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ORIGINAL RESEARCH

Long-Term Impacts of Intense Pulsed Light Therapy on Ocular Surface Health and Tear Film Dynamics in Patients with Dry Eye Disease: Detailed Analysis and Observations Over a 1-Year Follow-Up Period

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ABSTRACT

Introduction: To evaluate the long-term effects of intense pulsed light (IPL) therapy on patients with dry eye disease (DED) associated with meibomian gland dysfunction (MGD).
Methods: A retrospective case series was performed with 110 participants undergoing IPL therapy. Assessments included the eye fitness test (EFT) to gauge subjective symptoms, along with objective measures using the Tearcheck® device (ESW Vision, Houdan, France) noninvasive first breakup time (NIFBUT), noninvasive average breakup time (NIABUT), central tear meniscus height (CTMH), thinnest tear meniscus height (TTMH), and ocular surface inflammatory risk evaluation (OSIE) assessed using the SCHWIND SIRIUS device (SCHWIND eye-tech-solutions GmbH, Kleinostheim, Germany).
Results: This study documented significant improvements in subjective and objective

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symptoms associated with DED and MGD. Subjective symptoms measured by the EFT showed an average increase of 9.74 points (range −10 to 28, standard deviation [SD] ± 7.54), indicating reduced symptoms. Objective measures of tear film stability, represented by NIABUT, increased by an average of 4.04 s (range −15.00 to 14.40, SD ± 4.91). Tear film stability evaluation (TFSE) scores decreased by 229.12 points on average (range −1775 to 528, SD ± 384.94), suggesting enhanced tear film stability. OSIE type 1 showed a reduction in inflammation, with a percentage decrease of 4.98% (range −45 to 5, SD ± 7.33). Additionally, OSIE capture time decreased by 3.25 s on average (range −27 to 22, SD ± 10.35), further indicating an improvement in ocular surface health.

***Conclusion*:** IPL therapy was shown to be a promising, noninvasive approach for improving quality of life in patients with DED by effectively managing symptoms and stabilizing tear film. The findings support the use of IPL as a sustainable treatment modality for DED associated with MGD.

Keywords: Intense pulsed light therapy; Dry eye disease; Tear film stability; Longitudinal study; Ocular surface health; Meibomian gland dysfunction

Key Summary Points

Why carry out this study?

Individual treatments for dry eye disease (DED), such as intense pulsed light (IPL) therapy, have shown efficacy in managing symptoms associated with meibomian gland dysfunction (MGD).

However, the long-term effects of IPL therapy specifically have not been comprehensively studied over an extended period. Understanding these effects is crucial for developing effective treatment plans.

Evaluating the long-term efficacy of IPL therapy can provide valuable insights into its potential as a sustainable treatment modality for DED, potentially leading to improved patient outcomes and expanding therapeutic options for those suffering from this condition.

What was learned from the study?

The study found significant improvements in both subjective symptoms and objective measures of tear film stability and ocular surface health in patients treated with IPL therapy.

Eye fitness test (EFT) scores increased, indicating reduced symptoms, and tear film stability measures like noninvasive first breakup time (NIFBUT) and noninvasive average breakup time (NIABUT) also showed significant improvements.

IPL therapy led to a notable reduction in ocular surface inflammation, as evidenced by decreased ocular surface inflammatory risk evaluation (OSIE) type 1 scores and capture time.

These findings suggest that IPL therapy is a safe and effective approach for managing DED associated with MGD, particularly in severe cases, and supports its use as a long-term treatment option.

INTRODUCTION

Dry eye disease (DED), a complex and multifaceted condition, stands as a significant public health concern, impacting the lives of millions globally, with a prevalence that has been steadily increasing [1]. Characterized by a loss of homeostasis in the tear film, DED manifests through a load of symptoms such as ocular discomfort, visual disturbance, tear film instability, and potential damage to the ocular surface [2]. The etiology of DED is diverse, encompassing environmental factors, systemic diseases, medications, and age-related changes, making its management both challenging and critical

for maintaining patients' ocular health and overall quality of life [3–7]. The pathophysiology of DED complexly involves the interplay between tear hyperosmolarity and ocular surface inflammation, leading to a vicious cycle of tear instability and surface damage. This disruption in the delicate balance of the tear film components—comprising aqueous, lipid, and mucin layers—results in increased tear evaporation or decreased tear production, further exacerbating the condition [7]. Meibomian gland dysfunction (MGD), characterized by the obstruction of the meibomian glands and altered secretion of the lipid layer of the tear film, has been identified as a primary contributor to evaporative DED, highlighting the critical role of lipid layer integrity in maintaining tear film stability and preventing evaporation [8, 9].

Environmental and lifestyle factors play a substantial role in the exacerbation of DED symptoms [10–12]. Prolonged exposure to digital screens, air conditioning, and heating systems, coupled with low-humidity environments, contribute significantly to tear film evaporation and discomfort [13, 14]. Furthermore, the increasing prevalence of contact lens wear and the rising trends in cosmetic eyelid surgeries have been associated with alterations in the ocular surface and tear film dynamics, further complicating the landscape of DED management [15]. Current therapeutic strategies for DED focus on alleviating symptoms, restoring tear film stability, and addressing underlying causes such as MGD. These include the use of artificial tear substitutes, anti-inflammatory agents, punctal plugs, and eyelid hygiene practices. However, the limitations of conventional treatments, including transient relief and lack of long-term efficacy, underscore the need for innovative approaches that target the underlying mechanisms of DED and offer sustainable outcomes [16].

Intense pulsed light (IPL) therapy has emerged as a novel and promising treatment modality for DED, particularly in cases associated with MGD [17]. IPL therapy, traditionally utilized in dermatological treatments, has recently been recognized as an innovative approach for managing DED, especially when associated with MGD [18]. IPL technology employs multiple wavelengths of light to gently heat the eyelids, targeting the root causes of DED [19]. This process helps in unclogging the meibomian glands, reducing eyelid inflammation, and decreasing the bacterial load on the ocular surface [20]. The application of IPL has shown promising results in improving tear film stability, enhancing ocular surface health, and providing significant symptom relief for individuals with DED [21–25]. Its noninvasive nature, coupled with the potential for long-term benefits, positions IPL as a valuable addition to the spectrum of treatments available for DED, offering a new avenue of hope for patients seeking effective and sustainable management of their symptoms [26–33].

This study aims to explore the long-term efficacy of IPL therapy in treating DED associated with MGD over a 1-year follow-up period. It seeks to provide a comprehensive analysis of IPL's impact on tear film stability, ocular surface health, and symptomatology, offering insights into its potential as a sustainable treatment modality.

METHODS

Research Design

This study was a retrospective case series, focusing on historical data. The investigation took place at the Professor Munteanu Mihnea Eye Clinic, located in Timisoara, Romania, including a period from May 2021 until May 2023. The retrospective nature and the specific setting of this study were critical in assessing the effectiveness of IPL therapy for the relief of symptoms associated with MGD. A significant aspect of this study was its emphasis on evaluating the long-term effectiveness of the treatment across three follow-up visits, providing insightful data on its intermediate and long term.

Ethical Approval

Approval for this study was granted by the Ethics Committee at the Victor Babes University of Medicine and Pharmacy in Timisoara, Romania, under approval number 48/2021. Adhering to the Declaration of Helsinki, this research was

grounded in ethical principles, ensuring respect and integrity towards all participants. Digital informed consent was secured from each participant, clearly defining the study's aims, procedures, and the academic use of the collected data. Informed consent was obtained from all participants at the time of their initial clinical visit, allowing for the use of their data in future research studies, which enabled the retrospective analysis of historical data for this study.

Participant Selection Criteria

The participant cohorts consisted of adults diagnosed with symptomatic MGD who received IPL therapy at the designated clinic within the study timeline. Selection criteria were in strict accordance with the guidelines from the International Workshop on MGD [34], aiming for a precise and relevant demographic. To ensure the integrity of the study and minimize confounding factors, exclusion criteria were rigorously enforced. Our study specifically excluded participants with systemic pathologies known to affect tear film stability, such as thyroid disease and Sjögren's syndrome. Additionally, individuals who had undergone ocular surgery within the last 3 months or had experienced other ocular inflammatory conditions, such as uveitis, keratitis, or episcleritis, within the last 6 months were also excluded. Patients with glaucoma and significant skin pathologies—including those with pigmentation issues, trauma, or cancer—were not eligible to participate. Furthermore, individuals who had modified their MGD treatment regimen within 6 months prior to the study or at any point during its course were excluded to better isolate the effects of IPL therapy on DED associated with MGD. All patients at the clinic who met the inclusion and exclusion criteria between the specified dates were included in the study, and no patients were excluded for other reasons.

Study Procedures

Preliminary Evaluation

Before commencing IPL therapy, a thorough evaluation was conducted for each participant to determine their visual comfort and ocular health status. Ocular health status was assessed using several measurements including the noninvasive first and average breakup time (NIFBUT and NIABUT), central and thinnest tear meniscus height (CTMH and TTMH), and the ocular surface inflammatory risk evaluation (OSIE). These provided a comprehensive evaluation of tear film stability, tear volume, and ocular surface inflammation. This initial phase included determination of the skin phototype, ranging from I to V, to customize the IPL treatment accordingly. A preliminary questionnaire was also administered to gather essential participant information and identify any contraindications to IPL therapy.

IPL Treatment and Care

For the IPL sessions, participants were prepared by removing all facial makeup and wearing protective eyewear. A conductive gel was applied to the targeted facial regions, and a series of five IPL flashes were administered beneath the lower eyelids, from the nasal to the temporal side, ensuring even distribution of the therapy. IPL sessions were held on days 1, 15, 45, and 75, to meticulously document the therapy's effectiveness over time.

Utilizing Tearstim® technology (ESW Vision, Houdan, France), the IPL therapy was marked by its noninvasive approach and ease of application. TearStim is a device that employs intense regulated pulsed light (IRPL) technology specifically designed for the treatment of DED linked to MGD. This innovative device emits painless, controlled light pulses directed just below the eye, which stimulate the nerve endings to release neurotransmitters. This stimulation is crucial as it enhances meibomian gland function, improving tear quality and reducing symptoms of dryness. The post-treatment care was minimal, allowing for immediate resumption of normal activities, including makeup application.

Ocular Surface Assessment

The methodological framework incorporated the use of the Tearcheck® device (ESW Vision, Houdan, France) for a detailed ocular surface evaluation. This involved a comprehensive

assessment using the eye fitness test (EFT), which measures symptom severity. It is important to note that in the EFT, a higher score indicates a better outcome. The ocular surface evaluation also includes the measurements of the CTMH and TTMH for quantifying tear film volume. Additionally, the tear film stability evaluation (TFSE) and the OSIE were employed to gauge the level of inflammation and its response to the IPL therapy. In the context of DED, the OSIE provides an essential measure of disease activity by detecting and quantifying ocular surface staining. This procedure utilizes fluorescein dye, a vital diagnostic tool that adheres to altered epithelial areas, indicating potential inflammation. Through a detailed analysis of fluorescein staining patterns, OSIE enables clinicians to visualize and assess the severity of ocular surface damage. This approach enhances our understanding of the ocular surface condition in DED and aids in tailoring individualized treatment strategies aimed at promoting ocular surface healing.

Also, we measured the NIFBUT and NIABUT for assessing tear film stability with the SCHWIND SIRIUS corneal pachymetry and topography device (SCHWIND eye-tech-solutions GmbH, Kleinostheim, Germany). This device is programmed to automatically stop at 17 s, setting this as the upper limit for measurement duration across all sessions. Measurement timings were set at baseline and at 3, 6, and 12 months after the last IPL session. This study focused on evaluating the effectiveness of IPL therapy in follow-up intervals after the treatment. Harms were assessed through adverse events reported by patients during follow-up visits.

Data Analysis

The study employed SPSS Statistics software, version 29.0 (IBM Corporation), for data analysis. Sample size estimation was performed using the GRANMO calculator, version 7.12, aiming for 140 participants to detect a significant mean difference with an alpha risk of 0.05 and a beta risk of 0.2. This calculation was based on an expected standard deviation of 3.8, as noted in previous literature [35], and anticipated a 10% dropout rate. In this retrospective study, the sample size calculation includes an allowance for dropout to account for potential loss of follow-up in the collected retrospective data. Data were summarized using means, standard deviations, and ranges for continuous variables, and frequencies and percentages for categorical data.

Normality and variance homogeneity tests preceded the application of the Student *t*-test or Wilcoxon signed-rank test for within-group comparisons. Differences between initial and final evaluations were represented as $\Delta = \text{Last Visit} - \text{Baseline}$. Comparisons across groups utilized the unpaired Student *t*-test or Mann–Whitney *U* test, with a significance threshold set at $P < 0.05$. There is only one exposure group: patients with MGD who received IPL therapy. Comparisons were made between baseline and last visit data within this group.

RESULTS

This investigation included 110 individuals, corresponding to a total of 220 eyes under study. The age distribution of the participants was broad, with an average age of 51.88 years (SD = 15.26), covering a range from 18 to 86 years. Regarding the gender composition, the study was predominantly female, with 69 female participants (62.7%) and 41 male participants (37.3%). The study's findings on symptomatology and tear film characteristics are systematically organized in the results tables. Specifically, Table 1 outlines the evolution observed at various follow-up evaluations (3, 6, and 12 months).

A graphical synthesis of the key outcomes is presented in Figs. 1, 2, 3, 4, 5, 6, 7, and 8, comprising eight box-and-whisker plot comparisons that highlight notable trends and findings in the study. These plots are segmented as follows: (1) variations in EFT scores, (2) changes in NIFBUT, (3) alterations in NIABUT, (4) shifts in TFSE scores, (5) adjustments in CTMH, (6) modifications in TTMH, (7) trends in OSIE employing fluorescein Thilorbin, and (8) fluctuations in OSIE capture time. These segments comprehensively cover the scope of symptom changes, stability and quantity of the tear film, and the ocular

Table 1 Dry eye disease changes during follow-up

Variables	Baseline	3 months	6 months	12 months	*P*-value[a]	Difference confidence interval
Subjective symptoms						
EFT, score points, median (IQR)	34.00 (12.00)	40.00 (7.00)	41.00 (3.00)	42.00 (4.00)	< 0.01 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−1.87 to 0.04 (3 vs. 6) −2.47 to −0.81 (3 vs. 12) −1.50 to 0.13 (6 vs. 12)
Tear film stability						
NIFBUT, seconds, median (IQR)	7.40 (12.67)	17.00 (8.38)	17.00 (8.58)	17.00 (4.95)	< 0.01 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−0.89 to 1.51 (3 vs. 6) −2.73 to 0.02 (3 vs. 12) −2.83 to −0.49 (6 vs. 12)
NIABUT, seconds, median (IQR)	10.70 (9.38)	17.00 (4.95)	17.00 (6.67)	17.00 (2.85)	< 0.01 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−0.80 to 0.87 (3 vs. 6) −2.20 to −0.09 (3 vs. 12) −2.01 to −0.35 (6 vs. 12)
TFSE, score points, median (IQR)	114.50 (266.00)	92.50 (145.00)	93.50 (157.00)	74.00 (109.00)	0.28 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−7.67 to 48.52 (3 vs. 6) 40.70 to 99.13 (3 vs. 12) 31.23 to 67.75 (6 vs. 12)
Tear film quantity						
CTMH, mm, median (IQR)	0.34 (0.25)	0.39 (0.23)	0.37 (0.14)	0.35 (0.09)	0.19 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−0.02 to 0.04 (3 vs. 6) −0.03 to 0.04 (3 vs. 12) −0.03 to 0.02 (6 vs. 12)

Table 1 continued

Variables	Baseline	3 months	6 months	12 months	*P*-value[a]	Difference confidence interval
TTMH, mm, median (IQR)	0.43 (0.28)	0.43 (0.23)	0.40 (0.16)	0.37 (0.09)	0.03 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−0.02 to 0.07 (3 vs. 6) −0.00 to 0.08 (3 vs. 12) −0.01 to 0.04 (6 vs. 12)
Surface evaluation						
OSIE type 1, percentage, median (IQR)	4.00 (8.00)	3.00 (5.00)	2.00 (3.00)	1.50 (8.00)	< 0.01 (3 vs. 6) < 0.01 (3 vs. 12) < 0.01 (6 vs. 12)	−0.11 to 1.74 (3 vs. 6) 0.99 to 2.83 (3 vs. 12) 0.52 to 1.67 (6 vs. 12)
OSIE Capture time, seconds, median (IQR)	122.50 (12.00)	122.00 (6.00)	122.00 (7.00)	121.00 (4.00)	0.40 (3 vs. 6) 0.14 (3 vs. 12) 0.16 (6 vs. 12)	−2.97 to 1.13 (3 vs. 6) −1.87 to 2.16 (3 vs. 12) −0.98 to 3.10 (6 vs. 12)

DED dry eye disease, *EFT* eye fitness test, *CTMH* central tear meniscus height (below iris), *IQR* interquartile range, *NIABUT* noninvasive average breakup time, *NIFBUT* noninvasive first break up time, *OSIE* type 1 ocular surface inflammatory risk evaluation (with fluorescein sodium and oxybuprocaine hydrochloride), *TFSE* tear film surface evaluation, *TTMH* thinnest tear meniscus height

[a]W of Wilcoxon

surface condition, underpinning the therapy's impact.

In this study, significant changes were observed across various parameters over the 12-month period. The EFT scores increased by an average of 8.00 points, indicating an improvement in subjective symptoms. Both NIFBUT and NIABUT showed considerable increases, improving by 4.60 s and 4.15 s, respectively, which suggests enhanced tear film stability. In contrast, the TFSE score decreased by 58.50 points, reflecting a potential reduction in tear film quality or surface irregularities.

In terms of tear film quantity, minimal changes were noted, with the CTMH slightly increasing by 0.01 mm while the TTMH decreased by 0.04 mm. The OSIE type 1 showed a decrease from 4.00% to 1.50%, which suggests a reduction in ocular surface inflammation. Similarly, the time required to capture OSIE type 1 images decreased marginally by 2.50 s. All observed changes across these variables were statistically significant, with *P*-values less than 0.01, highlighting the effectiveness of the interventions or the progression of conditions under study. In the study, no significant harms or adverse events, defined as those requiring medical intervention, were reported by patients during the follow-up period. Minor adverse events that did not require medical attention were noted but were not deemed significant for this study.

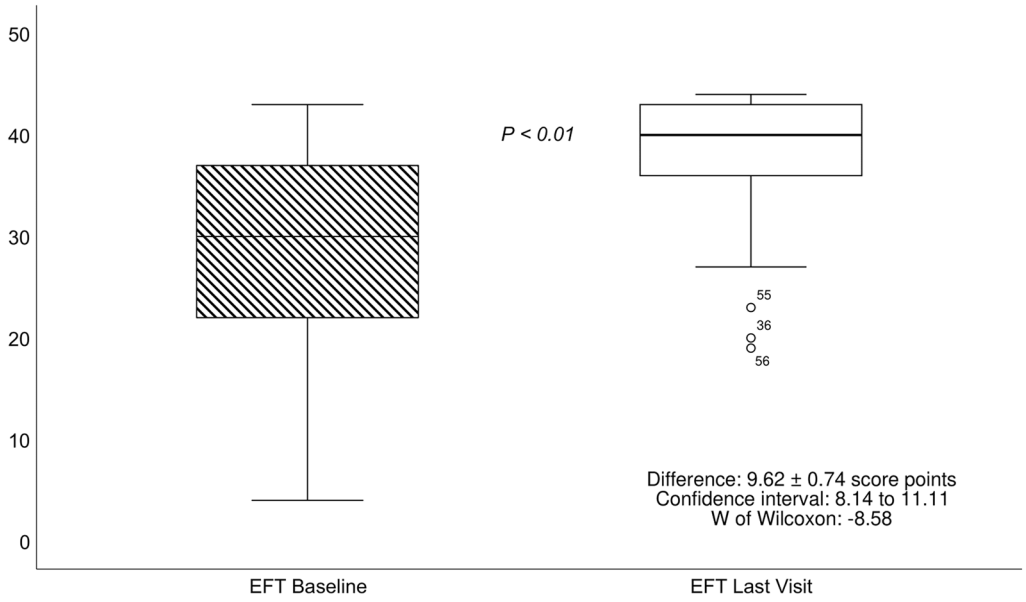

Fig. 1 Eye fitness test (EFT) comparison, measured in score points

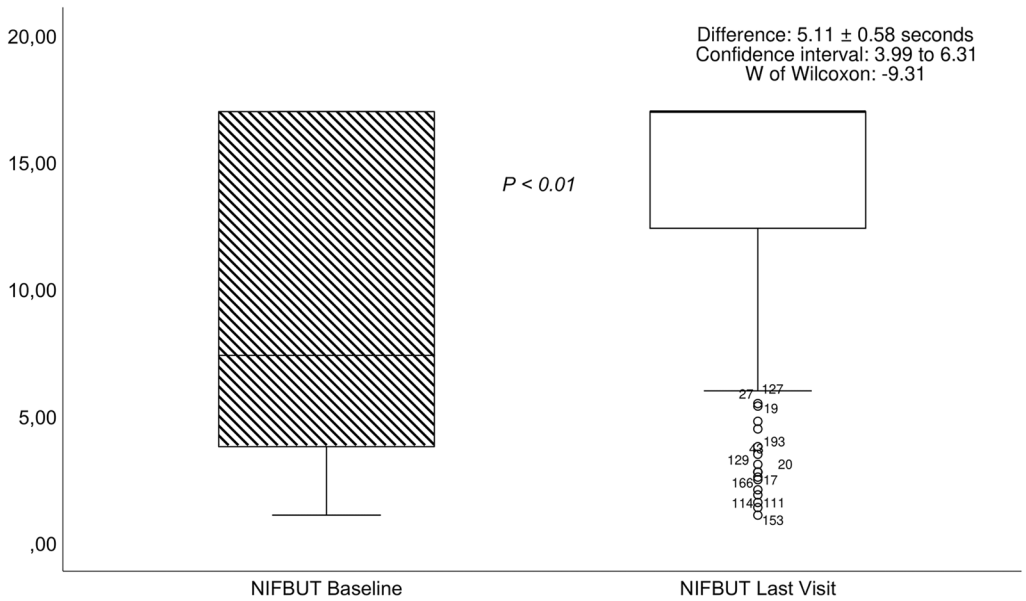

Fig. 2 Noninvasive first breakup time (NIFBUT) analysis, measured in seconds

DISCUSSION

This document provides an overview of the changes observed over a 12-month period in IPL treatment of DED. It reports an improvement in subjective symptoms of dryness, according to EFT. There is a noted increase in tear film stability, as seen through improvements in both the NIFBUT and NIABUT, implying a more stable and cohesive tear layer. The tear film's surface condition also improved,

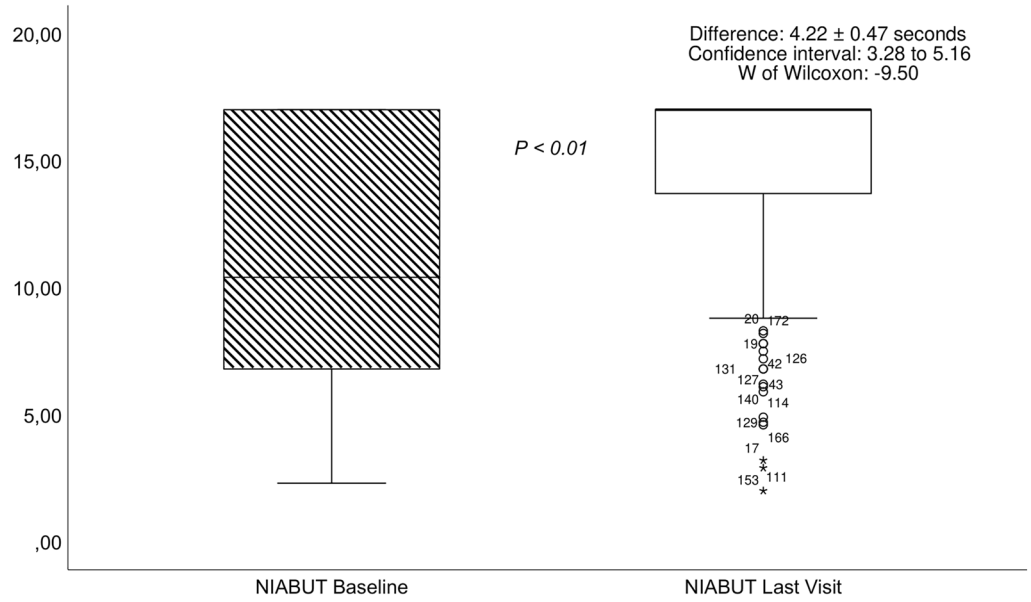

Fig. 3 Noninvasive average breakup time (NIABUT) distribution, measured in seconds

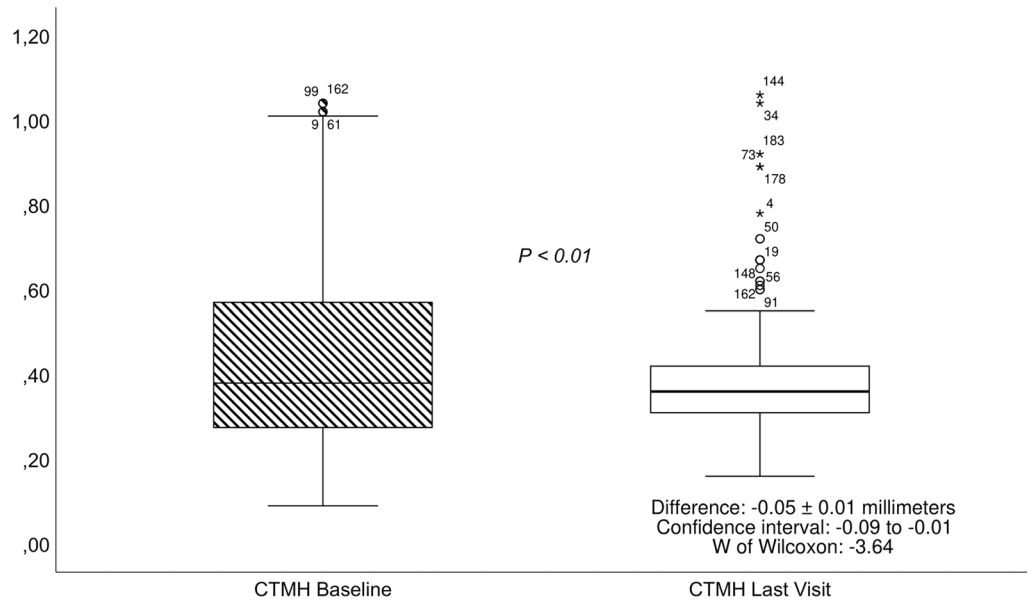

Fig. 4 Central tear meniscus height (CTMH) measurements, measured in millimeters

indicating a healthier ocular surface. On the matter of tear volume, the study observed a slight decrease, suggesting a reduction in tear production or retention. Lastly, the evaluation of the ocular surface showed a decrease in inflammation, pointing to a positive outcome in managing ocular surface inflammation.

Benítez-del-Castillo et al. [35] provide a foundational perspective by demonstrating the comprehensive effectiveness of IPL therapy in improving dry eye symptoms, meibomian gland

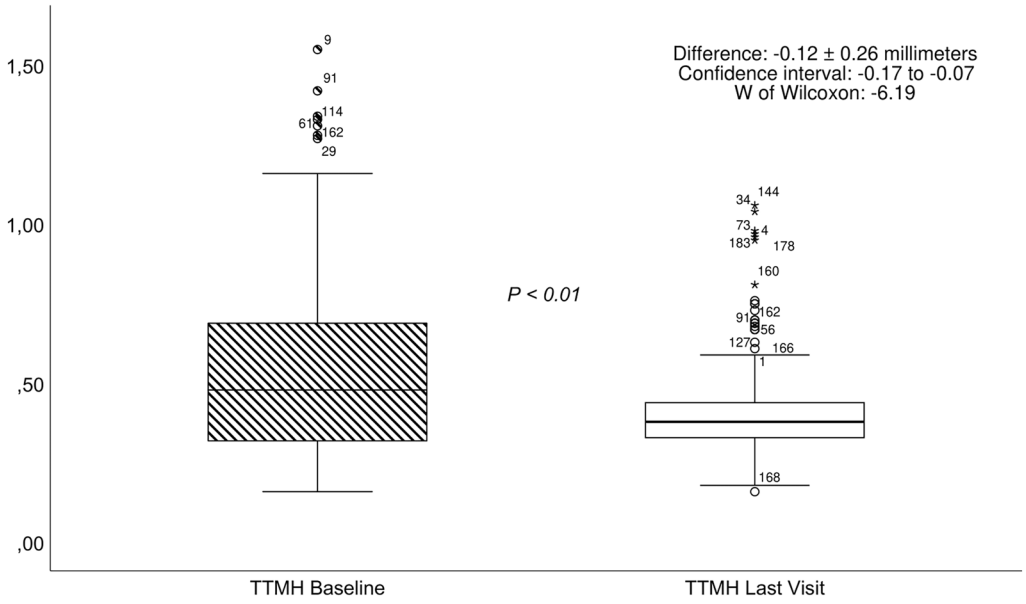

Fig. 5 Thinnest tear meniscus height (TTMH) comparison, measured in millimeters

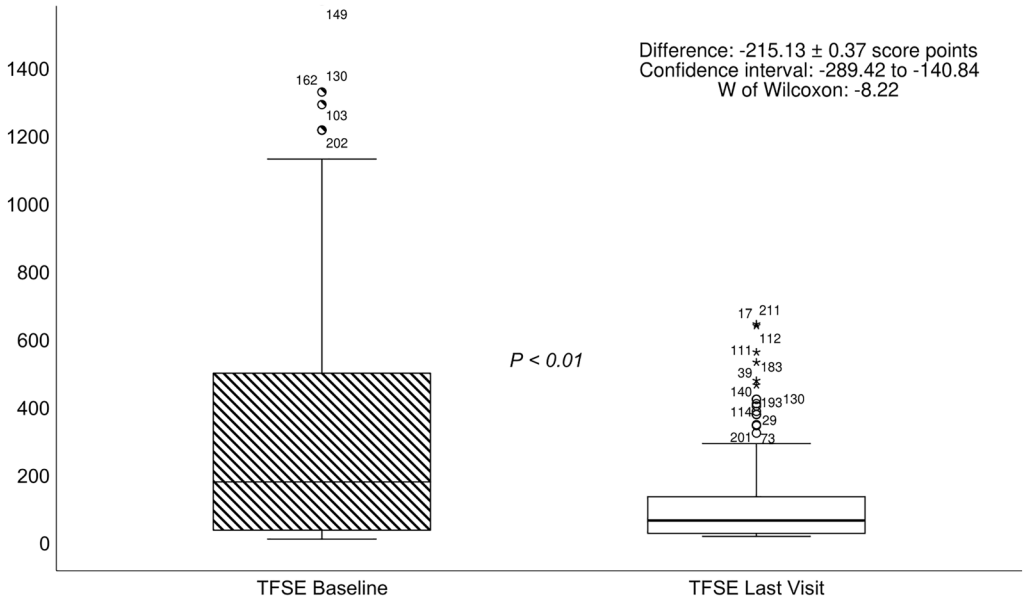

Fig. 6 Tear film stability evaluation (TFSE) scores, measured in score points

function, and ocular surface health in patients with MGD. Their work underscores the adaptability of IPL therapy across a spectrum of DED severities, echoing our study's findings on the wide-ranging benefits of IPL in enhancing tear film stability and ocular surface condition. This broad applicability sets the stage for a nuanced discussion on IPL's role in DED management. Extending the discourse, Qin et al. [36] assess IPL's impact on severe evaporative DED, highlighting the therapy's significant improvements in both signs and symptoms of the condition.

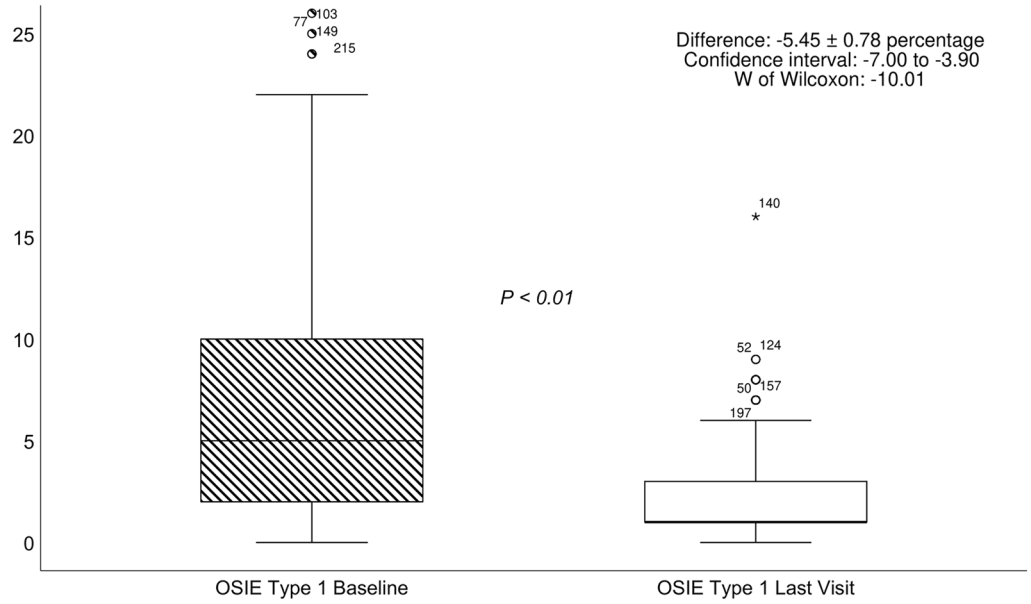

Fig. 7 Ocular surface inflammatory evaluation (OSIE) with fluorescein Thilorbin, measured in percentage

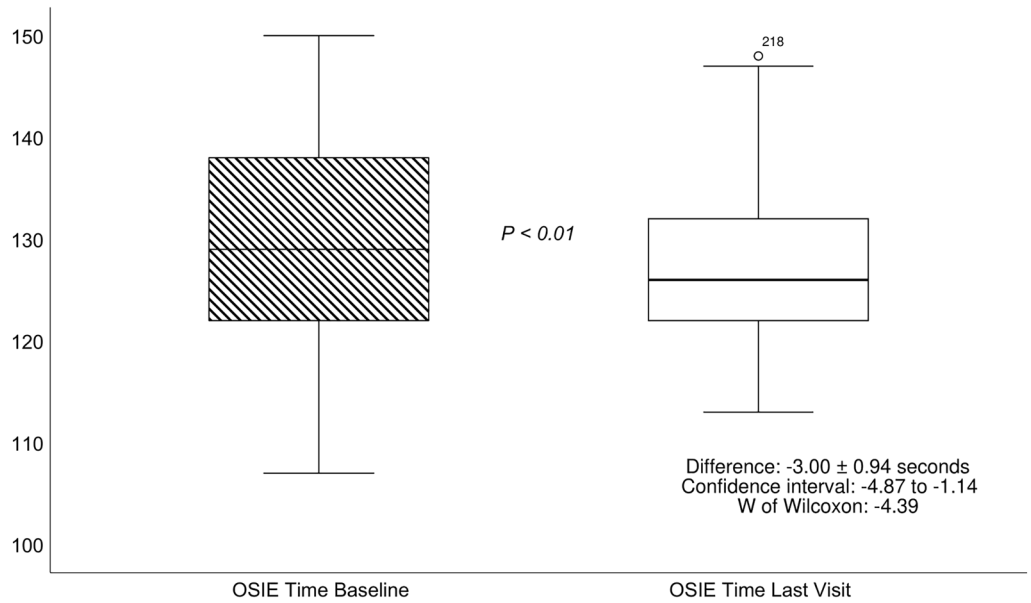

Fig. 8 Ocular surface inflammatory evaluation (OSIE) capture time, measured in seconds

Similarly, Gouws et al. [37] compare IPL with a 445 nm laser device, noting equivalent symptom reduction efficacy, thereby reinforcing the therapeutic value of IPL within a diverse array of treatment options. These studies collectively affirm our results, advocating for IPL's integration into personalized treatment regimens for DED.

Transitioning to more specialized discussions, Ballesteros-Sánchez et al. [38] explore a combinative treatment approach, integrating IPL with microblepharoexfoliation and meibomian gland

expression. Their findings of enhanced improvements in dry eye indicators parallel our observation of IPL's standalone efficacy, suggesting potential synergistic benefits from multimodal treatment strategies involving IPL. Yin et al. [39] and Chung et al. [40] delve into IPL's nuanced applications, examining its effectiveness across different MGD stages and the addition of upper eyelid treatment. These studies not only corroborate our findings on IPL's broad therapeutic potential but also emphasize the importance of customized treatment plans based on patient-specific needs and disease characteristics.

Finally, studies by Benyousef et al. [22], Jiang et al. [41], and Trone et al. [42] highlight technological advancements and novel device comparisons within the realm of IPL therapy. Their research into new-generation IPL devices and combined IPL and photo-biomodulation treatments offers insights into the continuous evolution of IPL technology. This progression in device innovation and treatment methodology aligns with our study's implications for ongoing improvement in IPL therapy's efficacy and patient outcomes. In sum, the collective research narrative—from the general efficacy of IPL in managing MGD and DED to the specific benefits of advanced treatment protocols and innovative devices [22, 35, 37–45]—underscores a holistic view of the significant role of IPL therapy in DED management. Our study contributes to this body of evidence, advocating for a multifaceted approach to IPL application that is both informed by broad clinical insights and attuned to the nuances of individual patient care.

Limitations

One notable limitation of this study is its retrospective case series design, which may introduce selection bias and limit the control over confounding variables compared to a randomized controlled trial. Additionally, the study's focus on patients with MGD as the primary cause of DED may not fully represent the diverse etiologies of DED, potentially limiting the generalizability of the findings. The slight decrease in tear volume observed warrants further investigation, as it may impact the overall efficacy of IPL therapy in long-term DED management.

In this study, data from subjects who received delayed treatment as per the manufacturer's recommended protocol were included in the 1-year follow-up analysis. While this was intended to provide a complete picture of the treatment's efficacy across varying timelines, it is acknowledged as a limitation that may affect the generalizability of the treatment effects observed.

Although the EFT provided consistent data collection as the default variable of the Tearcheck® device, it is acknowledged that more widely validated tests such as the Ocular Surface Disease Index (OSDI) and five-item Dry Eye Questionnaire (DEQ-5) are commonly used in the scientific community for assessing symptom severity in DED. The use of the EFT over other established measures may affect the comparability of our results with other studies. Future studies could benefit from incorporating these validated tests to allow for broader comparability of results across studies.

In this study, we did not assess eyelid margin abnormalities, focusing instead on the primary effects of IPL treatment on MGD. We acknowledge this as a limitation and plan to explore these aspects in future research to gain a fuller understanding of MGD pathophysiology and treatment efficacy.

This study relied on patient-reported outcomes and clinician-assessed measures, which may be subject to reporting bias. Patients may overreport improvements due to the placebo effect or underreport symptoms due to recall bias. Clinician assessments, while standardized, may also be influenced by subjective interpretation. To mitigate this, future studies should incorporate objective biomarkers and automated measurement tools to complement subjective assessments and reduce potential biases in reporting.

The absence of blinding in this study is a significant limitation. Both patients and clinicians were aware of the treatment being administered, which could introduce bias in the reporting and assessment of outcomes. Blinding participants and clinicians in future studies, possibly through the use of a sham treatment group, would help

to minimize bias and provide a more robust evaluation of the true efficacy of IPL therapy.

Despite the initial target sample size of 140 participants, the inclusion of 110 individuals resulted in a recalculated power of approximately 0.81, which remains within an acceptable range for detecting significant differences, though slightly lower than the targeted power. This consideration is noted to contextualize the study's findings.

Future Lines of Research

Future studies could explore the application of IPL therapy across a broader spectrum of DED etiologies, including non-MGD-related DED, to assess its efficacy in a wider patient population. Longitudinal studies with larger sample sizes and randomized controlled trials are needed to validate the findings and further elucidate the mechanisms by which IPL therapy influences tear film dynamics and ocular surface health. Investigating the potential cumulative effects of repeated IPL treatments over several years could also provide valuable insights into the long-term sustainability of IPL therapy as a DED treatment modality.

Practical Applications

The positive outcomes observed in this study highlight the potential of IPL therapy as a valuable addition to the current treatment options for DED, particularly for patients unresponsive to conventional therapies. The ability of IPL therapy to improve tear film stability and reduce ocular surface inflammation offers a noninvasive, safe, and effective treatment alternative. Ophthalmologists and clinicians should consider IPL therapy in their treatment arsenal for DED, especially for cases associated with MGD, taking into account the patient's specific condition, preferences, and potential contraindications.

In clinical practice, the insights from this study are particularly valuable for guiding patient expectations and treatment adherence over the first year of therapy. Our results provide detailed timelines for expected improvements based on the severity of the disease, allowing practitioners to offer tailored advice to patients. For instance, significant relief might not be evident immediately after the first session but becomes more pronounced by the end of the fourth session and further improves at 3 months. By setting realistic expectations from the outset, clinicians can help mitigate patient disappointment and potential discontinuation of treatment. Clear communication about the anticipated timeline for seeing improvements and side effects can ensure patients remain committed to the treatment plan. Additionally, managing expectations can foster trust and satisfaction, leading to better adherence and outcomes. Thus, this study not only underscores the efficacy of the treatment but also serves as a practical guide for optimizing patient management and satisfaction throughout the course of therapy.

CONCLUSIONS

In conclusion, IPL therapy offers a promising and sustainable treatment option for patients with DED, especially those suffering from MGD. The study corroborates IPL therapy's long-term efficacy in enhancing tear film stability, reducing ocular surface inflammation, and improving subjective symptoms of dryness. These findings advocate for the inclusion of IPL therapy in the repertoire of treatment modalities for DED, emphasizing its role in improving patients' quality of life by alleviating the discomfort and symptoms associated with the condition.

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Data Availability. The raw data supporting the conclusions of this article will be made available by the authors on request.

Declarations

Conflict of Interest. Cristina-Patricia Pac, Mihnea Munteanu, José-María Sánchez-González, Carlos Rocha-de-Lossada, Nadina Mercea, Francis Ferrari, Horia T Stanca, Dan Andrei Radu Cosnita, Mihaela Ionica, Ovidiu Boruga, Ciprian Danielescu, and Alexandru Blidisel have nothing to disclose.

Ethical Approval. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Victor Babes University of Medicine and Pharmacy Timisoara (protocol code 48/2021). Digital informed consent was secured from each participant, clearly defining the study's aims, procedures, and the academic use of the collected data. Informed consent was obtained from all participants at the time of their initial clinical visit, allowing for the use of their data in future research studies, which enabled the retrospective analysis of historical data for this study.

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