

## The Effects of Intense Pulsed Light on Tear Osmolarity in Dry Eye Disease

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### Abstract

**Purpose:** In this prospective study we show the influence of Intense Pulsed Light Therapy (IPL) on tear osmolarity, an increasingly important metric of dry eye disease. Previous studies have measured the effectiveness IPL has had on other metrics including tear break up time (TBUT), lipid layer grade (LLG), tear evaporation rate (TER), tear meniscus height (TMH), and subjective responses from patients.

**Methods:** Single center prospective study included 16 patients and 32 eyes. Patient ages ranged from 18 to 90 years old with 75% of participants being female. All patients had an at least one eye with a tear osmolarity of 308 mOsm/L or greater, or had an inter-eye difference in tear osmolarity of 11 mOsm/L or greater. Tear osmolarity was measured bilaterally before a single IPL treatment followed by one drop of topical NSAID. Bilateral tear osmolarity was then measured again one month later.

**Results:** Average tear osmolarity pre-treatment OD was 309 mOsm/L and OS was 306.75 mOsm/L. Average tear osmolarity post-treatment was OD 296.75 mOsm/L and OS 296.06 mOsm/L. Paired t tests were performed showing the change in tear osmolarity to be statistically significant in each eye, OD  $p=0.0029$  and OS  $p=0.0011$ . Average inter-eye difference in osmolarity went from 11.81 mOsm/L to 6.81 mOsm/L, statistically significant with  $p=0.0148$ .

**Conclusions:** A statistically significant decrease in tear osmolarity from abnormal to normal range as well as a reduction in inter-eye difference demonstrates an improvement in tear film quality after one treatment with IPL, thus suggesting IPL's effectiveness at treating dry eye disease.

**Keywords:** Osmolarity; Intense pulsed light; Dry Eye Disease

### Introduction

Dry eye disease (DED) has become an increasingly prominent condition treated in primary eye care. As such, many different methods and technologies have been developed to diagnose and measure dry eye while advanced techniques are now available for its treatment. DED has been defined by the International Dry Eye Workshop (DEWS) as: "a multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by *increased osmolarity* of the tear film and inflammation of the ocular surface" [1]. Thus by definition, one important measure of dry eye is tear osmolarity.

Increased osmolarity, or hyperosmolarity, refers to a lower water to higher salt content in the tear film. Several studies have shown tear osmolarity to be very effective at diagnosing dry eye [2,3] and one found it to have "superior diagnostic performance" [4] over five other dry eye measures that included corneal staining, conjunctival staining, meibomian gland grading, tear break up time (TBUT), and Schirmir test. That study determined a sensitivity threshold for mild dry eye to be 308 mOsm/L. In addition they found a correlation between "inter-eye differences in osmolarity" and "increasing disease severity." Subjects with mild/moderate dry eye had an inter-eye difference of  $11.7 \pm 10.9$  mOsm/L while normal subjects had an inter-eye difference of  $6.9 \pm 5.9$  m Osm/L [4]. A recent study determined, "With effective treatment, the tear osmolarity returns to normal, and its variability

between eyes and with time disappears" [5]. Thus we have an objective basis to determine the effectiveness of dry eye treatments.

Intense Pulsed Light (IPL) is a technology that was developed by dermatology to treat rosacea and acne. It is now being used throughout the world in ophthalmology to treat ocular rosacea as well as DED resulting from meibomian gland dysfunction (MGD). Toyos et al. in 2005 in a case report showed an improvement in Shirmir test and TBUT after 4 IPL treatments for a single patient [6]. Toyos et al. then showed in 2015 a statistically significant increase in TBUT in 78 patients after IPL [7]. Finally Craig et al. showed in 2015 an improvement in lipid layer grade (LLG), tear evaporation rate (TER), tear meniscus height (TMH), and subjective improvements after IPL [8]. This study is to add to this body of evidence to show what effect Intense Pulsed Light therapy has on tear osmolarity.

### Materials and Methods

This study was performed on all patients presenting to a single clinic for IPL treatment over a two month period. To be considered for the study patients had to present with DED based on signs and symptoms including abnormal meibum secretions, inflamed lid margins, lid telangiectasia, reduced TBUT below 10 seconds, and subjective complaints. In addition at least one eye had to have an abnormal tear osmolarity measure of 308 mOsm/L or greater, or an inter-eye difference of 11 mOsm/L or greater. All patients actively sought out IPL treatment having previously undergone several other dry eye therapies. All gave informed consent to participate in this study, be treated with IPL, and have their tear osmolarity measured. This study

was done in accordance with the guidelines of the Declaration of Helsinki.

Sixteen patients (with thirty two eyes) were included in the study. Patients' ages ranged from 18 to 90 years old. Patients were predominantly female (75%). Tear osmolarity was measured using the TearLab<sup>®</sup> in each eye prior to receiving IPL treatment [9]. For a full description of the IPL procedures used see Toyos et al. [7]. A summary of the procedure is as follows: IPL is performed using the Diamond Series Q4 by DermaMed Solutions. Treatment power ranges from 8 J/cm<sup>2</sup> to 20 J/cm<sup>2</sup> depending on the severity of the patient's condition and Fitzpatrick Skin Type [10]. The patient's eyes are patched and ultrasound gel is applied to the face from tragus to tragus, including the nose. The patient then receives two full passes of the IPL device. Once the IPL is completed the ultrasound gel is cleaned off and the patient's meibomian glands are expressed using a cotton tip applicator. For this study patients then used one day of topical once a day nonsteroidal anti-inflammatory drug (NSAID) to reduce inflammation from the lid expression. The treatment was performed in one office by a single clinician. Patients then returned one month later for tear osmolarity to be measured again.

## Results

Tear osmolarity measurements prior to IPL treatment in the right eye ranged from 284 to 335 mOsm/L with a mean of  $309 \pm 13.03$  mOsm/L. The left eye ranged from 291 to 325 mOsm/L with a mean of  $306.75 \pm 11.28$  mOsm/L. Post treatment tear osmolarity in the right eye ranged from 280 to 313 mOsm/L with a mean of  $296.75 \pm 7.86$  mOsm/L while the left eye ranged from 285 to 304 mOsm/L with a mean of  $296.06 \pm 6.22$  mOsm/L. Paired, two-tailed, t-tests showed a statistically significant difference in the right eye before and after IPL treatment ( $p=0.0029$ ) as well as in the left eye ( $p=0.0011$ ).

Further analysis was done to see if the inter-eye difference decreased. Pre-treatment differences ranged from 2 to 26 mOsm/L with a mean of  $11.81 \pm 6.78$  mOsm/L while the post-treatment differences ranged from 0 to 19 mOsm/L with a mean of  $6.81 \pm 5.94$  mOsm/L. Paired, two-tailed, t-testing showed a statistically significant difference ( $p=0.0148$ ).

## Discussion and Conclusion

This prospective study shows that one month after a single treatment of Intense Pulsed Light and one day of QD NSAID, patients showed a statistically significant lower tear osmolarity in both eyes from abnormal to normal levels. It further shows an abnormal inter-eye difference prior to treatment being reduced into the normal range. These are important findings as we are discovering how significant tear osmolarity measures are in determining the severity of a patient's dry

eye. This demonstrates another measure in which IPL therapy has shown to be beneficial in the treatment of dry eye.

The primary limitation to this study is its size, with only sixteen patients at a single location. Further study should be conducted to measure tear osmolarity after IPL with a broader patient base. Also study could be performed to measure osmolarity effects after multiple IPL treatments and over longer periods of time.

## Author Disclosure Statement

Rolando Toyos discovered the IPL treatment technique and was provided a consulting fee by DermaMed Solutions for consulting and medical-technical input to the manuscript. Patient study data was collected by Dr. Toyos and Toyos Clinic staff prior to involvement with DermaMed and was not compensated in any way by DermaMed Solutions. Dr. Toyos was not compensated in any way by TearLab.

Dustin Briscoe is an optometrist with Toyos Clinic and served as a primary contributor to manuscript preparation and statistical analysis. He was not compensated by DermaMed Solutions or TearLab.

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