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## Chapter

# Intense Regulated Pulsed Light (IRPL) for Dry Eye Treatment

*Eduardo Rojas Alvarez and Naima Pino Urias*

## Abstract

IRPL was traditionally used for the treatment of a variety of dermatological diseases such as rosacea. However, third-generation equipment was created specifically for periocular application with multiple homogeneously sculpted pulses “It is the only IRPL device medically certified to treat Meibomian Gland Dysfunction.” Several hypotheses or effects of how the device works have been proposed. Ablation of the small telangiectatic vessels around the eyelid, elimination or reduction of the ectoparasite Demodex, which resides in the meibomian glands and consumes meibum secretions in patients who have rosacea, photomodulation of the glands stimulates cellular activity, improving the micro and macro structure of the meibomian glands. In addition, the modification would decrease the inflammation surrounding them.

**Keywords:** regulated intense pulsed light, dry eye, meibomian glands

## 1. Introduction

Dry eye syndrome (DES) due to meibomian gland dysfunction (MGD) is a chronic alteration manifested by both quantitative and qualitative changes of the meibum, affecting the tear film and causing ocular irritation, inflammation, and/or pain [1]. According to Rouen, the worldwide prevalence rate of the syndrome is between 5% and 50%, but it can even reach 75%, depending on the geographical region and the age of the person, being more frequent in adults over 40 years old, predominantly in women. 2.7% of those suffering from DES are adults between 18 and 45 years of age [2].

The basic treatment for people suffering from DES consists of the administration of artificial tears, the use of warm compresses, changes in the usual diet, increasing the intake of omega-3 oils, and the use of antibiotics and/or topical corticosteroids. However, despite the large number of options for management, in most cases, patients are not completely satisfied, causing discomfort and difficulties in their daily lives, which leads to the search for other therapies [3].

Intense regulated pulsed light (IRPL) is a digital device traditionally used for the treatment of a variety of dermatological conditions such as rosacea. However, third-generation equipment was created specifically for periocular application with multiple homogeneously sculpted pulses. IRPL uses a xenon flash lamp to emit wavelengths of light from 400 to 1200 nm. When placed over the light, a filter restricts the wavelength to the visible light range of 500 nm. When applied to the skin, this

500 nm light allows the blood vessels to capture the light and coagulation to occur, and eventually, they close [4].

IRPL is a relatively new therapy, which as of 2017, the Tear Film and Ocular Surface Society, included within the alternatives for the management of DES. However, the use of IRPL was well recognized in the field of dermatology for the treatment of dermal conditions such as rosacea, cavernous hemangiomas, and hypertrichosis, among others [5]. Its mechanism of action is developed through the uptake of light by the oxyhemoglobin present in red blood cells, generating heat and activating the coagulation process that induces thrombosis of blood vessels [6].

## 2. Development

IRPL was proposed as a therapy for DES when it was discovered by chance that patients who were being treated for rosacea and who also suffered from this syndrome, with intense pulsed light, improved their symptomatology during the application of this technology. In order to be able to use and disseminate the efficacy of the use of IPLR in DES, it is essential to describe the effects it causes, and the improvement perceived by the patients after the therapy. The epidemiological characteristics of DES, such as the factors that predispose to its development, are unknown in our environment. Variables such as age, sex, systemic diseases, including those of autoimmune origin (rheumatoid arthritis, Sjögren's syndrome), diabetes, rosacea; ocular pathology: glaucoma, conjunctivitis; and to establish vulnerable groups that suffer from DES.

### 2.1 Definition

IRPL was traditionally used for the treatment of a variety of dermatological diseases such as rosacea. However, third-generation equipment was created specifically for periocular application with multiple homogeneously sculpted pulses, "It is the only IRPL device medically certified to treat GMD. Within its fundamental parameters, it includes an area to be treated of 7.5 cm<sup>2</sup> with a wavelength between 580 and 1200 nm, at temperatures ranging from -5°C to + 65°C" [3, 7].

### 2.2 Technical specifications

Features	IRPL
Dimensions: length x width x height	345 x 320 x 440 mm
Weight:	11.5 kg
Packaging dimensions: length x width x height	740 x 460 x 610 mm
Packaging weight:	175 kg
Noise level:	55 dBA
Energy consumption:	540 VA

### 2.3 Mechanism of action

Several hypotheses or effects of how the device works have been proposed.

- Heat stimulation of the MG, with the aim of altering the physical properties of the meibum inside, causes it to become increasingly fluid. However, this theory is not very well accepted, as the effect of intense light on the temperature increase in the eyelid may be modest and transient [6].
- Ablation of the small telangiectatic vessels around the eyelid decreases local inflammation by reducing the levels of inflammatory mediators reaching the MG. It also provides a hypoxic environment, which has been found to be beneficial to the gland [6].
- Elimination or reduction of the ectoparasite Demodex, which resides in the meibomian glands and consumes meibum secretions in patients who have rosacea. In addition, the presence of the ectoparasite promotes a proinflammatory environment that affects the surface of the eyelid and then the eyeball. However, the Demodex exoskeleton could be vulnerable to the energy of the device, thus contributing to DES treatment [6].
- Photomodulation of the glands stimulates cellular activity, improving the micro and macro structure of the Meibomian glands. In addition, the modification would decrease the inflammation surrounding them [6].
- IRPL can stimulate the mitochondria in the tarsal plate, modifying their reagent production [6].

## **2.4 Method of application**

- First, the entire region near the eyeball (lower and lateral skin) is cleaned, then both eyes are closed and a bilateral occluder is placed. Next, proceed to place gel all over the area where the treatment will be applied, starting from the temporal orbital region, inferior skin to the lower eyelids, and finally to the contralateral region [8].
- Then, five flashes should be applied, starting in the internal nasal region until reaching the temporal region, in both eyes, then the gel is removed from the face region and lidocaine in eye drops is instilled at the rate of one drop in both eyes. The examination is continued with the anterior biomicroscope and the MG expression is performed, previously applying topical anesthesia, located in the palpebral conjunctiva in the MG area, pressure is applied on the skin with the index finger close to the same gland to explore, for 30 seconds [8].
- The process should be repeated on both eyes and on the upper and lower eyelids. To do so, the patient should direct his gaze in a direction opposite to the eyelid being examined. Finally, the meibomian secretion located on the palpebral edges is cleaned [8].

## **2.5 Research carried out**

IRPL as management for DES is a new treatment that is revolutionizing ophthalmic medicine, therefore, the studies consulted to perform the comparison of results include research developed in European countries, pioneers in this area of health.

In the first study conducted by Toyos in 2015, the treatment was performed on 78 patients (156 eyes) with dry eye syndrome (DES), caused by dysfunction of the meibomian glands (MGD), a statistically significant improvement in tear breakup time (TBUT) was observed from the beginning to the end of the treatment, 86% of the participants improved their TBUT in both eyes, in 9% no changes were evident and in 5% TBUT deteriorated in one of the eyes [4].

A second study conducted in 2020 by Vergés showed that 44 consecutive patients (88 eyes), ranging from 22 to 78 years, had significant improvements in single and total signs and symptoms. The most significant changes were seen in dryness, foreign body sensation, and pain. The OSDI questionnaire showed a significant decrease in total symptoms. The percentage of patients with a normal index improved from 23.8% (10 patients) at baseline to 80.9% (34 patients) at the last visit, after 23 weeks. Clinical signs also improved, by more than 90%, with telangiectasia and blepharitis standing out. No statistical differences were observed between age and sex. Clinical improvement started after the second and third weeks of IRPL application. Subsequently, the results remained stable until the last visit, after 11 weeks. No local, periocular, or systemic complications were reported [9].

In our study in Ecuador of 64 patients with diagnosis of DES, we performed three sessions of IRPL in the Exiláser Ophthalmologic Center. The majority of patients were male, a similar prevalence found in the study of evaluation of IRPL and the efficacy of meibomian gland expression in the relief of signs and symptoms by Dell, et al. with 58%, [10] unlike what was observed in the study conducted by Yun Tang et al. in 2020, in which the prevailing sex was female [11].

The average age of our study was 56 years, being the most frequent patients older than 58 years, and the ages of the universe were from 25 to 79 years [11]. In the first investigation in which the effects of IPRL for DES were studied by Toyos, McGill, and Briscoe, they obtained that the most frequent range was from 21 to 84 years, with a median of 54 [4]. In the work carried out by Yun Tang in order to study the main effects of IPRL, developed in China, the prevalent age range was from 23 to 86 years, with a median of 45 years [11]. In a review carried out in Mexico by Mendoza and Fortoul, they rightly mention that the prevalence of DES increases over the years, with 2.7% in people aged 18 to 34 years, to 18.6% in the population older than 75 years, justifying the higher percentage found in the present study [12].

Patient's profession is a variable that has also been related to the increased risk of DES, especially those who must remain for long periods of time in front of screens such as cell phones, telephones, and computers, among others, in addition, occupations that require exposure to toxic environmental factors such as carbon dioxide or carbon monoxide. In the course of the analysis of our research, it was found that most of the universe corresponds to other professions among which were drivers, health professionals, engineers, and architects, the same that are related to the established risk factors.

In the review carried out in Mexico, it was found that the permanent use of masks necessary to combat SARS-CoV-2 increases the risk of suffering DES, a preventive measure used in all the occupations mentioned [12]. In a study carried out in Cuba by Diburnet et al. 42% of the patients read excessively, corresponding in the study to teachers and students; it was also mentioned that 34% were exposed to digital media without blinking [7].

Regarding personal pathological antecedents, it was evidenced that more than half of the patients did not report the presence of any underlying systemic disease. However, arterial hypertension, type II diabetes mellitus, and autoimmune diseases

such as systemic lupus erythematosus and Sjögren's syndrome were present. In addition, it was observed that a large percentage presented more than one particular pathology, among them thyroid disorders, especially hypothyroidism.

The risk factors established in several reviews for DES include systemic diseases, as indicated in the article by Rouen et al. published in 2018, in which autoimmune diseases, mainly Sjögren's syndrome, and chronic conditions, such as thyroid disorders, diabetes, rosacea, allergy, and conjunctivitis, are established as predisposing to the appearance of DES [2].

In a study conducted in Palestine during the period 2016 and 2017 by Shanti et al.; it was evidenced that 17% of the 769 participants reported having type II diabetes mellitus, while 20.9% reported having arterial hypertension [13]. It should be noted that the drugs used for these pathologies, such as antihypertensives, antihistamines, and diuretics, are factors associated with DES.

To finish with the personal history, in Ref. to the ophthalmologic, the reviewed bibliography mentions that surgeries or ocular lesions can influence the presence of DES [2]. The cases analyzed in our study did not have previous eye surgeries. However, ocular lesions were present, the most prevalent being a history of cataracts, followed by myopia and conjunctivitis.

DES significantly affects the daily lives of many people, especially in their daily activities. The main symptoms reported by patients who were seen at the Exiláser clinic during the period 2016–2021 were ocular pain, irritation on the ocular surface, and burning. The study conducted by Armas N. et al., in Cuba with a sample of 103 patients, determined that the main symptom presented by patients was ocular dryness at 64.1% followed by a gritty sensation at 59.2% and itching at 33% [14]. The study conducted by Perez MV. et al. at the University of Caracas in the year 2000 shows that the most frequent symptoms are ocular burning, foreign body sensation, and photophobia [15].

The results obtained show that the most prevalent sign was conjunctival hyperemia, followed by ocular dryness and irregularities of the palpebral edge, among which were trichiasis and telangiectasis, especially blepharitis. It should be mentioned that these signs decreased during the course of the IRPL sessions, the patients showed improvement in discomfort and it was demonstrated by the decrease in the irregularities of the palpebral rim.

The glandular expression before the IRPL sessions was predominantly granular/lumpy, followed by nontransparent fluid. After the IRPL sessions, nontransparent fluid predominated, followed by clear transparent fluid. However, granular glandular expression persisted in some patients.

In previous years, established treatments for this syndrome only included artificial tears and eye drops, which lubricated the ocular surface, reducing tear osmolarity and decreasing inflammation. The components of these substances are hyaluronic acid, carmellose, and polyacrylic acid. Eyelid hygiene also helps to control DES, using lotions and gels without preservatives, in addition to the use of warm compresses and massages, which help in cleansing and favor glandular expression [16]. However, despite all the therapies, people with DES did not show significant improvement.

In the article published in 2017 by Dell et al., which evaluates the efficacy of PLRI in relieving the signs and symptoms of DES due to meibomian gland dysfunction, they propose that the mechanism of action of this therapy is based on the transmitted energy ranging from 550 mm to 1200 mm, which is absorbed by the abnormal blood vessels and destroyed by thrombolysis [10]. The abnormal blood vessels, during the disease release inflammatory and proinflammatory substances, when they are

destroyed, a large number of inflammation-causing substances decrease, which impairs the obstruction in the meibomian glands, being the main cause of DES.

Another hypothesis is the enhancement of the production of glandular expression, which decreases the bacterial load, especially mites (*Demodex*), after transferring heat to the eyelids and meibomian glands. In the study carried out by Miotto et al., they also mention that heat production destroys pigmented skin lesions, which has been the mechanism of action used in dermatological diseases such as rosacea, stating that the proposed mechanisms of action significantly increase the lipid levels of the lacrimal expression, which could increase the flow of secretion of the meibomian glands, and these effects would be cumulative, so that in the course of the three sessions, ocular improvement would be presented with greater duration, unlike empirical treatments [17].

The above is reflected in the level of pressure that had to be exerted for glandular expression before and after treatment. There was a predominance of severe pressure, before completing the IRPL sessions, and moderate pressure, followed by mild pressure after completing the treatment.

One of the most commonly used tools in the DES is the OSDI test, which evaluates 12 items, and after the answers, the degree of affectation in the person's daily life can be established. In this research, most of the participants presented a DES of moderate severity, followed by mild and finally a severe degree; the minority obtained a score lower than 12, similar results found in previously developed studies, for instance, the application of the OSDI test in Monterrey by Garza et al., in which they studied the prevalence, symptoms, and risk factors for diseases of the ocular surface, in the same, most of the participants, presented a score higher than 12.

The research conducted in 2015, by Gonzalez et al., aimed at validating the OSDI test, it states that it is reliable and its results are valid and reliable, it was performed on 132 people with a diagnosis of DES with an average age of 53 years [18]. In the present study, the OSDI test was used, to analyze the changes that occur after the sessions of IRPL. With respect to physical symptoms, the most prevalent was the sensation of a foreign body—grit, which was present almost all of the time, and the most frequent in daily activities was working in front of digital screens. Wind was the environmental factor that most affected the population. After the application of the PLRI, the symptoms decreased significantly, in agreement with the findings of the study by Miotto et al. [8], in which all 32 patients showed a decrease in the OSDI scale score.

The study conducted by Mejia et al. in 2019, in which they determined the effects of PLRI in 25 people with the use of visual symptom scales, determined the decrease in the score from an average of eight before the sessions to an average of three after the application of PLRI [19]. A research developed in Argentina in 2018, in order to describe the treatment and results obtained from the LPRRI in 100 cases of DES, used a scale from 1 to 10 that rated the health status perceived by the participants, before the treatment an average health score of seven was obtained and after the treatment it increased to eight [20].

### **3. Conclusions**

- The majority of the patients were male, older than 58 years, with an average age of 56 years. Within the occupations, the most prevalent was found in the other category, which included: health personnel, drivers, engineers, and architects, followed by retirees.

- Regarding personal history, the most prevalent were arterial hypertension, thyroid diseases, diabetes mellitus, and Sjögren's syndrome, some of the patients presented more than one personal history. Among the ophthalmologic antecedents, cataracts, glaucoma, and pterygium were the most common.
- The most common symptoms in people treated at the Exiláser Ophthalmology Center were ocular pain, burning, photophobia, and foreign body sensation. The most characteristic signs were conjunctival hyperemesis and ocular dryness, followed by irregularity of the palpebral rim and blepharitis, which decreased after the IRPL sessions.
- The results showed improvement in glandular expression and decrease in pressure exerted, from severe to moderate intensity. Before treatment, granular glandular expression predominated and afterward nontransparent fluid prevailed, followed by clear transparent fluid.
- With the application of the OSDI test, it was found that the most common physical symptom during the day was foreign body sensation—grit, followed by photophobia. With respect to daily activities, the affectation was present during exposure to digital screens. Finally, the predominant environmental factor was the wind. After the application of the IRPL, the symptomatology decreased considerably.

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