Lasers in dermatology: Four decades of progress
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Summary
Advances in laser technology have progressed so rapidly during the past decade that successful treatment of many cutaneous concerns and congenital defects, including vascular and pigmented lesions, tattoos, scars and unwanted hair, can be achieved. The demand for laser surgery has increased as a result of the relative ease with low incidence of adverse postoperative sequelae. In this review, the currently available laser systems with cutaneous applications are outlined to identify the various types of dermatologic lasers available, to list their clinical indications and to understand the possible side effects.

Abbreviations used
<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>APTD</td>
<td>Argon-pumped tunable dye</td>
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<td>CO2</td>
<td>Carbon dioxide</td>
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<td>CW</td>
<td>Continuous wave</td>
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<td>Er:YAG</td>
<td>Erbium:YAG</td>
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<td>FDA</td>
<td>Food and Drug Administration</td>
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<td>IPL</td>
<td>Intense pulsed light</td>
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<td>KTP</td>
<td>Potassium titanyl phosphate</td>
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<td>LP</td>
<td>Long-pulsed</td>
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<td>Nd</td>
<td>Neodymium</td>
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<td>PDL</td>
<td>Pulsed dye laser</td>
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<td>PDT</td>
<td>Photodynamic therapy</td>
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<td>QS</td>
<td>Quality-switched</td>
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<td>YAG</td>
<td>Yttrium-aluminum-garnet</td>
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Laser history
The term laser is an acronym for light amplification by the stimulated emission of radiation. The first laser was developed by Maiman\(^1\) in 1959 using a ruby crystal. The concept of stimulated light emission was initially introduced by Einstein\(^2\) in 1917. In 1963, Dr. Leon Goldman pioneered the use of lasers for cutaneous applications by...
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to treat vascular lesions include: Argon (488-514 nm), APTD (577 and 585 nm), KTP (532 nm), Krypton (568 nm), Copper vapor/bromide (578 nm), PDL (585-595 nm), Nd:YAG (532 and 1064 nm).

The flashlamp-pumped PDL was the first laser specifically developed for treatment of vascular lesions based on the principles of selective photothermolysis.\(^\text{12}\) The PDL has revolutionized the treatment of many vascular lesions and is considered the laser of choice for most benign congenital and acquired vascular lesions because of its superior clinical efficacy and low risk profile.\(^\text{17}\) This laser has been used to successfully treat a variety of vascular lesions such as port-wine stains, facial telangiectases, hemangiomas, pyogenic granulomas, Kaposi's sarcoma and poikiloderma of Civatte.\(^\text{18,19}\)

PDL with longer wavelengths (585, 590, 595 and 600 nm) and extended pulse duration have been developed to effect relatively deep tissue penetration.

Laser treatment for hypertrophic scars, keloids

Hypertrophic scars and keloids develop as an abnormal response to cutaneous injury and are characterized by an over abundance of collagen. These types of scars are notoriously difficult to eradicate and have a high rate of recurrence after traditional treatments including surgical excision, dermabrasion, radiation and intralesional therapy.\(^\text{20,21}\) Progress in laser technology and refinements in technique have made laser therapy one of the most advantageous modalities for the treatment of hypertrophic scars and keloids. In 1995, Alster and Williams performed the first controlled study of the response of hypertrophic scars and keloids to the PDL on median sternotomy scars.

Lasers use for the treatment of hypertrophic scars and keloid are CW Lasers (CO\(_2\), largon,
Nd:YAG) and PDL. The PDL has become a first line treatment for hypertrophic scars and keloids.

**Pigment-specific lasers**
Melanin-specific, high-energy, QS laser systems can successfully lighten or eradicate a variety of benign epidermal and dermal pigmented lesions and tattoos with minimal risk of untoward effects. Epidermal lesions (solar lentigines, ephelides, café-au-lait macules, and seborrheic keratoses); dermal and mixed epidermal/dermal lesions (melanocytic nevi, blue nevi, nevi of Ota/Ito, infraorbital hyperpigmentation, Becker's nevi, and nevus spilus); and amateur, professional, and traumatic tattoos have all been shown to be amenable to laser treatment. Laser systems used for eradication of benign pigmented lesions and tattoos have included not only CW and quasi-CW lasers (argon, CO2, copper vapor, krypton, KTP). But also the 510-nm PDL and various QS systems (532- and 1064-nm Nd:YAG, 694-nm ruby, 755-nm alexandrite). LP laser systems (ruby, alexandrite, 810-nm diode, and 1064-nm Nd:YAG) have also been used to better target some dermal pigmented lesions.

**Photoepilation**
Excessive hair growth in cosmetically undesirable locations may be the result of a variety of factors, ranging from hereditary causes and endocrine disease to exogenous drug therapy. Until recently, electrolysis was the only method for long-lasting hair removal; however, it is associated with as much as 50% hair regrowth and the potential for scarring and dyspigmentation. Laser systems and IPL sources currently approved by the FDA for the reduction of hair include: LP ruby (694 nm), LP alexandrite (755 nm), Pulsed diode (800 nm), LP Nd:YAG (1064 nm) lasers, IPL (590-1200 nm) sources. LP Nd:YAG laser systems are more effective particularly in patients with darker skin phototypes.

**Ablative laser systems**
Cutaneous laser resurfacing has experienced unparalleled growth in the field of aesthetic operation during the past decade. High energy, pulsed and scanned CO2 and erbium:YAG lasers have been in widespread use since the mid-1990s and the success of these lasers in photodamaged facial skin has been well documented. Because of flexibility and low side effect profile, the high energy, pulsed and scanned CO2 has been considered the gold standard for facial rejuvenation system.

**Nonablative laser systems**
One of the newest trends in dermatology has been the development of nonablative laser systems. The infrared systems that have been used for nonablative dermal remodeling include: Nd:YAG laser (1320 and 1064 nm), Diode laser (1450 nm), Er:glass laser (1540 nm).

**Laser phototherapy**
UV phototherapy has long been a mainstay in the treatment of psoriasis. Recently, a 308-nm xenon chloride excimer laser has demonstrated clearing of psoriatic plaques with fewer treatments than traditional narrow-band UVB therapy. The laser only targets the affected areas of the skin, thus sparing the surrounding tissue from unnecessary radiation exposure. The 308-nm excimer laser has also been used to treat problems of dyspigmentation. In a pilot study, Spencer et al demonstrated slight to complete repigmentation in 57% of 23 patches of vitiligo that received at least 6 treatments during 2 to 4 weeks. These results are encouraging because conventional phototherapy often requires months of treatment before improvement is seen. Acne vulgaris is another cutaneous condition amenable to phototherapy. Investigators have reported a decrease in acne lesions after exposure to blue, red, violet, or UV light. The mechanism of action by which blue light is thought to be effective is its absorption by endogenous porphyrins produced by Propionibacterium acnes with subsequent phototoxic effects. More recently, 1450 nm
Diode lasers have been used to target sebaceous glands in the treatment of acne.\(^{30}\)

**Optical imaging**
Diagnostic, noninvasive imaging is one of the most exciting developments in laser technology. Confocal scanning laser microscopy allows real-time imaging of tissue in vivo and can provide rapid, high-resolution imaging of skin cytology including the epidermis, microvascular blood flow and inflammatory cells.\(^{28}\) Potential clinical applications include non invasive skin imaging, detection of tumor margins and diagnosis of lesions without biopsy.

**Laser safety**
Of paramount importance is the general safety of both the patient and the operating room personnel during laser irradiation. Key laser safety issues include flammability, ocular safety, electric hazards, laser plume and infectious agents and controlled access to the laser suite.

**Anesthesia**
Most dermatologic laser procedures can be performed without any form of anesthesia. The most commonly used topical anesthetic compounds for cutaneous laser procedures are: EMLA Cream (Lidocain 2.5% & Prilocain 2.5%), Ela-max Cream (Lidocain 2.5%)\(^{31}\), S-Cain Peel (Lidocain & Tetracain).

**Side effects and complications**
PDL treatment of port-wine stains, hemangiomas, telangiectases, and vascular ectasias typically result in a variable degree of short-term purpura formation. Pigmented lesions may lighten, darken, or recur after QS laser irradiation. Transient pigmentary alteration is the most common postoperative side effect and may last for several months after treatment. Complications of laser-assisted hair removal using LP lasers are usually minor and transient. The most common adverse reactions include pain during treatment, erythema and perifollicular edema.

**Conclusion**
Although lasers capable of cutaneous application have been available for more than 4 decades, it has been only within the past several years that their use gained widespread acceptance within the medical field. Lasers have essentially revolutionized cosmetic dermatology, providing safe and reliable means for treating a variety of cutaneous pathologies. With continued research and development, it is expected that new discoveries will continue to emerge leading to significant treatment advances in laser surgery.

**References**