https://doi.org/10.5272/jimab.2025311.5962

Journal of IMAB. 2025 Jan-Mar;31(1)

Journal of IMAB
ISSN: 1312-773X
https://www.journal-imab-bg.org

Original article

INTENSE PULSED LIGHT (IPL) – TREATMENT STRATEGY FOR MEIBOMIAN GLAND DYSFUNCTION

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ABSTRACT

Meibomian gland dysfunction (MGD) is a primary cause of dry eye syndrome, as the meibomian glands produce lipids that maintain tear film integrity and reduce its evaporation. Blockage of these glands can result in symptoms associated with dry eye disease. Intense pulsed light (IPL) therapy is a novel treatment option for dry eye syndrome caused by MGD.

Purpose. The purpose of our study is to assess the safety and effectiveness of IPL for treating dry eye syndrome caused by MGD in various age groups, by analyzing the non-invasive tear breakup time (NITBUT) and Schirmer's test results both before and after two IPL treatments.

Materials and methods: A total of 120 subjects, each with varying degrees of MGD, underwent IPL treatment in both eyes. Each patient received two procedures spaced two weeks apart. Tear breakup time (TBUT) and Schirmer's test were evaluated at baseline and two weeks following the final treatment.

Results: The majority of tests demonstrated improvement in key clinical parameters, including tear breakup time, Schirmer's test, meibum quality, and the Standard Evaluation of Eye Dryness Questionnaire. IPL therapy shows therapeutic potential for treating MGD, enhancing tear film quality, and alleviating dry eye symptoms.

Conclusion: IPL presents a promising area for development, offering the potential for improved outcomes in patients with MGD, and is currently the focus of ongoing research.

Keywords: dry eye syndrome, meibomian gland dysfunction, non-invasive tear film breakup time, schirmer's test, IPL treatment,

INTRODUCTION

Over the past three decades, awareness of dry eye syndrome has increased significantly worldwide. A healthy ocular surface is essential for maintaining clear vision. Dry eye only became officially defined as a disease condition just over 30 years ago. In 2007, the first TFOS DWES definition of dry eye was published after a three-year international consensus process that focused on the clinical effects and associated signs [1]: "Dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles.".

There are two forms of dry eye, aqueous-deficient and evaporative, or a combination of these, with or without other etiological factors for dry eye syndrome [2]. Both forms can cause damage to the interpalpebral ocular surface and are associated with symptoms of ocular discomfort. Meibomian gland dysfunction, a contributing factor in the development of the evaporative form, is considered a leading cause of dry eye syndrome in various clinical and population-based studies [3].

Meibomian gland dysfunction is a primary cause of dry eye syndrome. These glands, located along the posterior lamella of the eyelids between the tarsal plate and the palpebral conjunctiva, produce lipids that are essential for maintaining the integrity of the tear film and reducing evaporation. When the Meibomian glands become obstructed, they can contribute to the symptoms of dry eye syndrome. The International Workshop on Meibomian Gland Dysfunction (IWMGD) defines Meibomian gland dysfunction as a persistent, widespread abnormality of the glands, typically marked by severe duct obstruction and/or changes in the quality or quantity of glandular secretion [4].

Until recently, the primary treatments for Meibomian gland dysfunction have consisted of lipid-based tear substitutes, Omega-3 fatty acids, Meibomian gland expression, and topical anti-inflammatory medications [5]. Despite numerous treatment strategies, patients with dry eye syndrome may not achieve complete or long-lasting

symptom relief, highlighting the ongoing need for more effective therapies.

Intense pulsed light (IPL) represents a novel treatment option for dry eye syndrome caused by Meibomian gland dysfunction. This technique has been utilized in dermatology for over a decade to treat skin lesions. The first article on their use in dermatology dates back to 1997, with Raulin et al. successfully applying them to treat 14 patients with telangiectasias of the face or leg or with poikiloderma of Civatte. IPL systems emit high-intensity, pulsed, and polychromatic light with wavelengths ranging from 500 to 1200 nm. This light is directed onto the skin and absorbed by chromophores like melanin, hemoglobin, and water, generating heat (>80 °C) [6]. The depth of penetration and the behavior of absorbed light are functions of wavelength for heat production and selective photothermolysis. Specific filters and clinical parameters, such as the Fitzpatrick or Toyos scale for skin type, are commonly used to achieve the optimal wavelength to the target structure and minimize the risk of adverse events by adjusting treatment intensity [7]. In addition, the duration and intervals between pulses can be controlled, influencing the amount of energy delivered (J/cm2) and allowing appropriate thermal relaxation of the target tissue, avoiding damage to surrounding structures [6]. Rolando Toyos presented the seminal report on IPL for the treatment of dry eye syndrome in 2002 after observing the beneficial effects of IPL on Meibomian dysfunction in patients treated for facial rosacea [8]. They reported reduced facial erythema and improved signs and symptoms of meibomian dysfunction.

OBJECTIVE

The aim was to investigate the efficacy and safety of intense pulsed light (IPL) for the treatment of dry eye syndrome due to Meibomian gland dysfunction in patients in different age groups by examining the non-invasive tear film breakup time (NIBUT) and Schirmer's test measured before IPL treatment and their change after two IPL treatments.

MATERIALS AND METHODS

This is a prospective study conducted at Zora Eye Hospital. A total of 120 subjects with first-, second- and third-degree Meibomian gland dysfunction were studied, 58 (48.3%) of them were male, and 62 (51.7%) were female. 49 (40.8%) people out of the total number of patients were aged up to 45 years, and 71 (59.2%) were aged above 45 years. Medical history was taken, and complete ophthalmological status was obtained for all patients. The Ocular Surface Disease Index (OSDI) questionnaire for measuring the severity of dry eye disease were distributed. 90% of the patients had complaints related to light irritation, feeling of "sand in the eyes", red eyes and eye problems while using a computer.

The ANTARES corneal topographer (CSO, ANTARES - 2017) was utilized in Meibo-Scan and NIBUT mode, using infrared light, to assess both meibography and tear film breakup time. Patients underwent non-contact infrared meibography following eyelid eversion and surface imaging. Meibography was conducted on the upper and lower eyelids of both eyes for each patient. The degree of Meibomian gland dysfunction, automatically recorded by the apparatus, was classified into four categories: grade zero (0% gland loss), grade one (< 25% gland loss), grade two (25% - 50% gland loss), grade three (51% - 75% gland loss), and grade four (greater than 75% gland loss).

The non-invasive tear film breakup time was measured without contact using a built-in, video-assisted specialized software program. Values were recorded before IPL treatment as well as after the first and second procedure. The measurement was conducted for each individual eye, with the reported values representing the average breakup time. Tear film stability is assessed according to the non-invasive breakup time, which is categorized as follows: normal (≥ 14 seconds), critical (7-14 seconds), and marked instability (< 7 seconds).

The Schirmer test 2, used to measure tear secretion, was performed on all patients before IPL treatment as well as after the first and second procedure. Specially filtered paper strips with 5 mm wide and 35 mm long markings were used for the test. After five minutes, the results were assessed by measuring the wet portion of the test strip. The severity of tear deficiency was classified into three categories: mild (14-9 mm), moderate (8-4 mm), and severe (less than 4 mm).

The IPL treatment protocol with the M22 Lumenis device consists of two sessions, each two weeks apart. Most IPL devices operate at low-intensity energy levels (8.5-20 J/cm²) and should be configured to the 'Dry Eye' setting. Protective eye shields are applied, and the treatment area must be clean of makeup and covered with ultrasound gel. The procedure begins at one temple, moving to the other, covering the lower eyelids and treating the nose area with slightly overlapping applications. After the procedure, manual expression of the Meibomian glands is performed to help with meibum secretion.

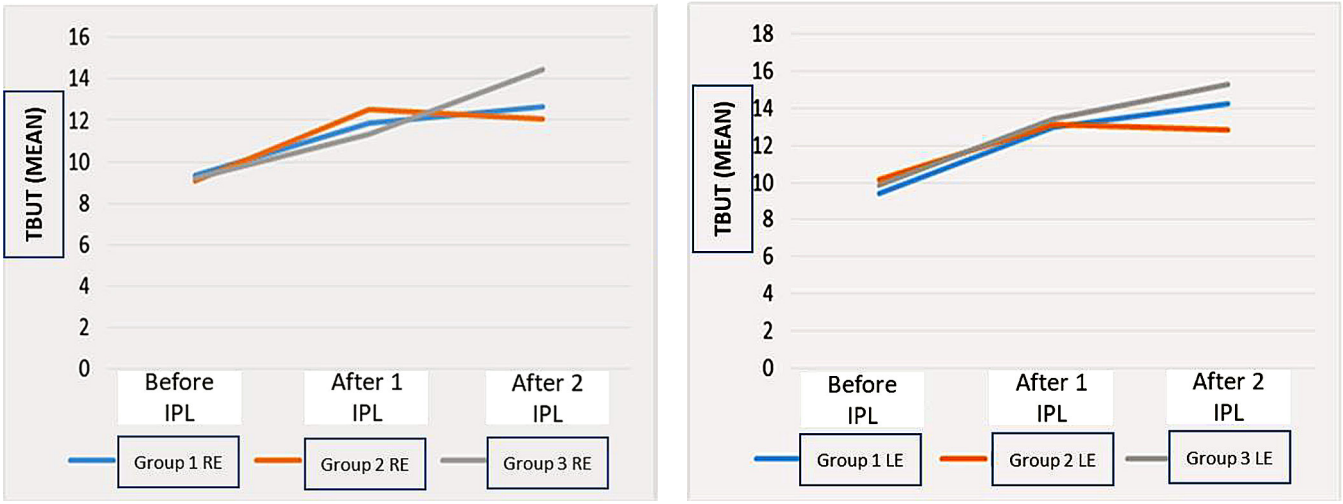
RESULTS

The specialized statistical package SPSS (Statistical Package for the Social Sciences) version 20.0 was used to process the study's data; the assumed level of significance is á=0.05.

Evaluation of the short-term effect of IPL treatment combined with Meibomian expression on TBUT for both right and left eyes showed a statistically significant increase in mean values after the procedure ($p<0.05$). Exceptions were observed only in patients in group 3 before IPL and after the first IPL ($p>0.05$). After the first and second IPL, changes were not statistically significant except in group 3 in the right eye, where TBUT values increased after the second IPL.

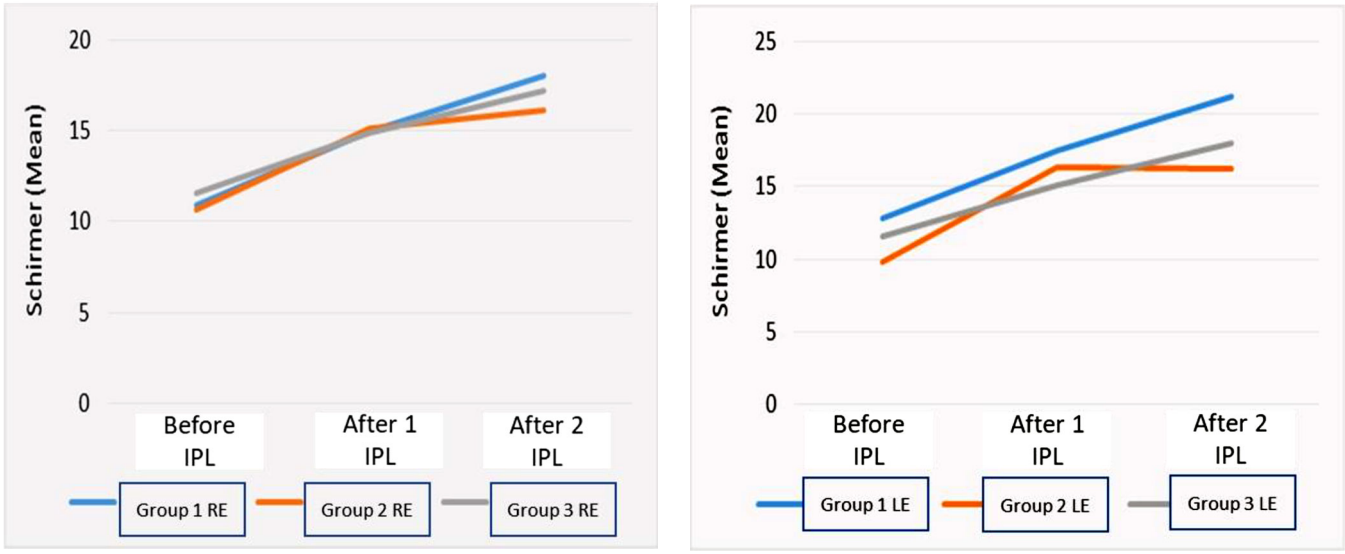
The factors tested, including gender, age, and use of artificial tears, have not shown a significant impact on the results. This indicates that the findings are consistent across all patients, irrespective of their gender, age, or use of artificial tears.

Fig. 1. Tracking of TBUT change before IPL, after first and after second IPL for right (RE) and left eye (LE)



Schirmer's test results of both eyes increased statistically significantly after the procedure in all groups ($p<0.05$). After the first and second IPL, changes were not statistically significant, only in groups 1 and 2 in the right eye and groups 2 and 3 in the left eye ($p>0.05$). Here again, gender, age, and the application of artificial tears had no significant effect on the results described above ($p>0.05$).

Fig. 2. Schirmer's test of the right (RE) and left eye (LE) before the first procedure, after the first and second IPL procedure



DISCUSSION

IPL treatment due to Meibomian dysfunction was first reported in an article in 2015. Over the past few years, we have seen a surge in studies evaluating the efficacy of IPL as a treatment modality for dry eye syndrome secondary to Meibomian gland dysfunction [9]. The results of our trial support those of Toyos R, et al. Furthermore, the present study confirmed improvement in patients' symptom scores improvement in TBUT and Schirmer's test after two IPL treatments. We conclude that IPL offers significant efficacy in treating dry eye syndrome. These results underscore the potential of IPL as a promising new therapeutic approach [8].

Several studies have demonstrated a positive effect on Meibomian gland macro- and microstructure from IPL treatment. Yin Y, et al. found a 4%-5% reduction in meibomian gland dropout after IPL treatment [10]. However, these results are not ubiquitous. One hypothesis is that mechanical stimulation of stem cells in meibomian glands may be the cause of the reduced gland dropout [11]. The location and migration of stem cells in meibomian glands remain misunderstood. One possibility is the presence of stem cells between the acinus and ductus undergoing asymmetric cell division, with the more differentiated daughter cells migrating to the acinus of the meibomian glands [12]. Whether IPL can activate stem cells responsible for meibomian glands is an intriguing question that requires further elucidation and studies.

IPL has been shown to alleviate dry eye symptoms by regulating the concentration of lipids, including triglycerides, cholesterol, and phospholipids, in the tear film. Ahmed SA, et al. observed significant improvements in tear protein concentration and molecular weight after IPL therapy, with the most marked effects seen in the molecular weight of tear lysozyme, lactoferrin, and albumin levels [13]. A study by Gao YF, et al. found that inflammatory markers, such as interleukin-6, decreased one week after treatment compared to their levels one month later. This finding suggests that IPL treatment begins to exert its effects at an early stage [14].

Numerous studies report that IPL aids in liquefying obstructed meibum through thermal pulsation therapy. In their research, Godin et al. emphasize that Meibomian gland dysfunction plays a crucial role in dry eye syndrome among patients with Sjögren's syndrome and should not be overlooked when considering treatment options. Thermal pulsation helps release meibum from blocked channels, offering a therapeutic option for patients with Sjögren's disease who suffer from both Meibomian gland dysfunction and dry eye symptoms [15].

Antiglaucoma therapy has been shown to cause dry eye in 90% of cases [16]. Beta-blockers have been found to be associated with the greatest risk of developing dry eye, followed by prostaglandin analogues [17]. Beta-blockers have pro-apoptotic activity and independently, although to a lesser extent, damage the ocular surface [18]. These pharmacologically induced ocular surface alterations can cause a significant reduction of the lipid layer of the tear film and consequently lead to the evaporative form of dry eye syndrome. IPL has been shown to affect dry eye symptoms in patients on antiglaucoma therapy. Gupta PK, et al. reported that there was a significant decrease in meibum viscosity and a significant increase in lipid flux. This improvement has not been reported in glaucoma patients on other treatments [19]. Craig JP, et al. reported a significant increase in tear film breakup time (TFT) from baseline to the end of IPL sessions [20].

An additional issue that needs discussion is the duration of the healing effect. In terms of studies conducted so far with a follow-up time of more than 6 months, the effect of treatment on symptomatic relief and meibum characteristics seems to be longer lasting, over 1 year, whereas tear film stability deteriorates after about 6 months. However, there is insufficient evidence, and larger, randomized, long-term controlled trials are needed.

CONCLUSION

There is considerable evidence that IPL treatment is a safe procedure that often improves dry eye symptoms and several clinical parameters, particularly tear film stability and meibum characteristics. Based on the current literature, the combination of IPL with meibomian gland expression appears to be the most effective. IPL treatment for dry eye syndrome caused by meibomian gland dysfunction is a promising area of development, offering the potential for improved outcomes in patients with this condition, which is currently being explored in ongoing studies.

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Please cite this article as: Dimitrova M, Kuneva I. Intense Pulsed Light (IPL) - Treatment strategy for Meibomian gland dysfunction. *J of IMAB.* 2025 Jan-Mar;31(1):5962-5966. [Crossref - https://doi.org/10.5272/jimab.2025311.5962]

Received: 05/11/2024; Published online: 23/01/2025

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