Future Directions in Cutaneous Laser Surgery

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KEYWORDS

• Laser • Cutaneous lasers • Wavelength • Picosecond • 1565 nm • 1940 nm • 1210 nm

KEY POINTS

- Numerous innovations have been made in cutaneous laser surgery.
- In addition to perfecting already established treatment modalities, the scope of the field is continuously expanding, with new clinical indications being added to the armamentarium of laser experts.
- More selective treatment of existing targets ensures improved efficacy, with fewer side effects and treatment sessions.
- The identification of new targets allows for more effective treatment of common cutaneous conditions.
- Adjunctive applications optimize treatment results and the diagnostic acumen of clinicians.
- Future applications will include waveforms beyond those in the visible light and infrared spectrum, such as microwaves, ultrasound waves, and radiofrequency.

INTRODUCTION

Laser therapy has advanced in the treatment of various skin lesions and conditions, benefiting both patients and physicians. In the past 45 years there have also been important advances in the understanding of cutaneous physiology and laser technology, leading to a plethora of laser devices on the market enabling specialized treatment of multiple skin disorders. Developments of new, more precise lasers and targeted therapy aim to provide safer outcomes, with optimal lesion clearance and improved patient satisfaction.

Laser therapy has revolutionized the treatment of both classic and aesthetic dermatology. Many conditions are routinely, sometimes exclusively, treated with lasers, such as vascular and pigmented lesions, acne scars, tattoos, rhytides, and acne and precancerous lesions when combined with a photosensitizer. However, many cutaneous lesions and conditions do not always completely resolve, causing disappointment to both doctors and patients.

This article presents an overview of the future course of cutaneous laser therapy and technology. To enhance efficacy and specificity of treatment, new wavelengths directed at both old and new targets are on the horizon. New applications, including the use of lasers to aid in the detection of skin cancers and to enhance drug delivery, are being used and investigated. A trend toward combining different lasers and light sources to optimize results continues, with different laser combinations being used as new technologies emerge. To reach a broader population, advancements in at-home devices have been made for which, although not a replacement for existing laser devices that create a deeper and more

Financial Disclosures: Dr Fabi is a consultant/speaker for Ulthera, Inc and Lumenis. Dr Metelitsa is a consultant for Cutera, Cynosure and Clarion.

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Dermatol Clin 32 (2014) 61–69
http://dx.doi.org/10.1016/j.det.2013.09.004

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significant level of injury, there is a demand. There is also no denying that the future includes waveforms beyond those in the visible light and infrared spectrum, such as microwaves, ultrasound waves, and radiofrequency.

NEW WAVELENGTHS, NEW TARGETS

Anderson and colleagues proposed the theory of selective photothermolysis (SP) in 1983. The concept refers to the precise targeting of a structure or tissue using a specific wavelength of light with the intention of absorbing light into that target area alone, the goal being that sufficient energy is absorbed by the target, leaving the surrounding tissue relatively unaffected.[1,2]

For years commonly targeted chromophores have included hemoglobin, deoxyhemoglobin, melanin, and water, which have allowed the successful treatment of vascular and pigmented lesions and conditions, as well as laser hair removal, the improvement of acne scar remodeling, and rhytid improvement. However, of the many available laser wavelengths in the marketplace, none have ever specifically targeted the sebaceous glands involved in sebaceous hyperplasia and the pathophysiology of acne.

Until now dermatologists have relied on topical photodynamic therapy (PDT), which requires the interaction of an exogenous photosensitizer, an activating light source, and the presence of oxygen, to target sebaceous glands. A topical nonphotosensitizing prodrug, 5-aminolevulinic acid (ALA), and methylaminolevulinic acid, its more lipophilic methylated counterpart, are preferentially absorbed by and metabolized within sebaceous glands, as well as superficial melanin, superficial cutaneous vasculature, and rapidly proliferating cells, producing highly photoactive protoporphyrin IX (PpIX).[3,4] PpIX excitation occurs with a light source of an appropriate wavelength, leading to the formation of cytotoxic singlet oxygen and other reactive oxygen species, with subsequent target cell death and localized oxidative stress.[5] Secondary vascular damage also results from vasoconstriction, thrombosis, ischemia, and subsequent necrosis of the vessels associated with the target.

Although not specific in treating sebaceous glands alone, well-controlled clinical studies have demonstrated the ability of pulsed lasers, specifically pulsed dye laser and intense pulsed light (IPL), to successfully target cutaneous sebaceous glands via photodynamic and photothermal mechanisms, leading to the improvement of sebaceous hyperplasia.[6,7] Several randomized controlled clinical trials have also demonstrated statistically significant reductions in inflammatory lesions of acne vulgaris using PDT,[8–12] improvement which is thought to partly contribute to the apoptosis of sebocytes from PDT.[13]

Wavelength 1720 nm and Sebaceous Glands

An SP in vitro study to determine wavelengths potentially able to target sebaceous glands was performed by Sakamoto and colleagues.[14] Absorption peaks near 1210, 1728, 1760, 2306, and 2346 nm were found with the use of a free-electron laser pulsed at an infrared CH(2) vibrational absorption wavelength band on natural and artificially prepared sebum. Laser-induced heating at 1710 and 1720 nm was about 1.5-fold higher in human sebaceous glands than in water. Histology of skin samples exposed to pulses of approximately 1700 nm and 100 to 125 milliseconds showed evidence of selective thermal damage to sebaceous glands. With the use of wavelengths that more specifically target sebum, the investigators hypothesized that SP of sebaceous glands, another part of hair follicles, may equate to the success of permanent hair removal via laser.[14]

In a pilot clinical study to evaluate the efficacy of a novel 1720-nm laser in the treatment of sebaceous hyperplasia, 4 patients underwent a test spot, followed by 2 full treatment sessions using the 1720-nm laser (Del Mar Medical Technologies, Del Mar, CA, USA). A 400-μm fiber, with a mean fluence of 45 J/cm^2, spot size of 750 μm, and pulse duration of 50 milliseconds was used to deliver the energy. The desired end point was a change from pretreatment granular yellow appearance to a creamy-white smooth surface. Damage to adjacent normal skin showed no change until the pulse duration exceeded twice that of the sebaceous hyperplasia. A panel of 3 independent dermatologists blinded to the date of the photographs evaluated the photos and scored them based on a global assessment comprising: (1) lesion diameter, (2) lesion height, and (3) lesion color. Many of the lesions resolved almost completely after a single treatment, and no additional treatment was required. There was a mean global improvement of 3.9 (3 = 51%–75% improvement and 4 = 76%–99% improvement). Crusts were noted by all patients, which resolved within 10 days.[15]

Complete heating of the sebaceous gland and sparing of the surrounding skin offered by the investigated device resulted in clinically apparent improvement with a minimum of adverse effects. Further studies are warranted, with larger sample sizes, to investigate the efficacy of this novel wavelength and possible future wavelengths in the SP of sebaceous glands and its impact in the improvement of sebaceous hyperplasia, ectopic