HA in patients with Sjögren-related DED.[39] Both groups showed significant improvements in OSDI, NIBUT, corneal staining, and meibomian gland function. However, the IPL combined with 0.05% CsA group demonstrated a greater increase. In another study, Ahn *et al*. retrospectively compared IPL monotherapy with IPL combined with a 3-month course of 0.1% FML in patients with ocular surface inflammation.[40] Although both groups improved in MGE, MQ, and OSDI, no significant advantage was found in the IPL-FML group. Moreover, 6.9% of FML users developed transient intraocular pressure elevation, underscoring the risk–benefit balance of steroid use in this setting.

The short-term use of anti-inflammatory agents immediately following IPL appears to be a common and potentially useful adjunct, particularly in high-risk or refractory inflammatory cases. However, the supporting evidence remains weak for pharmacologic adjuncts in general, including tear substitutes and secretagogues such as diquafosol. In addition, well-designed comparative studies are needed to evaluate the potential synergistic effects of IPL in combination with standard pharmacologic treatments for MGD, such as tetracyclines and macrolide antibiotics.

Eyelid hygiene and warm compresses

Warm compresses and eyelid hygiene were employed in 27.4% and 22.6% of studies, respectively. Among these, both interventions were used together in 17.9% of studies, while warm compresses alone was used in 9.4% and eyelid hygiene alone in 4.7%. These findings indicate that although these therapies were adopted in a subset of trials, the majority of studies evaluated IPL as monotherapy. Moreover, no study directly compared IPL monotherapy versus IPL with these managements.

According to the 2011 International Workshop on MGD and the MGD clinical practice guidelines published in the Japanese Journal of Ophthalmology, warm compresses and eyelid hygiene are considered the baseline therapy for MGD and are basically recommended as first-line management.[41,42] However, no studies have directly compared IPL with conventional care versus IPL alone. Only one previous study in patients with mild-to-moderate MGD reported that conventional care with warm compresses and eyelid hygiene alone achieved comparable outcomes to IPL.[43] Based on current guidelines and available evidence, conventional care should be maintained as the basic management approach for MGD regardless of IPL use. Nevertheless, further comparative and long-term studies are warranted to evaluate IPL alone versus IPL combined with conventional care.

Conclusions and Future Directions

This review systematically examined procedural characteristics and adjunctive strategies in IPL therapy for MGD across 110 clinical studies. Rather than focusing on efficacy outcomes alone, this synthesis emphasized how IPL has been implemented in real-world research settings, with attention to protocol variability, treatment parameters, and the use of adjunctive modalities.

Several consistent procedural patterns emerged. Most studies employed three to four IPL sessions spaced at 2–3-week intervals, typically targeting the lower eyelid using manufacturer-approved energy settings. However, in patients with more severe or refractory MGD, extended treatment regimens beyond four sessions have been explored. In addition, some studies suggest that inclusion of the upper eyelid and preauricular area may provide additive benefits. Adjunctive MGX was associated with improved tear film stability and gland function. Although some studies incorporated additional elements such as LLLT, HEM, or pharmacologic agents, the supporting evidence for these adjuncts remains unclear. Eyelid hygiene and warm compresses are

recommended as baseline management for MGD, and evidence is lacking from comparative studies evaluating IPL alone versus IPL combined with home care. Devices, filters, and light guides showed minimal impact on clinical efficacy, and procedural features such as the number of flashes and double pass techniques were reported variably and without controlled comparison.

The accompanying Table 1 outlines provisional procedural recommendations based on current evidence. However, across nearly all procedural variables, high-quality comparative evidence is limited, and the current literature often relies on small sample sizes, heterogeneous designs, or nonrandomized comparisons. This paucity of robust data underscores that many commonly adopted protocol elements remain empirical rather than evidence-based.

Furthermore, an equally important challenge lies in the lack of standardized outcome measures or biomarkers to evaluate IPL effectiveness. Current assessments, such as changes in MGE, MQ, LLT, and meibography-based gland atrophy or dropout, represent promising objective indicators, yet none have been universally validated. Establishing such quantitative benchmarks would be critical for determining true treatment responsiveness,

Table 1: Procedural recommendations for intense pulsed light treatment of Meibomian Gland Dysfunction

Procedural element	Key issues	Reported findings	Cautions	Recommendations
Device	Efficacy across different approved systems	Comparable outcomes between M22, E-Eye, Eye-light, Aqua Cel, and Thermaeye Plus	No significant device-specific AE differences reported	Use any approval-grade device; select based on availability and operator experience
Session number and interval	Number and frequency influence treatment efficacy and durability	3–4 sessions every 2–4 weeks common; more sessions may ↑ response in refractory cases	More sessions ↑ treatment burden, and cost	Standard 3–4 sessions at 2–4 week intervals; extend in severe/ refractory cases
Treatment area	Anatomical coverage affects efficacy and AE risk	Upper eyelid or preauricular inclusion may improve lid margin scores, reduce inflammation	Upper eyelid ↑ risk of eyelash singeing, erythema, edema	Lower eyelid standard; add upper eyelid or preauricular selectively with caution
Energy setting	Adjusted by skin type and device guidance	Safe and effective within manufacturer-recommended ranges	No controlled comparison of energy levels; excessive fluence or mismatched energy setting may ↑ sharp pain or burning discomfort, especially in previously inflamed skin areas	Follow device-specific recommended range; adjust for Fitzpatrick skin type
Number of shots	Determined by treatment area and tip size	Adequate coverage yields improvement	Excessive shots may ↑ local erythema or discomfort	Adjust number to area size; avoid overtreatment
Double pass	Originally in Toyos protocol; repeated irradiation	Presumed enhanced effect; no RCT evidence	No proven superiority; theoretical ↑ risk of local AEs	Optional; use cautiously
Filter type	Studies only in M22 system; wavelength affects pain/tolerance	Comparable efficacy across filters	Vascular dual-band: ↑ pain; Acne filter: variable discomfort	Choose based on tolerance and patient preference
Light guide configuration	Tip size affects comfort and precision	Small tip ↓ pain, precise periocular targeting	Large tip ↑ discomfort in upper eyelid and periocular areas	Use smaller tip for sensitive and small areas
MGX	Common adjunct; improves gland clearance	↑ TBUT, MQ improvement	Potential for transient lid tenderness	Recommend; especially in moderate-to-severe MGD
LLLT	Adjunct in some protocols; long-term maintenance	May sustain LLT and OSDI improvement	Limited evidence; paradoxical ↑ osmolarity in some reports	Optional; consider for maintenance in selected cases
HEM	Thermal preconditioning before IPL	Accelerates early improvement in LLT, NIBUT	No long-term durability data	Optional; consider for early symptom relief
Intraductal probing (MGP)	Invasive adjunct for severe obstruction	May enhance TBUT and MQ in refractory MGD	Invasive, potential for discomfort	Optional; Reserve for severe cases; only with experienced operators
Pharmacologic adjuncts	Anti-inflammatory benefit in inflamed MGD	May reduce postprocedure inflammation with cyclosporine; other medications remain limited	Steroid ↑ risk of IOP elevation	Optional; consider anti-inflammatory agents for inflammation
Eyelid hygiene and warm compress	Baseline maintenance therapy	Supports long-term gland health	None specific to IPL; adherence dependent	Recommend; maintain as standard MGD care

IPL=Intense pulsed light, HEM=Heated eye mask, LLLT=Low-level light therapy, MG=Meibomian gland expression, AE=Adverse event, RCT=Randomized Controlled Trial, TBUT=Tear Break-Up Time, MQ=Meibum Quality, LLT=Lipid layer thickness, NIBUT=Noninvasive tear break-up time, IOP=Intraocular pressure, OSDI=Ocular surface disease index, MGP=Meibomian gland probing, MGD=Meibomian gland dysfunction, ↑ =Increase, ↓=Decrease

minimizing under-or over-treatment, and guiding individualized retreatment strategies.

It should also be noted that the durability of IPL effects may largely depend on patients' adherence to maintenance practices such as eyelid hygiene, warm compress, and blinking exercises. These factors should be considered when evaluating the long-term effectiveness of IPL therapy.

Future research should prioritize well-designed, prospective, and adequately powered controlled study that directly compare key procedural parameters, including session number, interval, treatment area, device settings, and combinations with pharmacologic or physical adjuncts. In addition, efforts to define patient-specific treatment algorithms based on disease phenotype and inflammation severity are needed to support personalized care.

Data availability statement

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Financial support and sponsorship

Nil.

Conflicts of interest

The authors declare that there are no conflicts of interests of this paper.

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Supplementary Table 1: Summary of reviewed articles on intense pulsed light therapy for Meibomian gland dysfunction and dry eye disease

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Liu *et al*.[44]	2017	RCT, double-blind	44 (88 eyes; IPL 22; Control 22)	M22 (Lumenis, Israel)	3	Every 4 weeks	Yes	Yes	Yes	No
Arita *et al*.[13]	2019	RCT	45 (90 eyes; IPL-MGX 22; MGX 20)	M22 (Lumenis, Israel)	8	Every 3 weeks	Yes	Yes	No	No
Gao *et al*.[45]	2019	RCT	82 (IPL 41; Tobramycin/dexamethasone + warm compress 41)	M22 (Lumenis, Israel)	1	Once	Yes	No	Yes	No
Huang *et al*.[38]	2019	RCT, 3-arm	43 (IPL 14; MGP 15; IPL + MGP 14)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	Yes
Wu *et al*.[16]	2020	RCT, double-blind	62 (124 eyes; M22 58; E-Eye 66)	M22 (Lumenis, Israel); E-Eye (E-Swin, France)	3 (M22); 4 (E-Eye)	Day 1, 22, 43 (M22); Day 1, 15, 45, 75 (E-Eye)	Yes	Yes	No	No
Xue *et al*.[10]	2020	RCT, double-blind, 3-arm	87 (5-flashes 29; 4-flashes 28; Control 30)	E-Eye (E-Swin, France)	4	Day 0, 15, 45, 75	Yes	Yes	No	No
Ren *et al*.[46]	2021	RCT, paired-eye study	130 (260 eyes; IPL 130; NIL 130)	Eyesis (Shanxi Chengal Technology, China)	3	Every 1 month	Yes	No	No	No
Sagaser *et al*.[47]	2021	RCT	20 patients (IPL-MGX 10; MGX 10)	Not reported	4	Every 4–6 weeks	Yes	Yes	No	No
Shin *et al*.[32]	2021	RCT, crossover	60 (120 eyes; IPL + MGD to IPL 33; IPL to IPL + MGX 27)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	No	No	No
Yan and Wu[48]	2021	RCT	132 (IPL 66; Control 66)	RH-I1504005 (Shanxi Ruihao Biotechnology, China)	2	Not reported	Yes	Yes	No	No
Yan *et al*.[49]	2021	RCT, multicenter	120 (IPL 60; Control 60)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	Yes
Huo *et al*.[50]	2022	RCT	50 (IPL-MGX 26, Control24)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	No
Jiang *et al*.[15]	2022	RCT, multicenter, single-blind, non-inferiority	121 (Eyesis 58; E-Eye 63)	Eyesis (MDC, China) versus E-Eye (E-Swin, France)	2	Day 0, 7	Yes	No	No	No
Song *et al*.[51]	2022	RCT, single-blind	86 (172 eyes; IPL 45; Sham 41)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	No
Toyos *et al*.[52]	2022	RCT, double-blind	82 (IPL + MGX 39; MGX 43)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	No	No
Wu *et al*.[35]	2022	RCT	100 (IPL 50; Control 50)	M22 (Lumenis, Israel)	2	Day 0, 14	Yes	Yes	No	No
Yang *et al*.[53]	2022	RCT, evaluator-blind	76 (152 eyes; IPL 38; Control 38)	M22 (Lumenis, Israel)	2	Every 3 weeks	Yes	Yes	No	No
Yu *et al*.[54]	2022	Post-hoc analysis of RCT	120 (IPL 60; Control 60)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	Yes
Zarei-Ghanavati *et al*.[55]	2022	RCT	100 (IPL 50; Control 50)	E-Eye (E-Swin, France)	3	Day 0, 15, 45	Yes	Yes	No	No
Chen *et al*.[7]	2023	RCT, 3-arm	66 (132 eyes; IPL + DQS 22; IPL only 22; Sham 22)	M22 (Lumenis, Israel)	2	Day 0, 14	Yes	Yes	No	No
D'Souza *et al*.[56]	2023	RCT, double-blind	100 (200 eyes; IPL 50; Control 50)	Eye-light (Espansione, Italy)	3	Day 0, 15, 30	Yes	Yes	No	No

Contd...

Supplementary Table 1: Contd...

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Jang *et al.*[25]	2023	RCT, paired-eye	30 (60 eyes; 590-nm filter 30; Acne filter 30)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	No	No
Li *et al.*[11]	2023	RCT	150 eyes (50 per group: IPL + HEM, IPL, control)	M22 (Lumenis, Israel)	3	Day 0, 21, 42	Yes	Yes	No	No
Qin *et al.*[8]	2023	RCT, single-blind	49 (98 eyes; IPL 28; Control 21)	M22 (Lumenis, Israel)	3	Day 0, 21, 42	Yes	Yes	No	No
Zhang *et al.*[57]	2023	RCT	100 (IPL 50; Control 50)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	Yes	No
Cheng *et al.*[58]	2024	RCT, noninferiority	60 (3 mm 32; 10 mm 28)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	Yes
Huo *et al.*[39]	2024	RCT, double-blind	60 (IPL + Cyclosporine 30; IPL + Hyaluronate 30)	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	No	No
Martínez-Hergueta *et al.*[59]	2024	RCT, triple-blind	61 (IPL 31; Control 30)	M22 (Lumenis, Israel)	3	Day −7, +7, +21 (relative to surgery)	Yes	Yes	Yes	No
Niu *et al.*[60]	2024	RCT	30 (IPL 16; Control 14)	Solari (Lutronic, Korea)	3	Every 4 weeks	Yes	Yes	No	No
Qin *et al.*[17]	2024	RCT, non-inferiority	213 (M22 107; OPL-I 106)	M22 (Lumenis, Israel); OPL-I (Miracle Laser, China)	3	Every 3 weeks	Yes	No	No	No
Zhang *et al.*[61]	2024	RCT, paired-eye	22 (44 eyes; IPL 22; Control 22)	NA (Xenon-based IPL device, 560 nm-filter)	3	Day 0, 14, 28	Yes	No	No	No
Chiang *et al.*[62]	2025	RCT, paired-eye	24 (IPL + LLLT 24; LLLT 24)	Eye-light (Espansione, Italy)	4	Every 2–3 weeks	Yes	Yes	No	No
Lee *et al.*[26]	2025	RCT, paired-eye	30 (Acne filter (R)+590-nm filter (L) 19; 590-nm filter (R)+Acne filter (L) 14)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	Yes	No
Craig *et al.*[63]	2015	Prospective, double-blind, paired-eye	28 (IPL 28; Control 28)	E-Eye (E-Swin, France)	3	Day 1, 15, 45	Yes	Yes	No	No
Gupta *et al.*[64]	2016	Prospective, multicenter	100	Dermamed Quadra4 IPL (Lenni, USA)	3–6	Every 3–6 weeks	Yes	Yes	No	No
Jiang *et al.*[65]	2016	Prospective	40	E-Eye (E-Swin, France)	4	Day 1, 15, 45, 75	Yes	No	No	No
Albietz and Schmid[66]	2017	Prospective	26	E-Eye (E-Swin, France)	3	Day 0, 15, 45	Yes	Yes	No	No
Dell *et al.*[67]	2017	Prospective, multicenter	40 (80 eyes)	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	No	No	No
Karaca *et al.*[68]	2020	Prospective	26	E-Eye (E-Swin, France)	3	Day 1, 15, 45	Yes	Yes	No	No
Yin *et al.*[6]	2018	Prospective, comparative	35 (IPL 18; Control 17)	M22 (Lumenis, Israel)	3	Monthly	Yes	Yes	No	No
Choi *et al.*[4]	2019	Prospective	30	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	No
Vigo *et al.*[69]	2019	Prospective, case-series	56	E-Eye (E-Swin, France)	3	Day 1, 15, 45	Yes	Yes	No	No
Wei *et al.*[70]	2020	Prospective	53	RH-1 (Ruihao, China)	3	Every 3–4 weeks	Yes	No	No	No

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Supplementary Table 1: Contd...

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Chen *et al*.[33]	2021	Prospective, comparative, 3-arm	100 (MGX 32; IPL 33; IPL+MGX 35)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	No	No	No
Chen *et al*.[71]	2021	Prospective	48	E-Eye (E-Swin, France)	3	Day 1, 15, 30	Yes	Yes	No	No
Di Marino *et al*.[72]	2021	Prospective	20	Eye-light (Espansione, Italy)	4	Weekly	Yes	Yes	No	No
Huo *et al*.[73]	2021	Prospective	142 (Demodex 84; Control 58)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes	No	No
Iradier *et al*.[74]	2021	Prospective, case-series	195 (390 eyes)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	No	No
Li *et al*.[75]	2021	Prospective	32	M22 (Lumenis, Israel)	3	Every 4 weeks	Yes	Yes	Yes	No
Marta *et al*.[76]	2021	Prospective	31	Eye-light (Espansione, Italy)	3	Weekly	Yes	Yes	No	No
Vergés *et al*.[77]	2021	Prospective	44 (88 eyes)	Thermaeye Plus (MDS Medical Technologies, Spain)	4	Day 1, 14, 28, 49	Yes	Yes	No	No
Zarei-Ghanavati *et al*.[78]	2021	Prospective	50	E-Eye (E-Swin, France)	3	Day 0, 15, 45	Yes	Yes	No	No
Marques *et al*.[34]	2022	Prospective, comparative, evaluator-blind	62 (124 eyes; IPL + LLLT 31; IPL 31)	E-Eye (E-Swin, France)	3	Day 0, 15, 45	Yes	Yes	No	No
Martinez-de-la-Casa *et al*.[79]	2022	Prospective, case-series	30	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	No	No
Meduri *et al*.[80]	2023	Prospective, comparative	70	Eye-light (Espansione, Italy)	3	Day 1, 15, 45	Yes	Yes	No	No
Peng *et al*.[81]	2022	Prospective	37 (74 eyes)	Not reported	3	Every 4 weeks	Yes	Yes	No	No
Vigo *et al*.[36]	2022	Prospective, comparative	64 (IPL + Activa 30; IPL 34)	E-Eye (E-Swin, France)	3	Day 1, 15, 45	Yes	Yes	No	No
Wu *et al*.[82]	2022	Prospective	23	Not reported	4	Every 4 weeks	Yes	No	No	No
Zhao *et al*.[83]	2022	Prospective	26	Quantum (Lumenis, USA)	3	Every 3 weeks	Yes	No	Yes	No
Benitez-Del-Castillo *et al*.[84]	2024	Prospective, multicenter	160 (320 eyes)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	Yes	No
Castro *et al*.[19]	2023	Prospective, 3-arm	88 (176 eyes; Group1 29; Group2 30; Group3 29)	Group1 Eye-light (Espansione, Italy) + LLLT; Group2 E-Eye (E-Swin, France); Group3 Thermaeye Plus (MDS Medical Technologies, Spain)	3	Weekly (Group 1); Every 2 weeks (Group2 and 3)	Yes	Yes	No	No
Chelnis *et al*.[85]	2023	Prospective	31	OptiLight (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	No	No
Wang *et al*.[86]	2023	Prospective, case-series	17	M22 (Lumenis, Israel)	Not reported	Every 2 weeks	Yes	Yes	No	No

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Supplementary Table 1: Contd...

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Zhu *et al*.[29]	2023	Prospective, comparative	136 (190 eyes; IPL + MGX 64; Control 72)	M22 (Lumenis, Israel)	3–6	Every 3 weeks	Yes	No	Yes	No
Ballesteros-Sánchez *et al*.[87]	2024	Prospective, comparative	70 (IPL + MGD + MGE 40; Control 30)	Thermaeye Plus (MDS Medical Technologies, Spain)	3	Every 2 weeks	Yes	Yes	Yes	No
Patwardhan *et al*.[88]	2025	Prospective	Not reported (70 eyes)	Eye-light (Espansione, Italy)	3	Day 0, 15, 30	Yes	Yes	No	No
Teshigawara *et al*.[89]	2024	Prospective, paired-eye	67 (134 eyes; IPL-MGX 67; Control 67)	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	No	Yes	No
Kawagoe *et al*.[90]	2025	Prospective	56	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	Yes	No
Seo *et al*.[91]	2018	Prospective	17	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	No	No
de Alcântara *et al*.[92]	2022	Prospective	29	Etherea-MX (Vydence, Brazil)	3	Every 2 weeks	Yes	Yes	Yes	No
Stonecipher *et al*.[93]	2019	Retrospective	230	Epi-C Plus (Espansione, Italy)	1	Once	Yes	Yes	No	No
Arita *et al*.[94]	2020	Retrospective, multicenter	43 (23 IPL + MGX, 20 MGX only)	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	No	No
Fuentes Páez *et al*.[95]	2020	Retrospective, case-series	20	Thermaeye (Implantec, Argentina)	4	Day 0, 15, 45, 75	Yes	Yes	No	No
Qiao *et al*.[96]	2021	Retrospective, comparative	3689 (IPL + MGX 2282; MGX 1407)	Solari (Lutronic, Korea)	1–12	Every 2–3 weeks	Yes	Yes	No	No
Yurttaser Ocak *et al*.[97]	2020	Retrospective	43	NA (Xenon-based IPL device, wavelength 600 nm)	2–4	Every 2 weeks	Yes	Yes	No	No
Lee *et al*.[98]	2021	Retrospective	23 (45 eyes)	M22 (Lumenis, Israel)	3	Every 2 weeks	Yes	Yes	No	No
Murtaza *et al*.[99]	2021	Retrospective, case-series	48	BroadBand Light (Sciton, USA)	4	Monthly	Yes	Yes	Yes	No
Pérez-Silguero *et al*.[100]	2021	Retrospective	156	Eye-light (Espansione, Italy)	4	Day 0, 7, 30, 90	Yes	Yes	No	No
Solomos *et al*.[101]	2021	Retrospective	22	Eye-light (Espansione, Italy)	4	Weekly	Yes	Yes	No	No
Tang *et al*.[102]	2021	Retrospective, case-series	44	M22 (Lumenis, Israel)	3	Every 4 weeks	Yes	Yes	No	No
Arita and Fukuoka[30]	2022	Retrospective	12	Aqua Cel (Jeysis, Korea)	1–4	Every 2 weeks	Yes	Yes	Yes	No
Chung *et al*.[103]	2022	Retrospective, comparative	23	M22 (Lumenis, Israel)	3	Every 3 weeks (1–3 sessions) and Every 4 weeks (4–6 sessions)	Yes	Yes	Yes	No

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Supplementary Table 1: Contd...

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Fukuoka and Arita[18]	2022	Retrospective, comparative	59 (M22 29; Aqua Cel 30)	M22 (Lumenis, Israel); AQUA CEL (Jeisys, Korea)	4	Every 3 weeks	Yes	Yes	No	No
Han *et al.*[104]	2022	Retrospective	35 (70 eyes)	M22 (Lumenis, Israel)	4	Every 2–3 weeks	Yes	Yes	Yes	No
Kim and Min[27]	2022	Retrospective, comparative	91 (Vascular filter 47; 590 nm-filter 44)	M22 (Lumenis, Israel)	4	Every 4 weeks	Yes	Yes	Yes	No
Lee *et al.*[105]	2022	Retrospective	58	M22 (Lumenis, Israel)	4	Every 2–3 weeks	Yes	Yes	Yes	No
Lee *et al.*[20]	2022	Retrospective	90	Aqua Cel (Jeisys Medical, Korea)	1–5	Every 2 weeks	Yes	Yes	Yes	No
Martínez-Hergueta *et al.*[106]	2022	Retrospective	30	M22 (Lumenis, Israel)	3	Every 2 weeks	Yes	Yes	Yes	No
Trone *et al.*[107]	2022	Retrospective	45	Lacrystim (Quantel Medical, France)	3	Day 0, 15, 45	Yes	Yes	No	No
Yun and Min[108]	2022	Retrospective	90	M22 (Lumenis, Israel)	4	Every 4 weeks	Yes	Yes	Yes	No
Chung *et al.*[23]	2023	Retrospective, comparative	115 (Both 75; lower 40)	M22 (Lumenis, Israel)	4	Every 2–3 weeks	Yes	Yes	Yes (Group 1)	No
Whang *et al.*[109]	2023	Retrospective	45	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	Yes	No
Yin *et al.*[43]	2023	Retrospective, comparative	170 (IPL (MGD II–III) 28; eyelid hygiene (MGD II–III) 27; IPL + MGX (MGD III–IV) 49; IPL (MGD III–IV) 49)	M22 (Lumenis, Israel)	3	Every 4 weeks	Yes	Yes	Yes	No
Ahn *et al.*[40]	2024	Retrospective, comparative	498 (IPL 238; IPL + steroid 260)	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	Yes	No
Han *et al.*[110]	2024	Retrospective, comparative	45 (90 eyes; nongluacoma 25; glaucoma 20)	M22 (Lumenis, Israel)	4	Every 3 weeks	Yes	Yes	No	No
Jeon *et al.*[111]	2024	Retrospective	36	M22 (Lumenis, Israel)	4	Every 2 weeks	Yes	Yes	Yes	No
Lee *et al.*[112]	2024	Retrospective	82 (0.1% HA 42; 0.15% HA 40)	M22 (Lumenis, Israel)	3	Not reported	Yes	No	Yes	No
Lee *et al.*[113]	2024	Retrospective	63	M22 (Lumenis, Israel)	3	Every 4 weeks	Yes	Yes	Yes	No
Lu *et al.*[21]	2024	Retrospective, comparative	90 (5-session 30; 3-session 60)	M22 (Lumenis, Israel)	5 (Group 1); 3 (Group 2)	Every 3–4 weeks	Yes	Yes	No	No
Min *et al.*[24]	2024	Retrospective, 3-arm	137 (Lower 34; both 47; lower + canthal 56)	M22 (Lumenis, Israel)	3	Every 3 weeks	Yes	Yes (Group 3)	Yes (Group 2)	No
Pac *et al.*[22]	2024	Retrospective	110	Tearstim (ESWvision, France)	3–5	Day 1, 15, 45, (75), (105)	Yes	No	No	No
Pac *et al.*[37]	2024	Retrospective, comparative	110 (IPL 73; IPL + heated Mask 37)	Tearstim (ESW Vision, France)	4	Day 0, 15, 45, 75	Yes	No	No	No
Pac *et al.*[114]	2024	Retrospective, case-series	110	Tearstim (ESW Vision, France)	4	Day 0, 15, 45, 75	Yes	No	No	No
Song *et al.*[115]	2024	Retrospective	18	M22 (Lumenis, Israel)	3–8	Every 4 weeks	Yes	Yes	No	No

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Supplementary Table 1: Contd...

Author	Year	Study design	Sample size	Device	Session	Interval	Regions			
							Lower eyelid	Preauricular area	Upper eyelid	Forehead
Lee *et al.*[116]	2025	Retrospective	218	M22 (Lumenis, Israel)	3	Every 2 weeks	Yes	Yes	Yes	No
Yang *et al.*[117]	2022	Retrospective	90	E-Eye (E-Swin, France)	3–4	Day 0, 15, 45, 75	Yes	Yes	No	No

Author	Energy (J/cm²)	Shot	Double pass	MGX	Eyelid hygiene	Warm compress	Medications
Liu *et al.*[44]	14–16	24	Yes	Yes	No	No	0.4% polyethylene glycol 3 times/day
Arita *et al.*[13]	11–14	26	Yes	Yes	No	Yes	3% Diquafosol 6 times/day
Gao *et al.*[45]	12–14	Not reported	No	No	No	No	Sodium hyaluronate 4 times/day in both groups
Huang *et al.*[38]	14–15	Not reported	No	Yes	No	No	Artificial tears 4 times/day
Wu *et al.*[16]	10–14 (Group 1); 9.8–13 (Group 2)	34–42 (M22); 8–10 (E-Eye)	Yes	No	No	Yes	0.1% sodium hyaluronate 4 times/day
Xue *et al.*[10]	9–13	10	No	No	No	No	NA
Ren *et al.*[46]	12	10	No	Yes	No	No	NA
Sagaser *et al.*[47]	Not reported	Not reported	Yes	Yes	No	No	Tobramycin/dexamethasone
Shin *et al.*[32]	9.8–13 (as mentioned)	Not reported	No	Yes	No	No	NA
Yan and Wu[48]	10–14	20–30	Yes	No	No	No	NA
Yan *et al.*[49]	12–15	14–16	No	Yes	No	No	0.4% polyethylene glycol 3 times/day
Huo *et al.*[50]	15–17	Not reported	Yes	Yes	Yes	Yes	Continue topical therapy
Jiang *et al.*[15]	5–15 (Group 1); 9.8–13 (Group 2)	10	No	No	No	No	NA
Song *et al.*[51]	10–14	24	Yes	No	No	No	Artificial tears
Toyos *et al.*[52]	11–15	Not reported	Yes	Yes	No	Yes	Artificial tears
Wu *et al.*[35]	11–14	24	Yes	No	No	Yes	0.1% sodium hyaluronate
Yang *et al.*[53]	11–14	12	No	No	No	No	Artificial tears
Yu *et al.*[54]	12–15	14–16	No	Yes	No	No	0.4% polyethylene glycol 3 times/day
Zarei-Ghanavati *et al.*[55]	11.4–13	10	No	No	Yes	Yes	Azithromycin drops for a month, artificial tears, liposic gel
Chen *et al.*[7]	Not reported	24	Yes	No	No	No	3% Diquafosol 6 times/day for 28 days
D'Souza *et al.*[56]	Not reported	10	No	No	No	No	Continue topical therapy
Jang *et al.*[25]	11–14	24	Yes	Yes	No	No	0.15% sodium hyaluronate
Li *et al.*[11]	11–14	24	Yes	Yes	No	Yes	NA
Qin *et al.*[8]	11–14	24	Yes	No	No	No	NA
Zhang *et al.*[57]	10–16	Not reported	Yes	Yes	Yes	Yes	Tobramycin, interferon drops, artificial tears, acaricide
Cheng *et al.*[58]	12–15	14–18	No	No	No	No	Artificial tears
Huo *et al.*[39]	15–17	Not reported	Yes	Yes	Yes	Yes	0.05% cyclosporine A (group C), 0.1% sodium hyaluronate (group S), both 4 times/day
Martínez-Hergueta *et al.*[59]	10–20	36	Yes	No	No	No	Routine postopeartive drops
Niu *et al.*[60]	9–13	Not reported	No	Yes	No	No	0.3% sodium hyaluronate
Qin *et al.*[17]	11–14	Not reported	No	Yes	No	Yes	0.3% sodium hyaluronate 4 times/day
Zhang *et al.*[61]	11–14	12	No	No	No	No	NA
Chiang *et al.*[62]	5.2–6.1	10	No	No	No	No	Artificial tears
Lee *et al.*[26]	Not reported	30–32	Yes	Yes	No	No	0.15% sodium hyaluronate
Craig *et al.*[63]	9–13	4	No	No	No	No	NA
Gupta *et al.*[64]	Not reported	44–48	Yes	Yes	Yes	Yes	Continue topical therapy
Jiang *et al.*[65]	9.8–13	8	No	No	No	No	Artificial tears
Albietz and Schmid[66]	9.8–13	10	No	Yes	Yes	Yes	Tear substitutes
Dell *et al.*[67]	Not reported	Not reported	No	Yes	Yes	Yes	Continue topical therapy
Karaca *et al.*[68]	Not reported	10	No	No	No	No	NA

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Supplementary Table 1: Contd...

Author	Energy (J/cm²)	Shot	Double pass	MGX	Eyelid hygiene	Warm compress	Medications
Yin *et al*.[6]	16–17	Not reported	No	No	No	No	Artificial tears
Choi *et al*.[4]	12–14	30–32	Yes	Yes	Yes	No	Artificial tears
Vigo *et al*.[69]	9.8–13	10	Yes	No	Yes	No	Hyaluronate, 0.3% cortisol phostphate twice/day for 10 days after 1st session
Wei *et al*.[70]	11–14	32	Yes	Yes	No	No	NA
Chen *et al*.[33]	11–14	32	Yes	Yes	No	Yes	0.1% sodium hyaluronate 4 times/day
Chen *et al*.[71]	9–13	8	No	No	No	No	NA
Di Marino *et al*.[72]	10–16	10	No	No	No	No	NA
Huo *et al*.[73]	15–17	Not reported	Yes	Yes	No	No	Sodium hyaluronate 4 times/day
Iradier *et al*.[74]	11–14	20	Yes	Yes	No	Yes	Artificial tears with lipid component every 3 h and corticosteroids 3 times/day for 5 days with cyclosporine and autologous serum in mixed type
Li *et al*.[75]	10–16	54	Yes	Yes	No	No	Sodium hyaluronate
Marta *et al*.[76]	Not reported	10	No	No	No	No	Tear substitutes
Vergés *et al*.[77]	8	12	No	No	No	No	Artificial tears under 3 times/day
Zarei-Ghanavati *et al*.[78]	11.4–13	10	Yes	No	Yes	Yes	Mixed-form atificial tears 4 times/day, 0.5% azithromycin once/day for a month, liposic gel once/day
Marques *et al*.[34]	9.8–13	10	No	No	Yes	No	Artificial tears
Martinez-de-la-Casa *et al*.[79]	11–14	20	Yes	Yes	No	No	NA
Meduri *et al*.[80]	6–14	10	No	No	No	No	Sodium hyaluronate 3 times/day
Peng *et al*.[81]	~12	10	No	Yes	No	No	NA
Vigo *et al*.[36]	9.8–13	10	No	No	Yes	No	Tear substitutes 4 times/day
Wu *et al*.[82]	Not reported	Not reported	No	No	No	No	Deproteinized calf blood extract eye drops 4 times/day for 16 weeks
Zhao *et al*.[83]	14–16	2–3	No	No	No	No	NA
Benitez-Del-Castillo *et al*.[84]	10–14	30	Yes	Yes	No	No	Netilmicin 0.3% + dexamethasone 0.1% 3 times/day for 3 days after each session
Castro *et al*.[19]	Not reported	10 (Group1 and 2); 8 (Group 3)	No	No	No	No	Artificial tears
Chelnis *et al*.[85]	12–19 (rectengular handpiece) and 11–14 (OPT handpiece)	Not reported	Yes	Yes	No	No	Artificial tears
Wang *et al*.[86]	10–16	Not reported	Yes	No	No	No	Topical steroid or immunosuppressants + artificial tears (preexisting)
Zhu *et al*.[29]	12–14	36–54	Yes	Yes	No	Yes	Levofloxacin 4 times/day, tobramycin-dexamethasone ointment twice/day
Ballesteros-Sánchez *et al*.[87]	8 (lower) and 5 (upper)	20	Yes	Yes	No	Yes	Dexamethasone for 5 days after 1st session
Patwardhan *et al*.[88]	66 (as mentioned)	20	No	No	No	No	NA
Teshigawara *et al*.[89]	11–16	30	Yes	Yes	No	No	Moxifloxacin, nepafenac, betamethasone
Kawagoe *et al*.[90]	11–16	30	Yes	Yes	No	No	NA
Seo *et al*.[91]	11	16	Yes	Yes	Yes	Yes	Artificial tears
de Alcântara *et al*.[92]	8–14	24	No	Yes	No	No	Continue topical therapy
Stonecipher *et al*.[93]	10–16	10	No	No	No	No	Gatifloxacin/prednisolone 3 times/day + doxycycline 100 mg twice/day for 2 weeks
Arita *et al*.[94]	13–15	26	Yes	Yes	No	No	Continue topical therapy
Fuentes Páez *et al*.[95]	8	8	No	No	Yes	No	Artificial tears
Qiao *et al*.[96]	9–13	10–15	Yes	Yes	No	No	Artificial tears
Yurttaser Ocak *et al*.[97]	Not reported	~10	No	No	No	No	Artificial tears
Lee *et al*.[98]	11–13	~26	Yes	Yes	Yes	Yes	0.18% sodium hyaluronate

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Supplementary Table 1: Contd...

Author	Energy (J/cm²)	Shot	Double pass	MGX	Eyelid hygiene	Warm compress	Medications
Murtaza *et al*.[99]	6–14	30	Yes	No	Yes	Yes	Artificial tears, cyclosporine, steroids, oral doxycycline, lid hygiene, omega-3
Pérez-Silguero *et al*.[100]	10–16	10	No	No	Yes	Yes	Continue topical therapy
Solomos *et al*.[101]	Not reported	10	No	No	Yes	Yes	Tear substitutes
Tang *et al*.[102]	14–16	12	No	Yes	No	No	NA
Arita and Fukuoka[30]	20 (lower) and 15 (upper)	~26	Yes	Yes	Yes	Yes	NA
Chung *et al*.[103]	13–14	~52	Yes	Yes	No	No	NA
Fukuoka and Arita[18]	10/15 (upper/lower in Group 1); 15/20 (upper/lower in Group 2)	~32	Yes	Yes	Yes	Yes	Continue topical therapy
Han *et al*.[104]	11–12	30–32	Yes	No	No	No	NA
Kim and Min[27]	13–19	24	No	Yes	No	No	NA
Lee *et al*.[105]	6–13	30–32	Yes	Yes	Yes	Yes	NA
Lee *et al*.[20]	15–16	26–30	Yes	Yes	No	No	Minocycline, diquafosol 3%, fluorometholone 0.1% for 4 weeks
Martínez-Hergueta *et al*.[106]	17–20 (lower) and 10–11 (upper)	30	Yes	Yes	No	No	NA
Trone *et al*.[107]	8 m	8	No	No	No	No	NA
Yun and Min[108]	13–19	24	Yes	Yes	No	No	NA
Chung *et al*.[23]	13 (lower) and 10–13 (upper)	30	Yes	Yes	No	No	0.18% sodium hyaluronate
Whang *et al*.[109]	13–19	40	Yes	Yes	No	No	0.5% carbomethyl cellulose 4 times/day
Yin *et al*.[43]	13–18	24	Yes	Yes (Group 3)	Yes (Group 2)	Yes (Group 2)	Artificial tears
Ahn *et al*.[40]	12–19	~26	Yes	Yes	Yes	Yes	0.1% fluorometholone twice/day (Group 2)
Han *et al*.[110]	Not reported	40	Yes	Yes	No	No	Continue topical therapy
Jeon *et al*.[111]	6–13	30–32	Yes	Yes	Yes	Yes	0.5% loteprednol 4 times/day for 2 months, 0.05% Cyclosporine twice/day
Lee *et al*.[112]	15	40	No	No	No	No	Fluorometholone, carbomer ointment, 0.1% or 0.15% sodium hyaluronate
Lee *et al*.[113]	15	40	Yes	Yes	No	No	Artificial tears, fluorometholone, carbomer ointment
Lu *et al*.[21]	13–18	Not reported	Yes	Yes	No	No	Artificial tears
Min *et al*.[24]	13–19	24 (Group 1); 48 (Group 2); 36 (Group 3)	Yes	Yes	No	No	NA
Pac *et al*.[22]	13	10	No	No	No	No	NA
Pac *et al*.[37]	Not reported	10	No	No	No	No	Continue topical therapy
Pac *et al*.[114]	Not reported	10	No	No	No	No	NA
Song *et al*.[115]	11–15	~26	Yes	Yes	Yes	Yes	Continue topical therapy
Lee *et al*.[116]	10–12	20–24	Yes	Yes	No	No	NA
Yang *et al*.[117]	12–13	10	No	Yes	No	No	None (refractory to conventional therapy)

NA: Not available, IPL=Intense pulsed light, HEM=Heated eye mask, LLLT=Low-level light therapy, MGX=Meibomian gland expression, RCT=Randomized Controlled Trial, MGP=Meibomian gland probing, MGD=Meibomian gland dysfunction, DQS=Diquafosol tetrasodium, MGE=Meibomian gland expressibility, HA=Hyaluronate