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MINIREVIEWS

# Review of laser and light therapy in the treatment of oculofacial pathology

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## Abstract

Demand for non-invasive techniques to treat oculofacial pathology has allowed for the growth and development of several new laser and light therapy modalities. These modalities include the use of intense pulsed light (IPL) and photodynamic therapy (PDT), light-emitting diode devices, as well as ablative and non-ablative lasers. Therapeutic applications in the periorbital area may involve the treatment of vascular lesions, telangiectasias, dyspigmentation, photodamage, hypertrichosis, rhytids, and scars. Laser and light-based technology offers patients treatment options that range from conservative to aggressive, allowing for choices between subtle results with little downtime or dramatic results with longer downtime. Advantages of laser treatments, as compared to traditional medical and surgical treatments, include a longer lasting effect than some of the conservative therapies and the ability to serve as a happy medium between non-invasive topical medicine and invasive surgical techniques. For patients seeking non-invasive alternatives, these modalities confer a major advantage over incisional surgery. Understanding appropriate usage, side effects, and outcomes is before treating functional and cosmetic issues. Here we present a review of current treatment modalities, their use, side effects, and outcomes.



**Key words:** Intense pulsed light; Ablative lasers; Non-ablative lasers; Fractional lasers; Photodynamic therapy; Non-invasive techniques

**Core tip:** Laser and light treatments have become an essential addition in the oculoplastic service armamentarium for the management of different pathological oculofacial conditions as well as for aesthetic improvement. Both the unique anatomy of the periocular area, and one's individual treatment goals for the patient, must help tailor the choice of laser, the energy level used, and the depth of treatment to achieve an optimum result.

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## INTRODUCTION

The demand for non-surgical treatment options for cosmetic and functional periorbital pathology has grown in recent years. Injectable soft tissue fillers[1] and neurotoxins[2] have maintained their popularity, as they are useful for addressing resting and dynamic rhytids as well as volume deficits. However, they are unable to address problems with the skin surface or quality. Chemical facial

**Table 1 Light and laser applications**

| Type of laser/light | Specific type | Tissue target chromophore | Applications | Advantages | Disadvantages |
|---|---|---|---|---|---|
| IPL | | Hemoglobin, melanin | Telangiectasias, pigmented lesions, hair removal, skin resurfacing | Not invasive/not a laser/light based | Not an option for darker skin types |
| PDT | | | Fine wrinkles, telangiectasias, hyper pigmentation | Treatment of specific areas, no damage to surrounding tissues | Pain during treatment |
| Ablative | $CO_2$ | Water | Skin resurfacing, scars, lesions | Excellent results, especially in skin resurfacing | Prolonged postoperative period, increased risk for side effects (erythema, dyspigmentation) |
| | Er:YAG | Water | Wrinkles | | |
| | Diode | Melanin | Hair removal, resurfacing | | |
| Non ablative | QS Nd:YAG | Melanin | Tattoo removal, pigment lesions | Less aggressive, low risk for side effects | Less effective when compared to ablative lasers |
| | QS alexandrite | Melanin | Tattoo removal, pigment lesions | | |
| | QS ruby | Melanin | Tattoo removal, pigment lesions | | |
| | QS frequency-doubled Nd:YAG | Melanin, hemoglobin | Pigmented lesions, red tattoos | | |
| | Pulsed dye (green) | Melanin, hemoglobin | Pigmented lesions, red tattoos, hemangiomas | | |
| | Argon | Melanin, hemoglobin | Telangiectasias, PWS | | |
| Fractionated | Ablative | Water | Dyspigmentation, acne, traumatic scarring, rhytides, skin resurfacing | Quick recovery | Erythema, edema, hyper-hypo-pigmentation, herpes simplex viral reactivation, bacterial infection |
| | Non ablative | Melanin, hemoglobin | Melasma, acne scars, hair removal, skin resurfacing | | |

IPL: Intense pulsed light; PDT: Photodynamic therapy; Er:YAG: Erbium-yttrium-aluminum-garnet; Nd:YAG: Neodymium-yttrium-aluminum-garnet.

peels, which vary in strength from mild alpha-hydroxy acids to intense phenol-based solutions, are an option to tighten and resurface the skin[3]. The mild peels, however, may not provide long-lasting, dramatic effects[4] and the stronger peels can not be used to treat darker skin types, can be painful, and are restricted in certain patients with cardiac conditions[5].

A multitude of laser and light-based technologies have been introduced to meet a broader range of needs. Concerns regarding excess upper or lower eyelid skin, periorbital rhytids, poor skin texture or pigmentation, presence of vascular lesions, or presence of scars may all be addressed by these modalities[6]. Current therapeutic options include light-based devices such as Intense Pulsed Light (IPL) Therapy[7], photodynamic therapy (PDT)[7], and light-emitting diode devices[7]. Laser alternatives include non-ablative[8] and ablative devices[8], both of which have the option of fractionated delivery. A newer modality that is outside the scope of this review utilizes radiofrequency energy for skin tightening and rejuvenation[6]. Each of these laser and light-based technologies are discussed below.

## LIGHT AND LASER APPLICATIONS

All applications are summarized in Table 1.

## IPL

IPL therapy is a non-invasive light-based technique that utilizes light in the wavelength range of 500 nm to 1200 nm to target the chromophores hemoglobin and melanin[9]. IPL has been successfully utilized to treat vascular and pigmented lesions of the oculofacial area[9], and may be used for hair removal[10] and photorejuvenation[11] as well. It is currently an FDA approved therapy for the treatment of photoaging. There is thought that IPL may be successful in reducing symptoms and improving clinical stigmata of dry eye syndrome associated with meibomian gland dysfunction in patients with facial rosacea[12]. The exact mechanism of action is unknown, but theories include obliteration of vessels leading to eyelid inflammation and/or heating of the meibomian glands, allowing for easier expression of the meibum.

IPL is administered by a flash lamp device that has the ability to emit light of multiple wavelengths. Individual filters are chosen to target preferential absorption by blood vessels or pigment, depending on the pathology requiring treatment. Unlike lasers, IPL uses a non-collimated, non-coherent light source. Moreno Arias *et al*[9] have proven that the use of different filters allows one to target red pigment for treatment of vascular lesions such as spider angiomas or telangiectasias, or melanin for

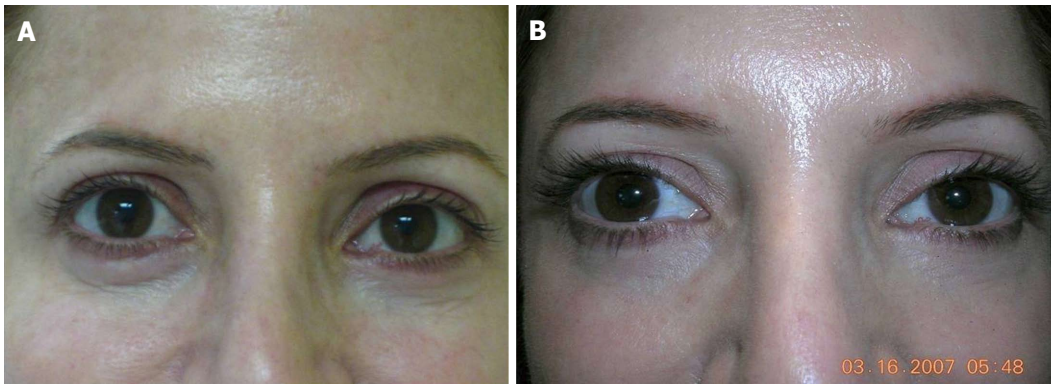


**Figure 1 (A) pre and (B) post pre ablative laser treatment comparison shows improvement with reduction of the appearance of fine wrinkles, and improvement of the tone of the skin.**

treatment of pigmented lesions such as actinic changes or freckles. Goldberg *et al*[11] have shown that IPL for photorejuvenation spares the epidermis and targets the dermis, generating collagen, and enabling skin tightening and contraction. Zandi *et al*[10] investigated the use of IPL for hair removal and proved that it is limited to pigmented follicles, as the target chromophore is melanin. The target chromophores for IPL also restrict its use primarily to patients of lighter skin types. Because the light is absorbed into pigment in the skin, patients with Fitzpatrick skin types V or VI are not good candidates for IPL use, and patients with skin type IV may require placement of a test spot before IPL treatment is considered[13]. Erythema of the treated areas is common for several days but is self-limited. Sun protection is required for all patients pre- and post-treatment. Uncommon side effects include pain, hypo- or hyper-pigmentation, and superficial crust or vesicle formation[14].

## PDT

PDT was first used to target malignant cells by light activation of a photosensitizing agent [5-aminolevulinic acid (ALA) and ALA methyl ester (Me-ALA)] in the presence of oxygen[15]. PDT is commonly used to treat premalignant and malignant lesions such as actinic keratoses, Bowen's disease, superficial basal cell carcinoma, and other non-melanotic skin cancers. PDT has proved useful in the treatment of other inflammatory conditions, such as acne vulgaris and psoriasis, infectious lesions, such as dermatophytosis, onychomycosis, leishmaniasis, warts and molluscum contagiosum, and in benign conditions such as sebaceous hyperplasia and nevi. Recently, MacCormack[16] has proved that PDT is useful for the cosmetic treatment of fine wrinkles, telangiectasias and hyper pigmentation. One of the main advantages of PDT therapy is that it treats specific areas without damaging the surrounding tissues. Contraindications are rare, and limited to some specific photodermatoses as well as allergies to ALA and Me-ALA. Pigmented lesions are not indicated for PDT, as melanin is a fluorescence quencher and may also inhibit light penetration[16].

The most common adverse events include pain and a burning sensation limited to the term of the irradiation and several hours afterwards. Other adverse effects include photosensitivity, related to the duration of ALA or Me-ALA application and skin necrosis with consecutive scarring and hypo- and hyper-pigmentation[16].

## ABLATIVE LASERS

As the desire to obtain cosmetic perfection grew, physicians began to search for other non-invasive approaches in the treatment of oculofacial pathology. In the early 1980s, ablative lasers were used more readily in the treatment of photoaging and scarring. To avoid many adverse reactions found in the first lasers, several short-pulsed, high-peak powered lasers were developed including the CW $CO_2$ laser and the erbium-yttrium-aluminum-garnet (Er:YAG) laser. These new lasers are better in their ability to control the depth of thermal damage at a specific pulse duration providing more accurate control and less overall damage as Alster[17] has demonstrated. The $CO_2$ laser, which has a higher ablation threshold and therefore targets the deeper tissues, is the most important surgical laser for cutting, vaporizing, and carbonizing. It emits a 10600-nm wavelength and is strongly absorbed by tissue water. Alexiades-Armenakas *et al*[18] in a review study have concluded that this laser is unique in that its penetration depth does not depend on melanin or hemoglobin. The $CO_2$ laser has proved useful in skin resurfacing and rejuvenation and even in blepharoplasty (Figure 1). This laser can also be beneficial in the improvement of fine wrinkles around the eyes. In general, this ablative laser is safer for skin types I -Ⅲ.

The Er-YAG laser, emits a wavelength of 2940 nm in the infrared range, closer to the absorption peak of water allowing for less thermal damage and quicker recovery time[19].

Ablative lasers have proved very useful in the treatment of facial rhytids, especially in the periorbital area which may not be improved with surgical face lift procedures. Scars from acne, trauma, and surgery are highly amenable to ablative laser techinques as well[18].

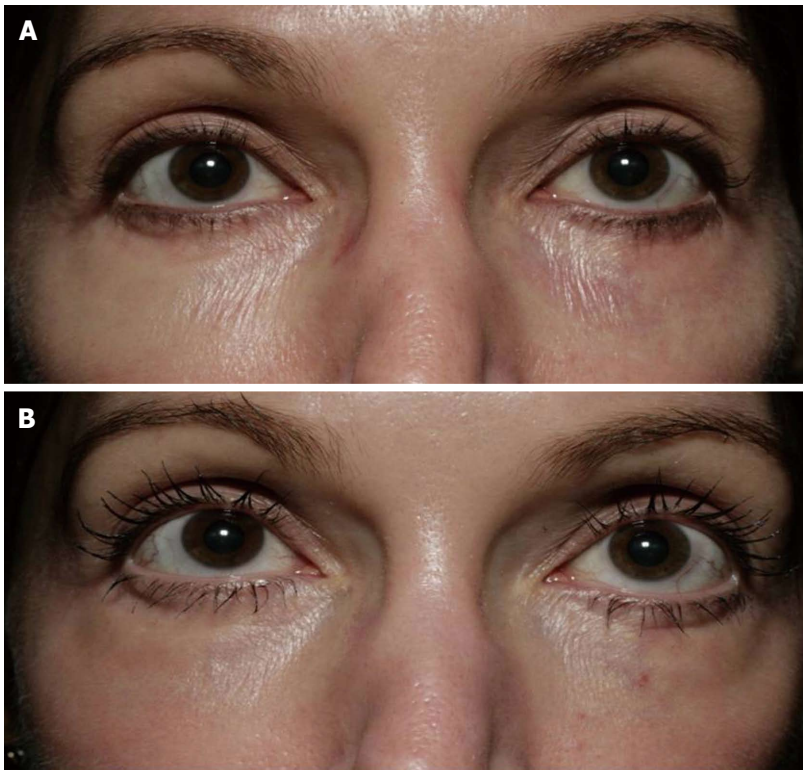


**Figure 2 Visible light lasers.** A: Patient demonstrating fine wrinkles prior to non ablative treatment of the upper and lower lids; B: Two weeks after a single treatment, the lids appear smoother with a subsequent reduction in wrinkles.

Absolute contraindications for laser treatment include active acne, deep acne pits or picks, and isotretinoin (Accutane) use in the past 2 years. Similarly, patients with reduced adnexal structures (*e.g.*, scleroderma, irradiation or burns) are poor candidates. History of herpetic infection is a relative contraindication only because most patients do not know their true status. Diseases with koebnerizing features, such as psoriasis or vitiligo, are also considered relative contraindications. Smokers are not excluded as treatment candidates[18].

Side effects following the ablative lasers include erythema, dyspigmentation (occurring more commonly in Fitzpatrick's skin types Ⅲ and Ⅳ), follicular, infectious, and eczematous reactions[18].

## NON-ABLATIVE LASERS

Ablative lasers, although more effective, are also more aggressive and come with the potential for more side effects and longer recovery periods. This led to the development and introduction of newer, non-ablative systems. As with ablative lasers, non-ablative lasers have water as their chromophore and utilize wavelengths in the infrared range[8]. However, at these lower wavelengths water is only moderately absorbed, leading to slower heating and coagulation of the target tissue[20]. The primary goal is to stimulate collagen production and remodeling with little to no healing time. There are a number of non-ablative lasers currently available, including the neodymium-yttrium-aluminum-garnet (Nd:YAG)[21,22] and erbium glass (Er:Glass)[23] lasers in wavelengths of 1410 to 1550 nm. Visible light lasers such as the pulsed dye and pulsed 532 nm systems[24,25] (Figure 2), Q-switched Nd:YAG[26], and Q-switched alexandrite lasers also conservatively remodel with minimal downtime. They target pigment, including both endogenous melanin as well as tattoo ink, so are particularly effective at tattoo removal.

Ciocon *et al*[20] investigated non-ablative lasers, concluding that their biggest advantage is that they minimize the risks of temporary and permanent scarring by delivering dermal energy with concomitant surface cooling while leaving the epidermis intact. The wavelengths of these lasers have lower absorption coefficients than either the $CO_2$ or Er:YAG lasers, so a large volume of tissue can be heated without direct thermal conduction or damage. Scarring and texture change, although rare, are still risks during application[8].

Non-ablative lasers are less aggressive but adverse events such as erythema, edema, pain, burning and abnormal sensation of the eyelids may be present in the immediate postoperative period[20].

## FRACTIONATED LASER DEVICES

Fractionated lasers, which are adaptations of ablative and non-ablative lasers, are designed to improve skin texture with minimal recovery time. Fractional photothermolysis was first introduced by Manstein *et al*[27] in 2004 as a modification of non-ablative laser therapy. This technology creates microscopic thermal zones of less than 400 μm diameter, extending to a depth of 1 mm or more. In between each treatment zone, the intervening tissue remains untouched. This allows for faster healing as the untreated tissue serves as a reservoir of healthy cells than migrate into the treatment zones. The treatment effect can be varied by changing the wavelength and pulse en-

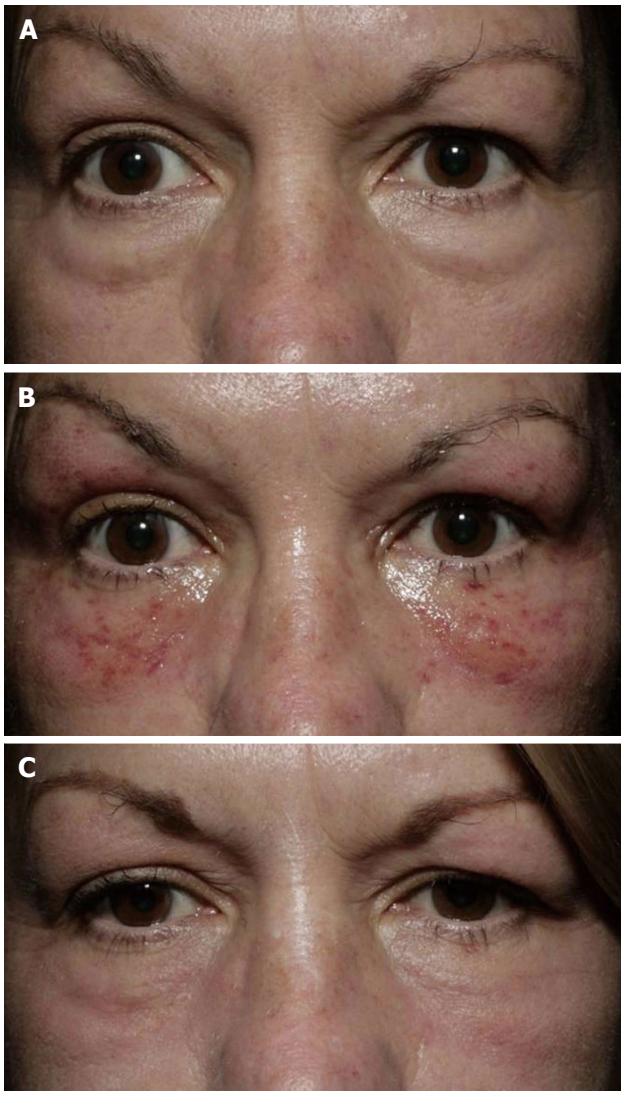


**Figure 3 These lasers are useful for improvement of skin texture, dyspigmentation, acne or traumatic scarring, and rhytides around the eyes and mouth.** A: Preoperative image before ablative fractional treatment of upper and lower lids; B: Three days post treatment, erythema and edema are present, skin is not completely re-epithelialized; C: One week post treatment a reddish hue to the skin is still visible.

ergy of the device[28]. In 2007, ablative fractional resurfacing devices were introduced, including fractional $CO_2$ and fractional 2940 nm Er:YAG lasers[29,30]. Both types of lasers induce collagenesis and epidermal turnover within several days. Since water is the target chromophore, collagen, blood vessels, and keratinocytes are all treatable. These lasers are useful for a wide array of indications including improvement of skin texture, dyspigmentation, acne or traumatic scarring, and rhytides around the eyes and mouth[27,31,32] (Figure 3). Dermal targeting allows for wrinkle effacement, scar revision and skin tightening. Targeting wider epidermal areas using ablative fractional lasers allows for treatment of photoaging changes including solar lentiges and dyspigmentation[33]. More limited data support the possible use of non-ablative fractional resurfacing for striae distensae[34-36], melasma[37-40], Nevus of Ota[33], poikiloderma of Civatte[41], and minocycline-induced hyperpigmentation[42].

In the immediate postoperative period, patients may report erythema, edema, flaking, xerosis, pruritis, bronzing, and acneiform eruptions[32]. Downtime is minimal for non-ablative devices, and may range from 1-7 d for ablative devices, during which desquamation may last for several days[32]. Rare side effects include hyper- and hypopigmentation, herpes simplex viral reactivation, and bacterial infection. Particular concern for scarring and hypopigmentation increases with higher energy fluences and more aggressive treatment, although the risks are significantly lower than those seen in fully ablative laser therapy.

## LASER COMPLICATIONS AND MANAGEMENT

Although lasers target specific chromophores, the surrounding scatter and the resulting thermal effect could cause collateral damage[43]. While the main tissue chromophores are targeted, other adjacent structures that are also rich in these chromophores are susceptible to inadvertent damage.

Laser complications can range from mild eyelid swelling and erythema, skin infections, hypo and hyper pigmentation to accidental corneal injury and potentially blinding macular injury[44,45].

Laser and light injury can be prevented if certain guidelines are followed such as eye protection during treatment for the patient, the operator, the observer and the assistant. Also, laser warning signs must be placed at the entrance of the laser treatment room when lasers are operating; adequate laser safety training for personnel must be provided. Potential injury to the surrounding tissues can be minimized by adjusting the treatment parameters appropriately, using cooling devices during the procedure, applying ice packs after the procedure, and elevating the head of the bed[46].

## CONCLUSION

The introduction of laser and light-based treatment has given ophthalmologists a powerful tool to manage periocular pathology and address cosmetic concerns. They offer multiple treatment options to patients seeking non-surgical oculofacial rejuvenation, and are best utilized as one component in an overall treatment strategy that may also include injectable neurotoxins, soft tissue fillers, or facial peels. Patients must be counseled regarding the limitations of these modalities, and must have realistic expectations of the outcomes. Use of this technology can provide long-lasting results, and in some cases can provide a very good alternative to surgical intervention.

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