

## Lasers in Facial Aesthetics- A Review

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### ABSTRACT

**Background:** Lasers and optical technologies play a significant role in aesthetic and reconstructive surgery. The unique ability of optical technologies to target specific structures and layers in tissues to effect chemical, mechanical or thermal changes make them a powerful tool in cutaneous rejuvenation, hair removal, fat removal and treatment of vascular lesions such as port-wine stains, among many other procedures. With the development of adjunct techniques such as epidermal cooling, lasers and optical technologies have become more versatile and safe. The constant improvement of existing applications and the emergence of novel applications such as photodynamic therapy, nanoparticles, spectroscopy and noninvasive imaging continue to revolutionize aesthetic medicine by offering a minimally invasive alternative to traditional surgery. In the future, therapies will be based on individualized, maximum, safe radiant exposure to deliver optimal dosimetry. Lasers and optical technologies are headed toward safer, easier and more quantifiable individualized therapy.

**Keywords:** Aesthetics, Lipolysis, Lasers.

### INTRODUCTION

Lasers, optical devices and related technologies play an increasingly significant role in aesthetic and reconstructive surgery. The most appealing feature of optical technologies is that their effects are localized to the region of light distribution, resulting in the ability to target specific structures and/or tissue layers within the skin or mucosal surfaces<sup>1</sup>. Furthermore, the tissue effects of these devices can be customized by adjusting the fluence rate, application time and spatial parameters. They allow precise control over the temporal and spatial evolution of heat and/or distribution of radiant energy to activate thermal, mechanical or chemical processes. This review



seeks to offer a panoramic view of the history of optical technologies, highlighting essential developments as applied to facial plastic surgery in the last 15 years, later

transitioning into a discussion of future trends and emerging optical technologies related to facial plastic surgery.

### REVIEW OF LASERS AND OPTICAL TECHNOLOGIES

#### A. Skin Rejuvenation

##### 1. Ablative Laser Therapy

Aging skin is characterized by excess rhytides and laxity. Over the past 10 years, a mainstay of skin rejuvenation has been laser resurfacing. Laser skin resurfacing was first described in 1985, following carbon dioxide (CO<sub>2</sub>) laser treatment of actinic cheilitis that unintentionally resulted in dramatic cosmetic improvement of the treated lip<sup>2,3</sup>. Laser skin resurfacing is ablative and relies on the selective photothermal destruction of specific layers of the epidermis and dermis combined with a limited or controlled depth of residual thermal injury. The

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interaction achieves thermal confinement, resulting in laser pulse durations that are shorter than absorbed photothermal energy dissipation time, an effect that promotes highly localized heating<sup>4</sup>. Heat induces dermal remodeling with new collagen synthesis and collagen contraction<sup>5-7</sup>. Ablative laser therapy has largely replaced the widespread use of chemical peels, which depend heavily on individual skin diffusion properties that are widely divergent among different facial regions and different people. In contrast, laser resurfacing produces fairly homogeneous and repeatable results. Laser skin resurfacing works best for patients with fair skin, while the results for patients with darker skin are less predictable and prone to pigmentary changes<sup>8</sup>.

Presently, both CO<sub>2</sub> and Erbium:YAG lasers are used for skin resurfacing. For most pulse durations, the CO<sub>2</sub> laser creates a zone of thermal injury up to 200  $\mu\text{m}$  in depth, leading to prolonged erythema and slower recovery times. In contrast, the use of an Erbium:YAG laser (pulse length, approximately 250 microseconds) has advantages such as relatively quick recovery times, much less erythema, higher light absorbance and the production of less thermal injury with each pass (approximately 50  $\mu\text{m}$ )<sup>9,10</sup>. However, slightly decreased clinical efficacy is also associated with the Erbium:YAG laser<sup>11</sup>. Resurfacing has also been performed using combinations of laser devices (eg Erbium:YAG and CO<sub>2</sub> lasers), laser and botulinum toxin injections, laser and traditional facial plastic surgery procedures and laser and metallic-based skin care products<sup>12-14</sup>.

## 2. Non-ablative Laser Therapy

While ablative laser skin resurfacing is in many ways safer and more predictable than the chemical peels that it has supplanted, its consequent epidermal and dermal destruction leads to prolonged recovery times and the potential for complications<sup>7</sup>. Non-ablative resurfacing aims to selectively heat dermal tissues, while sparing the epidermis from significant thermal injury thus reducing complications and recovery times.<sup>7,15</sup> This therapy relies on the selective heating of regions of tissue within the dermis, which is accomplished by using lower laser fluence rates or by protecting the epidermis using cryogen spray, contact, or air cooling. Diode lasers (532, 900 and 1450 nm), rare earth lasers such as Nd:YAG lasers and pulsed dye

lasers (PDLs) have all been reported to improve skin appearance and textures<sup>16-22</sup>.

## 3. Fractional Ablation

Fractional ablation, which is the most recent development in laser skin resurfacing, has existed conceptually for quite some time, though not implemented in practice. The term fractional photothermolysis was first coined by Manstein et al<sup>23</sup> in 2004. In fractional ablation, laser spots are small (approximately 100  $\mu\text{m}$ ) and are separated from one another by a considerable distance. Small regions of tissue injury (and hence remodeling) exist as islands surrounded by normal skin where reepithelialization is rapid<sup>23</sup>. The most popular fractional ablation devices operate at 1550 nm (Fraxel, Reliant Technologies, San Diego, California)<sup>23-25</sup>. Apart from being primarily used as a resurfacing tool, fractional photothermolysis has been used to treat pigmentation lesions, acne scars and surgical scars<sup>26-28</sup>.

Complications and adverse effects are short-term and usually limited to erythema, skin dryness, and facial edema. Fractional photothermolysis is generally associated with a relatively high patient satisfaction rate, as high as 75% according to Cohen et al<sup>29</sup>.

The main challenge for skin resurfacing in the future will be to achieve a long-term natural-looking substantial improvement in skin quality. Also, resurfacing and related technologies will strive toward achieving more dramatic results and postpone the need for traditional aging face procedures such as rhytidectomies and blepharoplasties.

## B. Vascular Malformations and Hemangiomas

Facial erythema and telangiectasias remain some of the most common complaints of cosmetic patients. These lesions often develop in patients with rosacea or in those with a long history of photodamage and can be a common sign of the aging process. These lesions can be easily treated with laser technologies. In order to effectively treat these lesions, it is necessary to target the oxyhemoglobin within the vessels.

The key to treating vascular malformations and hemangiomas is selective destruction of the

pathologic vasculature, while minimizing injury to surrounding normal tissues. A secondary challenge is protecting against absorption of light by epidermal melanin, which has an absorption profile similar to that of hemoglobin<sup>30</sup>.

Multiple lasers can be used to target the chromophore oxyhemoglobin; however, the most commonly used laser for treatment of these lesions remains the PDL. It was initially developed to treat capillary malformations, port-wine stains in children<sup>31</sup>. After PDL treatments, blood vessels were observed to contain agglutinated erythrocytes, fibrin and thrombi. One month after treatment, these damaged vessels were replaced by normal appearing vessels. Since its initial development, the use of PDL has been expanded to include facial telangiectasias, erythrotelangiectatic rosacea, facial rejuvenation and infantile hemangiomas<sup>32</sup>. PDL has also been used to successfully treat many other skin conditions with increased vascularity including psoriasis, scars, verruca and skin malignancies such as basal cell carcinoma<sup>33</sup>. The original PDL devices used short pulse durations (0.45–1.5 milliseconds), which are shorter than the thermal relaxation times of facial vessels. The best results for port-wine stain treatment are achieved using a PDL with cryogen cooling. Photodynamic therapy (PDT) and non-ablative therapies are effective against hereditary hemorrhagic telangiectasia<sup>34,35</sup>.

### C. Laser assisted hair removal

In 1996, Grossman et al<sup>36</sup> published the first report of laser hair removal by selective photothermolysis of hair follicles using a normal-mode ruby laser. As with other laser therapies, novel laser sources were soon introduced, including the Nd:YAG laser, the alexandrite laser and the diode laser<sup>37-39</sup>. Although laser hair removal typically entails multiple treatments to achieve desired results, patient satisfaction for laser hair removal is generally high. Long-pulsed Nd:YAG laser showed greater proportion of hair reduction in hypertrichosis of the face, axillae and legs compared with intense pulsed non laser light source in darker skinned individuals<sup>40</sup>. The main disadvantage of laser hair removal is the requirement for a considerable melanin gradient between skin and hair follicles.

### D. Tattoo removal

Laser tattoo removal was first attempted with the CO<sub>2</sub> laser nearly 30 years ago, yielding mediocre results<sup>41</sup>. Modern treatment is pinioned on the Q-switched Nd:YAG, Q-switched ruby and alexandrite lasers<sup>41,42</sup>. These technologies have since remained the standard for tattoo removal and are used in combination with cryogen spray cooling.

### E. Laser Fat Ablation and Laser Lipolysis

Although standard surgical liposuction is generally safe and has been reported to have a very low complication rate, it is limited to relatively large lobules of fat. The use of lasers in fat ablation would permit lipolysis on a mesoscopic scale, which is more suitable for use in the face. The first reported instance of laser fat ablation was via CO<sub>2</sub> laser<sup>43</sup>. The technique became known as laser lipolysis and has since moved to the use of Nd:YAG and diode lasers as primary light sources. Laser lipolysis was shown to be safe and minimally invasive (requiring only a small incision), while causing desired skin retraction. Furthermore, laser lipolysis caused thermal damage in the fat that led to better hemostasis and wound healing, less surgical trauma and faster recovery compared to traditional surgical liposuction<sup>44</sup>.

## CONCLUSION

Lasers have revolutionized the field of facial aesthetics. The clinician should understand the basics of laser science, tissue effects of lasers, various laser wavelengths and parameters. It is important on the clinician's part to take full advantage of the features of lasers and provide safe and effective treatment to the patient. While they currently have significant roles in rejuvenation, hair removal, and fat ablation, lasers and optical technologies are becoming increasingly important for noninvasive imaging and targeted individualized therapy. Treatment of complex lesions such as port-wine stains will become more sophisticated as high-resolution imaging modalities and the wound healing response are studied more extensively. The growing interest in therapies that take individualized maximum safe radiant exposure into consideration will increase the treatments' individuality, safety, accuracy and ease.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

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