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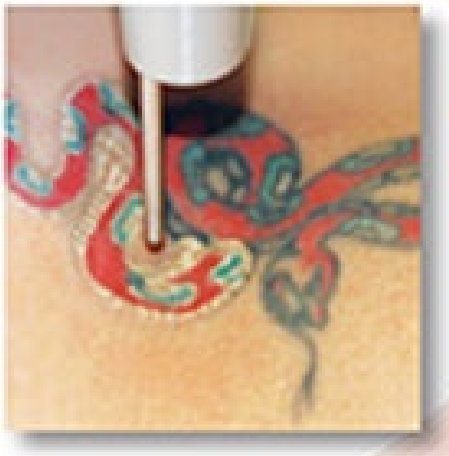
A Practical Guide to

Laser Procedures



Rebecca Small • Dalano Hoang

Foreword by John L. Pfenninger, MD

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A Practical Guide to

Laser Procedures

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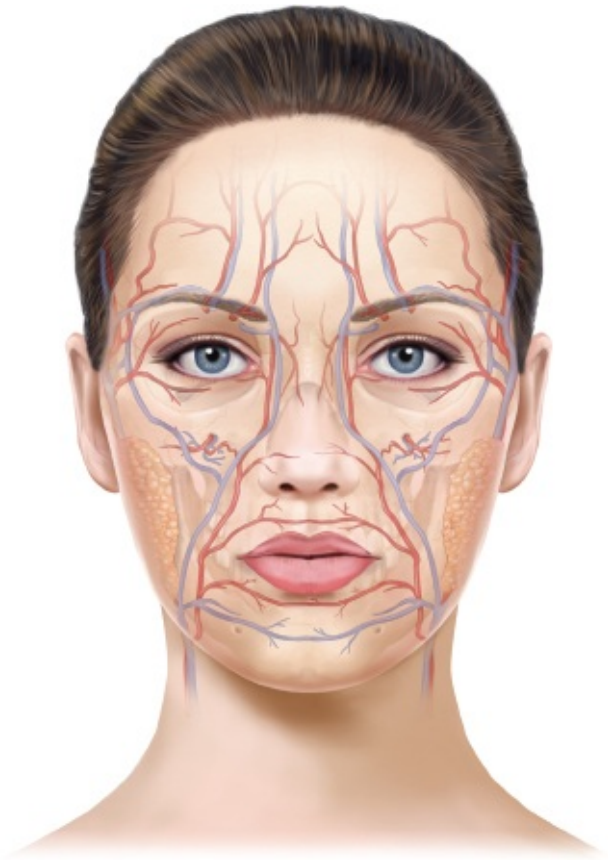
Foreword



As a lecturer, editor, author, and medical reviewer, I have had ample opportunity to evaluate many speakers as well as extensive medical literature. After reviewing this series of books on cosmetic procedures by Rebecca Small, MD, I have concluded that it has to be one of the best and most detailed, yet practical presentation of the topics that I have ever encountered. As a physician whose practice is limited solely to providing office procedures, I see great value in these texts for clinicians and the patients they serve.

The goal of medical care is to make patients feel better and to help them experience an improved quality of life that extends for an optimal, productive period. Interventions may be directed at the emotional/psychiatric, medical/physical, or self-image areas.

For many physicians, performing medical procedures provides excitement in the practice of medicine. The ability to see what has been accomplished in a concrete way provides the positive feedback we all seek in providing care. Sometimes it involves removing a tumor. At other times it may be performing a screening procedure to be sure no disease is present. Maybe it's making patients feel better about their appearance. For whatever reason, the "hands on" practice of medicine is more rewarding for some practitioners.

In the late 80s and early 90s, there was resurgence in the interest of performing procedures in primary care. It did not involve hospital procedures, but rather, those that could be performed in the office. Coincidentally, patients also became interested in less invasive procedures such as laparoscopic cholecystectomy, endometrial ablation, and more. The desire for plastic surgery "extreme makeovers" waned as technology was developed to provide a gentle, more kind approach to "rejuvenation." Baby boomers were increasing in numbers and wanted to maintain their youthful appearance. This not only improved self-

image, but it also helped when competing with a younger generation both socially and in the workplace.

These forces then of technological advances, provider interest, and patient desires have led to a huge increase in and demand for "minimally invasive procedures" that has extended to all of medicine. Plastic surgery and aesthetic procedures have indeed been affected by this movement. There have been many new procedures developed in just the last 10--15 years along with constant updates and improvements. As patient demand has soared for these new treatments, physicians have found that there is a whole new world of procedures they need to incorporate into their practice if they are going to provide the latest in aesthetic services.

Rebecca Small, MD, the editor and author of this series of books on cosmetic procedures, has been at the forefront of the aesthetic procedures movement. She has written extensively and conducted numerous workshops to help others learn the latest techniques. She has the practical experience to know just what the physician needs to develop a practice and provides "the latest and the best" in these books. Using her knowledge of the field, she has selected the topics wisely to include:

- A Practical Guide to: Botulinum Toxin Procedures
- A Practical Guide to: Dermal Filler Procedures
- A Practical Guide to: Chemical Peels, Microdermabrasion, and Topical Products
- A Practical Guide to: Laser Procedures

Dr. Small does not just provide a cursory, quick review of these subjects. Rather, they are an in-depth practical guide to performing these procedures. The emphasis here should be on "practical" and "in-depth." There is no extra esoteric waste of words, yet every procedure is explained in a clear, concise, useful format that allows practitioners of all levels of experience to learn and gain from reading these texts.

The basic outline of these books consists of the pertinent anatomy, the specific indications and contraindications, specific how-to diagrams and explanations on performing the procedures, complications and how to deal with them, tables with comparisons and amounts of materials needed, before and after patient instructions as well as consent forms (an immense time-saving feature), sample procedure notes, and a list of supply sources. An extensive updated bibliography is provided in each text for further reading. Photos are abundant depicting the performance of the procedures as well as before and after results. These comprehensive texts are clearly written for the practitioner who wants to "learn everything" about the topics covered. Patients definitely desire these procedures and Dr. Small has provided the information to meet the physician demand to learn them.

For those interested in aesthetic procedures, these books will be a godsend. Even for those not so interested in performing the procedures described, the reading is easy and interesting and will update the reader on what is currently available so they might better advise their patients.

Dr. Small has truly written a one-of-a-kind series of books on Cosmetic Procedures. It is my prediction that it will be received very well and be most appreciated by all who make use of it.

John L. Pfenninger, MD, FAAFP
Founder and President, The Medical Procedures Center

PC Founder and Senior Consultant, The National Procedures Institute
Clinical Professor of Family Medicine, Michigan State College of Human Medicine

Preface

Office-based cosmetic procedures such as botulinum toxin and dermal filler injections, chemical peels, lasers, and topical products have become the primary treatment modalities for facial aging over the last decade, and continue to be in high demand. Utilizing these procedures in an ongoing capacity can improve skin health and enhance appearance in a subtle, natural way with minimal risks relative to invasive surgical procedures.

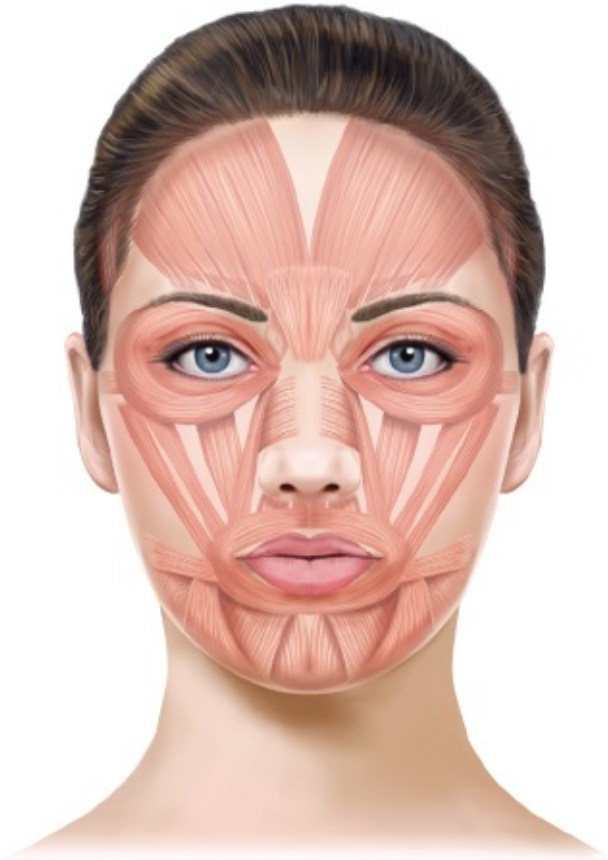
The Practical Guide series, including this current laser book, was created to assist providers with acquiring the necessary knowledge and skill to perform minimally invasive, office-based cosmetic procedures. The books are not intended to be comprehensive, but rather focus on treatments that address the most commonly encountered aesthetic complaints. In addition, procedures were chosen that consistently achieve good outcomes and have a low incidence of side effects. While treatments can be performed independently, most procedures discussed complement and work synergistically with other aesthetic procedures to enhance results. Instruction on how to safely and effectively perform each procedure is provided using a concise step-by-step format.

The goal of this book is to bridge the gap between the operating information provided by laser manufacturers that may be too basic, and other available learning materials that may be too advanced as they assume prior knowledge of lasers. A summary of key concepts and treatment principles is provided at the beginning for convenient referencing. The introduction discusses how to perform an aesthetic consultation, assess patients' aesthetic complaints, and other fundamentals essential for successfully performing laser treatments. Each chapter is dedicated to a particular laser indication and includes sections on patient selection, contraindications, procedure preparation, treatment techniques with practical

tips, desirable clinical endpoints to look for, and typical results with representative before and after treatment photographs. There are accompanying instructional videos to demonstrate procedures. Management of possible complications as well as the most commonly encountered issues seen in follow-up visits are reviewed. Up-to-date discussions of the latest technology developments and suggestions for combining lasers with other aesthetic procedures are also included for providers once they are familiarized with the basics.

The information presented in this Practical Guide series incorporates standard methods and techniques with practical suggestions and pearls from clinical experience gained from feedback teaching residents and fellow aesthetic providers. Hopefully, they will serve as clear and concise resources that assist providers to quickly and confidently gain proficiency with aesthetic procedures, and offer new treatment techniques for more seasoned providers. Books are of course not a replacement for experience and a formal training program, as well as precepting with an experienced provider, is recommended when learning aesthetic procedures.

Acknowledgments



I have profound gratitude and respect for Dr. Dalano Hoang, my associate editor and husband. He has been with me every step of the way as the Clinic Director of our aesthetic practice and much more. Although he personally does not perform aesthetic procedures, his knowledge of the many facets of aesthetic medicine is extensive and invaluable. His clear, concise writing style and encouragement have been instrumental in yielding this straightforward laser procedure book as well as the other procedure books in the Practical Guide series on botulinum toxin, dermal fillers, and chemical peels and topical products.

A special thanks to Dr. John L. Pfenninger, who has inspired me, supported me and taught me much about educating and writing.

The University of California, San Francisco and the Natividad Medical Center family medicine residents deserve special recognition. Their interest and enthusiasm for aesthetic procedures led me to develop the first family medicine aesthetics training curriculum in 2008, and motivated me to write articles and editorials about aesthetics for the American Family Physician.

I'd also like to acknowledge the expert team at Wolters Kluwer Health who made these books possible, in particular, Kristina Oberle, Rebecca Gaertner, Doug Smock, and Freddie Patane. I've thoroughly enjoyed working with Liana Bauman, the gifted artist who created all of the illustrations for these books.

I am grateful to the experienced laser physicians and the specialists from Alma, Cutera, Cynosure, Lumenis, Lutronics, Sciton, and Solta for sharing their photographs and their expertise on laser technologies.

As with all my other works, I am dedicating this latest book in the series to my amazing

son, Kaidan Hoang. I hope he's learning as much from me as I'm learning from him.

LASER PROCEDURES

Key References

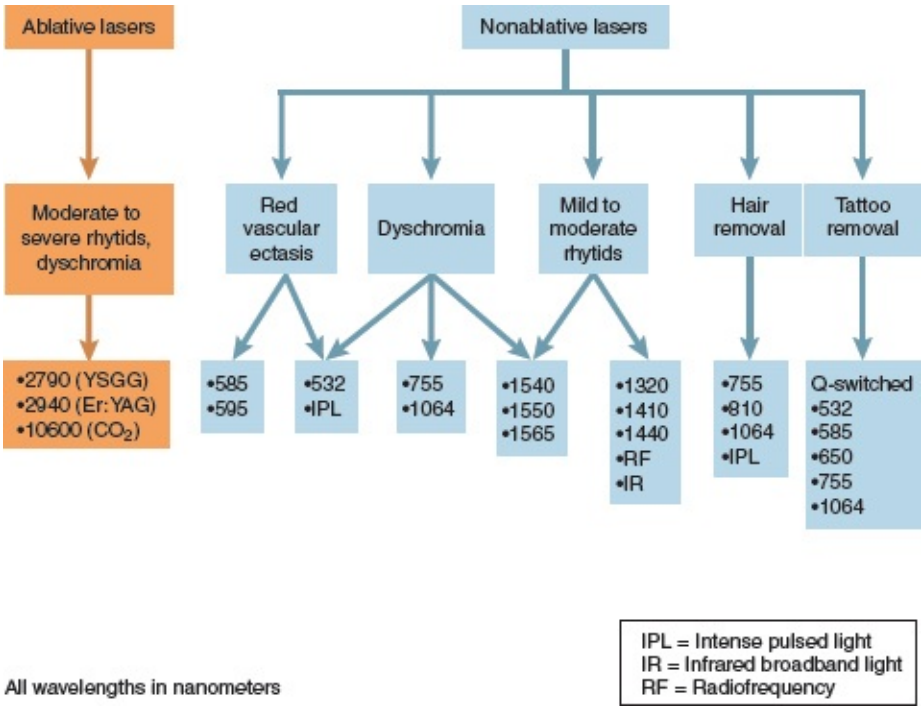


FIGURE 1 Lasers used for aesthetic conditions.

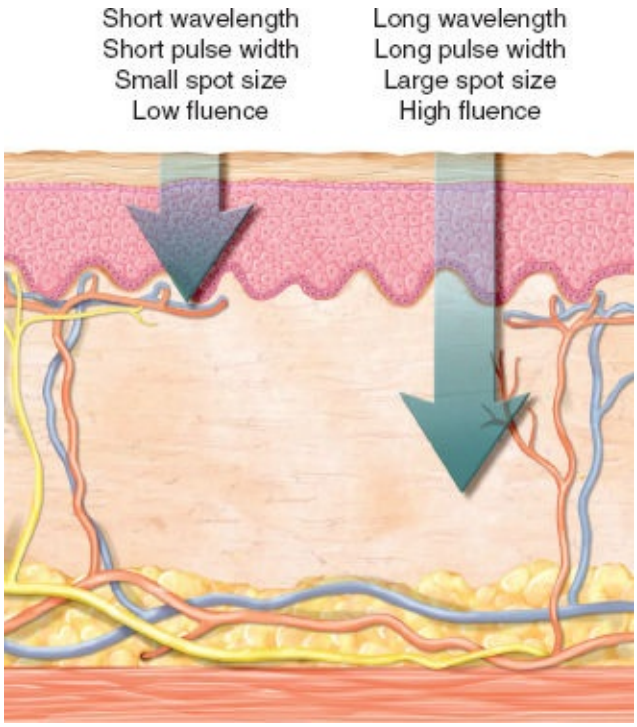


FIGURE 2 Factors affecting laser depth of penetration.

Patient Characteristics	Lesion Characteristics	Laser Parameters
Dark Fitzpatrick skin type (IV–VI) Nonfacial area	High density Intense color	Conservative: Long wavelength; Long pulse width; Large spot size; Low fluence
Light Fitzpatrick skin type (I–III) Face	Low density Faint color	Aggressive: Short wavelength; Short pulse width; Small spot size; High fluence

FIGURE 3 Laser treatment parameters used for different patient and lesion characteristics.

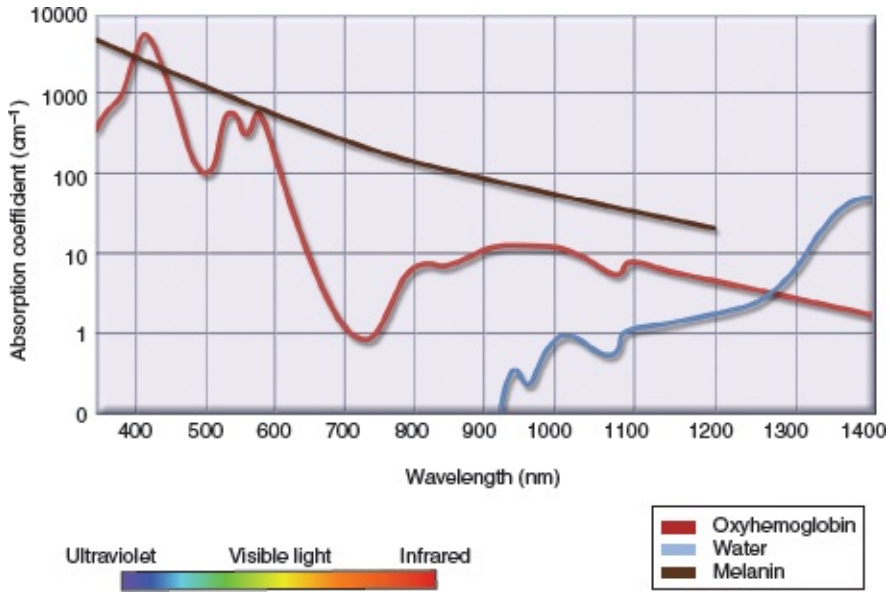


FIGURE 4 Absorption spectra of tissue chromophores.

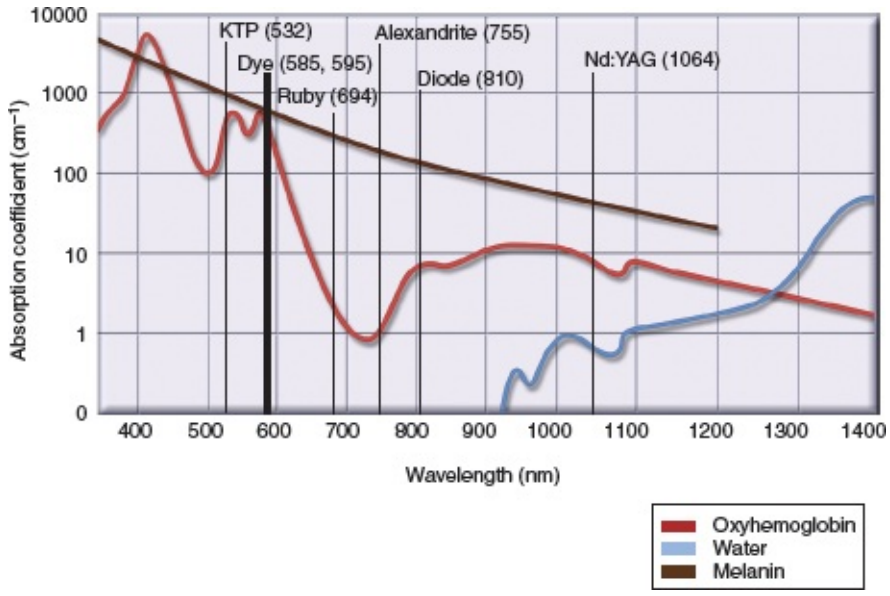


FIGURE 5 Absorption spectra of tissue chromophores and lasers used for aesthetic conditions.

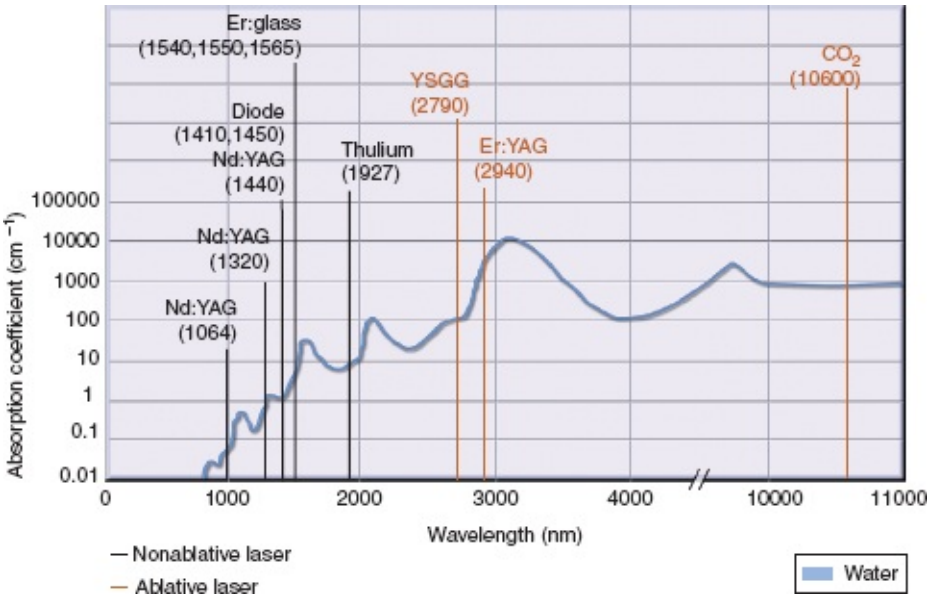


FIGURE 6 Water absorption spectrum and lasers used for skin resurfacing.

LASER PROCEDURES

Introduction and Foundation Concepts

Rebecca Small, M.D.

This Practical Guide focuses on laser and light-based technologies used to treat photoaged skin and other commonly encountered aesthetic conditions. The goals for rejuvenation of photoaged skin are to improve skin health and appearance through decreasing dyspigmentation, telangiectasias, erythema, and rhytids. A wide variety of laser and light-based technologies are available that target specific aspects of photoaging, enabling patient's individual rejuvenation needs to be met. This introduction presents the basic principles and concepts necessary to safely and effectively perform laser and light-based cosmetic treatments.

Skin Aging

Over time skin naturally thins and loses elasticity. These intrinsic aging changes are accelerated and compounded by sun exposure. Photoaging is the term used to describe cutaneous damage caused by overexposure to UV light and is also referred to as extrinsic aging, dermatoheliosis, actinic damage, and photodamage. To appreciate the contribution of photoaging to the appearance of aged skin, photoprotected skin such as the inside of the upper forearm or under the chin can be compared to the appearance of photoaged skin on face and back of the hands. Photoaged skin typically exhibits: **textural changes** such as rhytids (wrinkles) and roughness, **pigmentary changes** such as solar lentigines (sun spots), darkened ephelides (freckles) and actinic bronzing (background yellow-brown discoloration), **vascular changes** such as telangiectasias and erythema (redness), **sagging/laxity, fragility,** and **degenerative changes** such as actinic keratoses and neoplasia (skin cancers). Pigmentary changes, also referred to as **dyschromia,** can be darkened skin color referred to as **hyperpigmentation,** or lightened skin color referred to as **hypopigmentation**. Vascular changes are also referred to as **vascular ectasias.** Clinical findings seen in photoaged skin are reviewed in Figure 1 and Table 1.

What Aspects of Photoaging Can Be Treated with Lasers?

Laser and light-based technologies can reduce wrinkles and rough texture of photoaged skin, treat dyschromia and vascular ectasias. Treatment of photoaged skin using laser and light-based technologies is referred to as **photorejuvenation**. These treatments can also be readily combined with other minimally invasive aesthetic procedures such as dermal fillers, botulinum toxin, and topical products to enhance results (see Combining Aesthetic Procedures section below).

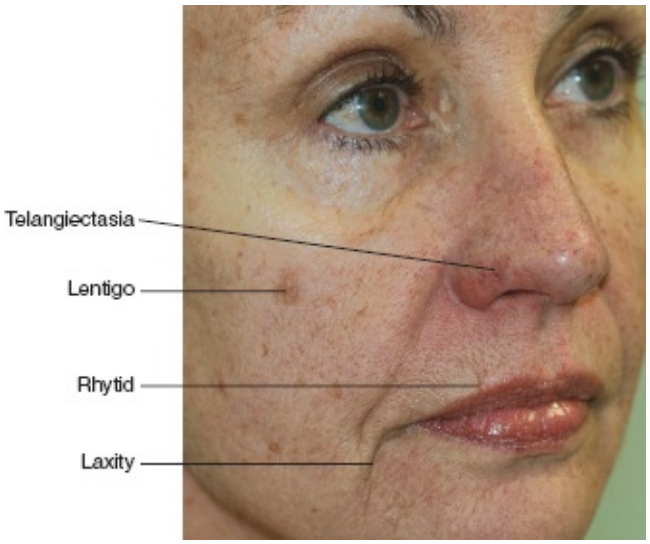


FIGURE 1 Photoaging changes. (Courtesy of R. Small, MD.)

TABLE 1

Clinical Findings in Photoaged Skin

Pigmentary changes
- Hyperpigmentation: lentigines, darkened ephelides, mottled pigmentation
- Poikiloderma of Civatte
- Hypopigmentation
- Sallow discoloration

Vascular changes
- Telangiectasias
- Erythema

Textural changes
- Rhytids
- Dilated pores
- Dry and rough skin
- Elastosis

Sagging and laxity

Degenerative changes
- Benign (e.g., seborrheic keratoses, sebaceous hyperplasia, cherry angiomas)
- Preneoplastic (e.g., actinic keratoses)
- Neoplastic (e.g., basal and squamous cell cancers and melanomas)

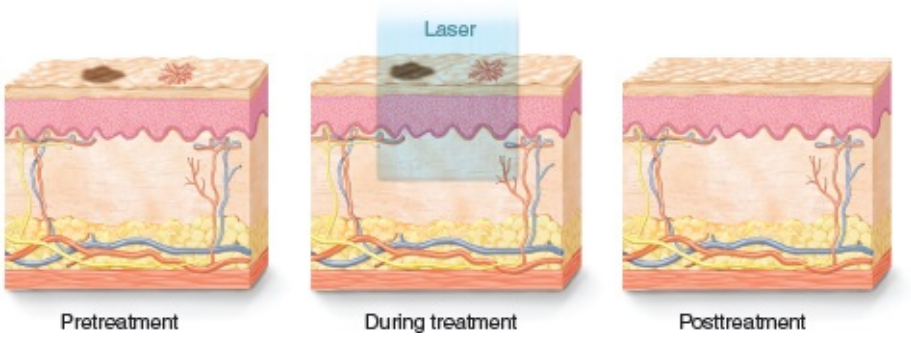


FIGURE 2 Selective photothermolysis.

Laser Principles

The term LASER originated as an acronym for Light Amplification by Stimulated Emission of Radiation. Laser devices produce light of a single wavelength with parallel rays that minimally disperse, thus forming a monochromatic, collimated, highly focused beam. Intense pulsed light (IPL) devices emit light that has a broad spectrum of wavelengths with rays that disperse, forming polychromatic, divergent beams. Both lasers and IPL devices, collectively referred to as lasers* in this book, operate under the principle of **selective photothermolysis**. According to this principle, light of a specific wavelength is selectively absorbed by an undesired skin lesion such as a solar lentigo or telangiectasia; the lesion is heated, damaged and eliminated while the surrounding skin is left unaffected (Fig. 2). Unlike tracing a blood vessel with electrocautery to remove the vessel, lasers are not aimed at their target, rather they are directed at the skin and once the beam encounters its target, laser energy is selectively absorbed by the desired target.

When laser energy impacts skin, the beam may be **absorbed,** reflected, transmitted, or scattered (Fig. 3). All four interactions occur to some degree, but absorption is the most important clinically. Upon absorption, heat from the laser can elicit a spectrum of tissue responses that range from synthesis of dermal collagen which reduces wrinkles, to damaging growth structures of hair follicles and endothelial cells of blood vessels which eliminate undesired hair and vascular lesions, respectively. Absorption of laser energy depends on the presence of chromophores, light absorbing compounds. Laser treatment parameters are selected to have greater absorption by the target chromophore in the undesired lesion than chromophores in the surrounding skin.

The primary **chromophores** in skin are melanin, oxyhemoglobin, and water, and each has a unique absorption spectrum (Fig. 4, Key References). The chromophore in red vascular lesions is **oxyhemoglobin,** which shows strong absorption at 400–600 nm with peaks at 418, 542, and 577 nm and has some absorption at 750–1100 nm. The chromophore in pigmented lesions and dark hair is **melanin**. Melanin absorbs light across a wide spectrum of wavelengths with greater absorption at short wavelengths and less absorption at longer wavelengths. Wavelengths between 600 and 1100 nm are preferentially absorbed by melanin over hemoglobin. Melanin is also present in the epidermis surrounding lesions. Epidermal melanin is an important consideration in patients with dark skin as it serves as a competing chromophore with target lesions (see Laser Treatments in Patients with Dark Background Skin section). The chromophore used for treatment of wrinkles and collagen remodeling effects is **water**. Water absorption starts to become significant around 950 nm and continues up to 11000 nm, with absorption peaks between 1000–1600 nm and at 3000 nm (Fig. 6, Key References). Chromophores found in cutaneous lesions treated with lasers are summarized in Table 2.

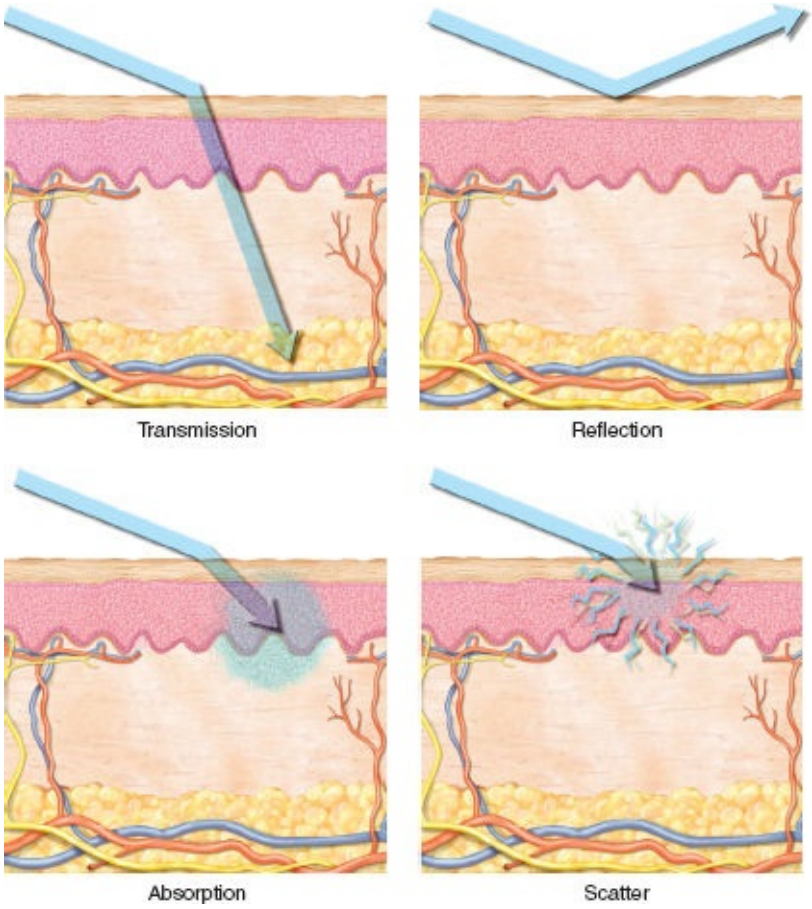


FIGURE 3 Laser-tissue interactions.

TABLE 2

Chromophores in Cutaneous Lesions Targeted with Laser Treatments

Skin Lesion	Chromophore
Hair	Melanin
Pigmented lesion	Melanin
Red vascular lesion	Oxyhemoglobin
Tattoo	Tattoo ink
Wrinkle	Water

What Are the Components of a Laser?

The key component of a laser is the lasing medium. The lasing medium is a substance, which, when stimulated by an external energy source, emits a particular wavelength of light. In other words, the lasing medium has properties that allow it to amplify light through an internal process of stimulated emission. A lasing medium can be a solid (e.g., alexandrite, ruby, neodymium-doped yttrium aluminum garnet), liquid (e.g., dyes) or gas (e.g., carbon dioxide). Lasers are often referred to by their lasing medium and the wavelength they produce. For example, a laser containing an alexandrite rod lasing medium will be referred to as a 755 nm alexandrite laser. In addition to the lasing medium, all lasers have an optical cavity surrounding the lasing medium that contains the

amplification process, a power supply or "pump" that supplies energy to the lasing medium, and a delivery system such as a fiber optic cable or articulated arm with mirrors that precisely delivers laser energy to the skin. Figures 5 and 6 in Key References list lasers used for treatment of photoaged skin including their lasing medium and wavelength.

Laser Parameters

Laser parameters are device settings that can be adjusted at the time of treatment. By appropriately selecting laser parameters of wavelength, fluence, pulse width, and spot size, specific lesions can be targeted with maximal efficacy and safety.

- **Wavelength (nm)** is selected such that it is preferentially absorbed by the chromophore in the lesion being treated. Wavelength also affects the depth of laser penetration in the skin. Short wavelengths penetrate superficially due to greater scattering of the laser beam and longer wavelengths penetrate deeper.
- **Fluence (J/cm^2),** also referred to as the energy density, is the energy (measured in joules) delivered per unit area (measured in cm^2) and is the intensity of the laser beam. Fluence is selected such that it is high enough to destroy the targeted lesion. Very high fluences can be associated with undesirable thermal injury to tissue surrounding the targeted lesion while very low fluences may not be effective for lesion removal.
- **Pulse width (range from picoseconds to seconds),** also referred to as pulse duration, is the length of time the laser beam is in contact with the skin. Short pulse widths penetrate superficially and longer pulse widths penetrate deeper. Additionally, short pulse widths are used for small lesions and long pulse widths are used for larger lesions.
- **Spot size (mm)** is the diameter of the laser beam on the skin surface. Small spot sizes penetrate superficially due to greater scattering of the laser beam and larger spot sizes penetrate deeper. Spot sizes used with fractional devices, also referred to as pixels, are very small (measured in μm) and are not adjustable. Pixels can penetrate very deeply and the principle of larger spot sizes having increased depth of penetration does not hold true when considering the tiny spot sizes used with fractional lasers.
- **Repetition rate (Hz)** is the rate at which the laser pulses. One hertz (HZ) is one pulse per second. Fast repetition rates allow for more rapid coverage of large, flat treatment areas and can shorten treatment times. Slower repetition rates aid in precise placement of laser pulses and are useful for treatment of single, discrete lesions or contoured treatment areas.
- **Power (W)** is the rate at which energy is emitted from the laser. One watt (W) is 1 joule per second. The power delivered per unit area is the **power density (W/cm^2),** also referred to as irradiance. These variables are not adjusted during treatments but rather are discussed when comparing different laser devices.
- **Cooling** affects treatment efficacy and protects the epidermis from thermal injury, however, is not usually adjusted during treatments. Some lasers utilize cooling methods such as cryogen sprays and contact cooling to protect the epidermis during treatment; external forced refrigerated air is also used. Too much cooling can reduce the efficacy of the treatment and even cause epidermal injury.
- **Scanners.** Some devices, particularly for ablative resurfacing, utilize scanners and

computer software to "randomly" deliver pulses within a set pattern so that the pulses are not adjacent to one another. Using nonadjacent pulses allows for high energies to be delivered to the skin without the effects of bulk heating and associated risk of thermal injury.

- **Spot density.** Fractional devices also have a density setting which determines the percentage of skin that is treated with a pulse. High-density settings are associated with more intense treatments, have longer healing times, and potentially greater improvements.
- **Variable pulse sequencing.** Some IPL devices have variable pulse sequencing where one output pulse is delivered as single, double, or triple pulses. Multipulse modes (e.g., triple pulsed mode) have delays between pulses and are safer on the skin as they allow thermal energy to dissipate between pulses. In addition, the overall pulse width is lengthened in multipulse modes and they are used to treat deeper lesions.

Laser parameters are typically selected using a computerized touch screen (Fig. 10). Other laser components used for treatments are also shown in Figure 10 including the laser arm, handpiece, and distance guide that aids in maintaining a constant distance between the laser tip and skin.

Thermal Relaxation Time

To understand how pulse width contributes to selectively targeting lesions, one must first understand the concept of thermal relaxation time. **Thermal relaxation** time is the time it takes a lesion to dissipate ~50% of its energy into the surrounding tissue. The most selective heating of a target lesion is achieved when laser energy is delivered to the target at a rate faster than the rate of heat dissipation away from the target. In other words, laser energy is confined to the target when the laser pulse width is shorter than the thermal relaxation time of the target. The ideal pulse width is long enough to heat the desired target, while short enough to limit transfer of damaging heat to surrounding tissues. A target's thermal relaxation time is proportional to the square of the target diameter. Small targets, such as fine telangiectasias, have short thermal relaxation times and require short pulse widths for treatment; larger caliber vessels have longer thermal relaxation times and require longer pulse widths for treatment. By choosing a wavelength that is selectively absorbed by the chromophore in the lesion, using adequate fluence to damage the lesion, and choosing a pulse width that allows for heating of the lesion rather than adjacent tissue, lasers selectively destroy lesions with minimal nonspecific thermal damage to surrounding skin. This is the principle of **selective photothermolysis** as it relates to laser parameters. Liquid nitrogen treatments provide a good analogy. If a wart is treated with liquid nitrogen for example, the freeze time (i.e., pulse width) needs to be long enough to freeze the wart but not so long that the cold extends beyond the wart and damages the tissue surrounding the wart.

Depth of Penetration

Deep penetration of laser energy is safer for the epidermis as it reduces superficial

absorption of heat and the likelihood of epidermal thermal injury. In addition, understanding how laser parameters affect the depth of penetration allows providers to better target lesions at different depths in the skin. Superficial penetration is associated with short wavelengths, short pulse widths, low fluences, and small spot sizes. Deeper penetration is associated with long wavelengths, long pulse widths, high fluences, and large spot sizes. These laser concepts, summarized in Figure 2, Key References apply to nonfractional devices. The depth of penetration with fractional lasers is primarily a function of fluence and wavelength. High fluences and wavelengths poorly absorbed by the water chromophore, have deep cutaneous penetration (see Wrinkles—Nonablative Resurfacing, Chapter 5 for further discussion).

Skin Anatomy

The skin is divided into three layers: the epidermis, dermis, and subcutaneous layer. The **epidermis** is the top layer of the skin and is composed of the outermost nonliving layer, the stratum corneum, and the living cellular layers of the stratum granulosum, stratum spinosum, and stratum basale (Fig. 4). The stratum corneum is composed of corneocytes (nonliving keratinocytes) and lipids and is often referred to as the epidermal barrier. It functions as an evaporative barrier to maintain skin hydration and suppleness, and as a protective physical barrier against microbes, trauma, irritants, and UV light. Constant renewal is necessary for the epidermis to maintain its integrity and function effectively. In healthy young skin, it takes approximately 1 month for keratinocytes to migrate from the living basal layer of the epidermis to the stratum corneum surface and desquamate during the process of epidermal renewal.

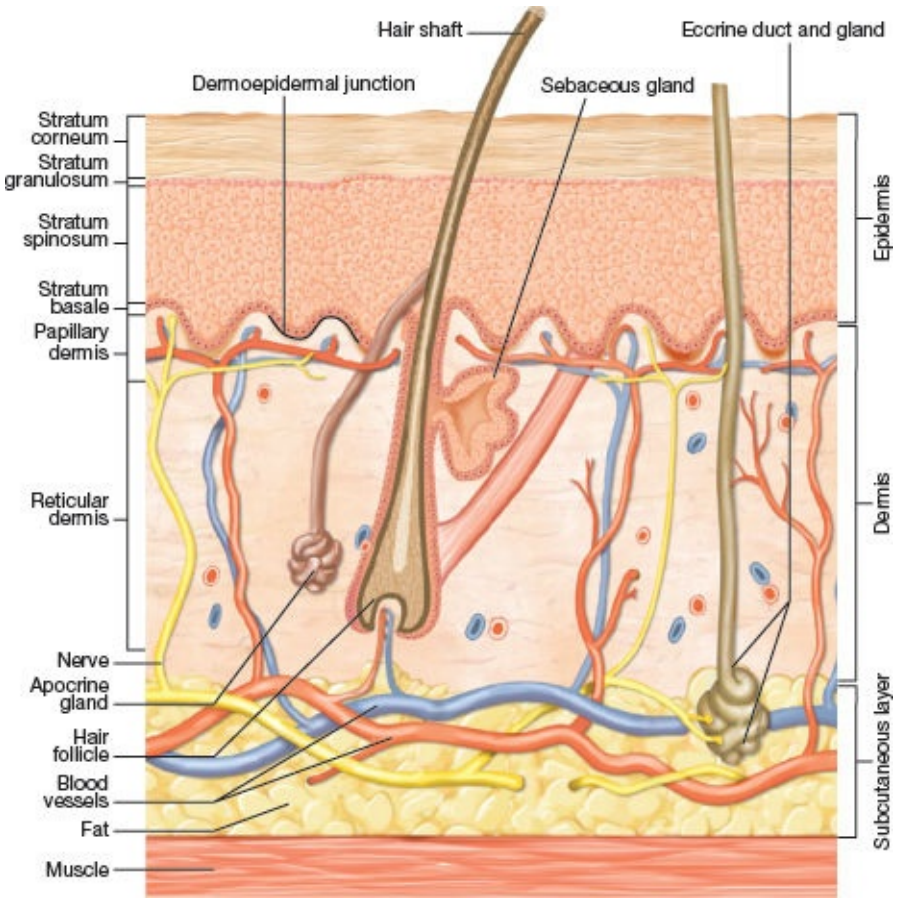


FIGURE 4 Skin anatomy.

Melanin pigment, which determines skin color and dyschromias, is primarily concentrated within the epidermis, and in some conditions is found in the dermis (e.g., some forms of melasma). There are two types of melanin pigment: pheomelanin and eumelanin. Pheomelanin is yellow to red in color and is the predominant type in light skin. Eumelanin is brown to black in color and is predominant in dark skin. The number of melanocytes is similar for both light and dark skin; however, the type and distribution of melanin within the epidermis differ. In light skin, melanosomes are small and contain few melanin granules, which are closely aggregated. In darker skin, melanosomes are large, and contain many melanin granules that are distributed singly. The key regulatory step in melanin synthesis (melanogenesis) is the enzymatic conversion of tyrosine to melanin by tyrosinase. This occurs within melanocytes that reside in the basal layer of the epidermis. Once synthesized, melanin is packaged into intracellular organelles called melanosomes that are distributed within the melanocyte and to surrounding epidermal keratinocytes. One melanocyte can contact 30–40 keratinocytes; referred to as an epidermal-melanin unit.

The **dermis** lies beneath the epidermis and is divided into the more superficial papillary dermis and deeper reticular dermis. The main cell type in the dermis is the fibroblast, which is more abundant in the papillary dermis and sparse in the reticular dermis. Fibroblasts synthesize most components of the dermal extracellular matrix, which include, structural proteins (such as collagen and elastin), glycosaminoglycans (such as hyaluronic acid) and adhesive proteins (such as fibronectin and laminins). Hyaluronic acid binds water and augments skin thickness by increasing skin hydration. Appendageal structures, also referred to as adnexa, such as hair follicles and sebaceous glands also reside in the dermis. These structures contain regenerative precursor cells that are integral in wound healing.

The **subcutaneous layer** or superficial fascia, lies below the dermis and above the muscle. This layer is composed of both fatty and fibrous components.

Histology of Photoaging

In the **epidermis,** UV exposure results in disorganized keratinocyte maturation and abnormal retention of cells. This creates a rough and thickened stratum corneum with poor light reflectance evident as skin dullness (also referred to as sallow discoloration). The disrupted epidermal barrier allows water to escape more freely from the skin, measured as increased transepidermal water loss, which causes dehydration. Impaired barrier function also allows for increased irritant penetration that can be associated with skin sensitivity. Pigmentary changes in photoaged skin are due to dysregulation of melanin synthesis and deposition in the epidermis. The number of melanocytes in the skin decreases naturally over time, however, chronic UV exposure results in an increased number of overactive melanocytes and disorganized melanin deposition in the epidermis. Regions with excess melanin are evident as hyperpigmentation such as freckles and lentigines, and regions with melanin deficiency are evident as hypopigmentation.

In the **dermis,** UV exposure has many damaging effects on the extracellular matrix. Hyaluronic acid diminishes and structural proteins such as collagen and elastin are degraded due to upregulation of enzymes (e.g., matrix metalloproteases) and weakened due

to crosslinkage. Overall collagen content decreases by approximately 1% per year in adults. The resultant dermal atrophy contributes to formation of fine lines and wrinkles. Advanced photoaged skin also has solar elastosis, which is disorganized clumping of damaged elastin fibers seen clinically as coarse wrinkling, sallow discoloration, and skin thickening. Abnormal dilation and proliferation of dermal blood vessels is visible as telangiectasias and erythema.

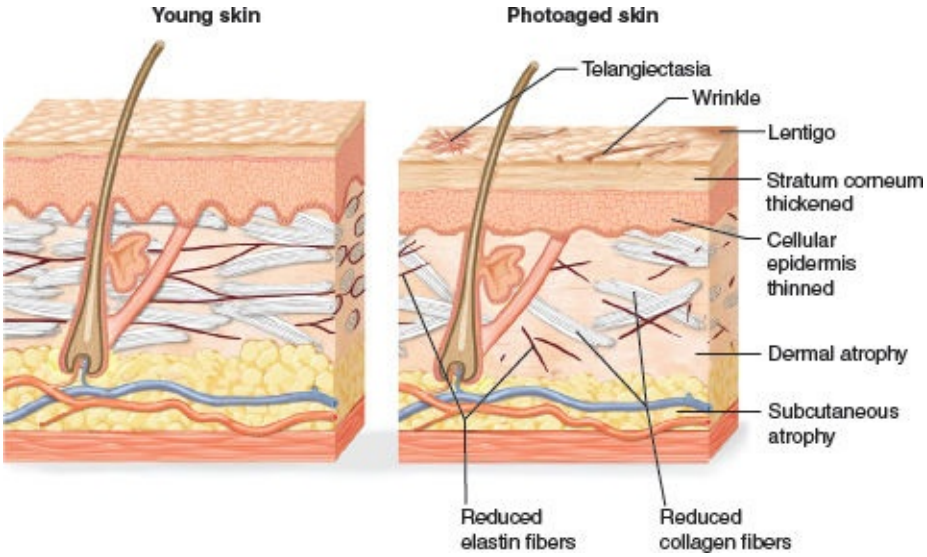


FIGURE 5 Histologic characteristics of young and photoaged skin.

Histologic changes seen in photoaged skin are illustrated in Figure 5. Relative locations of epidermal pigmented lesions such as lentigines, and dermal vascular lesions such as telangiectasias are shown in Figure 6.

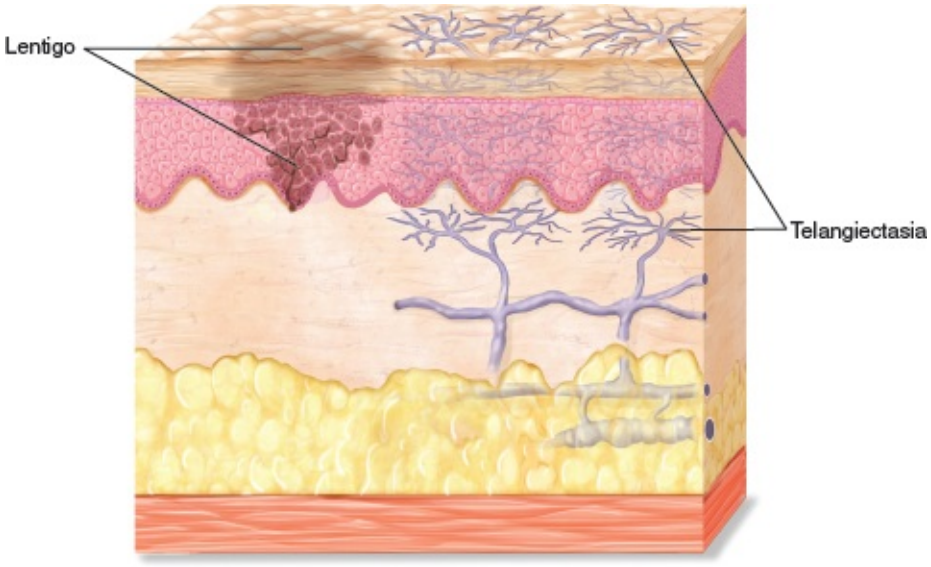


FIGURE 6 Lentigo and telangiectasia cutaneous locations.

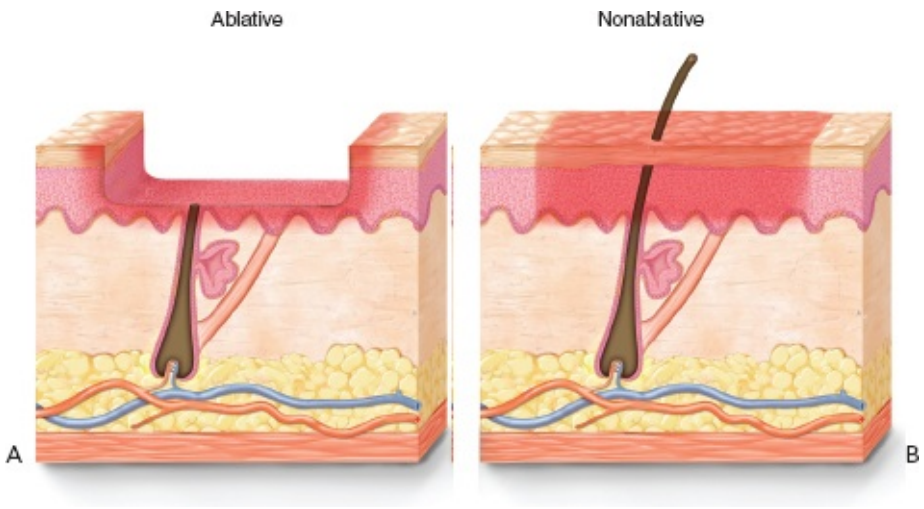


FIGURE 7 Ablative (A) and nonablative (B) laser-tissue interactions.

Laser Devices Overview by Type of Technology

Lasers can be broadly categorized into **ablative devices** (Fig. 7A) that heat and vaporize skin, and **nonablative devices** (Fig. 7B) that heat skin without vaporizing or removing tissue. Ablative devices target water as the chromophore and are primarily used for skin resurfacing to reduce wrinkles and pigmented lesions. Nonablative devices can target a broad range of chromophores. Some nonablative devices target water such as those used for nonablative skin resurfacing to reduce wrinkles. Other nonablative devices target melanin, oxyhemoglobin or tattoo ink, and have broad applications that include hair removal, tattoo removal, and treatment of vascular and pigmented lesions. Figure 1 in Key References gives an overview of lasers used for aesthetic conditions associated with photoaging including pigmented lesions, vascular lesions, wrinkles, and common aesthetic complaints such as hair removal and tattoo removal. A list of laser companies that manufacture devices used for treatments discussed in this book are provided in Appendix 6.

Fractional Lasers

Fractional refers to a method of delivering laser energy to the skin, whereby a portion or "fraction" of the skin is heated in microscopic columns, called microthermal zones (MTZs). MTZs are typically 100 μm wide and distributed in a grid-like pattern that appears as tiny dots, or pixels, on the skin surface (Fig. 8B). The penetration depth of fractional (also referred to as fractionated) lasers ranges from 300 μm–1.5 mm. Untreated tissue between MTZs serves as a reservoir of regenerative cells that migrate into the treated areas and facilitate rapid healing. The wound healing process stimulates collagen synthesis and dermal remodeling. Treating skin with fractional lasers is referred to as **fractional photothermolysis**. Fractional lasers are most commonly used for skin resurfacing and can be ablative or nonablative. Ablative fractional lasers vaporize tissue in the MTZs, leaving an open wound. Nonablative fractional lasers coagulate tissue in the MTZs, leaving the stratum corneum intact.

Fractional lasers deliver the fractionated beam to the skin using different methods. Some devices use a disposable roller on the tip that is continuously moved across the skin during treatment. Other devices use a stamping technique, where a lens inside the handpiece

fractionates the beam each time the laser pulses and all pixels are created at once. Other devices use scanners to fractionate the beam placing pixels sequentially on the skin during the pulse in a fixed or randomly distributed pattern. Fractional lasers are discussed further in Skin Resurfacing.

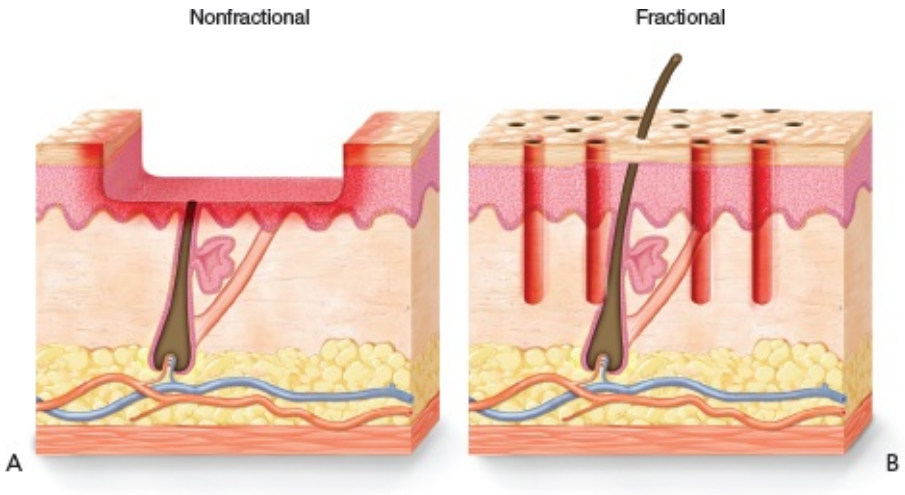


FIGURE 8 Nonfractional (A) and fractional (B) laser-tissue interaction.

Intense Pulsed Light

Intense pulsed light (IPL) devices emit a **broad spectrum of wavelengths** ranging from 500–1200 nm. IPL emissions are generated from flashlamps and transmitted to the skin via a sapphire or quartz tip. Output is refined using filters to select for certain desirable wavelengths and remove undesirable wavelengths. Although the light emitted by IPLs is polychromatic and noncoherent (nonlaser), they still operate under the principle of selective photothermolysis. Emitting a range rather than a single wavelength allows IPLs to target multiple chromophores (melanin, oxyhemoglobin, and to a lesser extent water) and lesions at different depths simultaneously. Consequently, IPLs have a wide variety of applications including treatment of photoaged skin for vascular and pigmented lesions, hair removal, and to a lesser extent, skin texture and rhytids. Short wavelengths (515–550 nm) are used to treat superficial lesions and patients with light Fitzpatrick skin types; long wavelengths (greater than 570 nm) are used for deeper lesions and dark Fitzpatrick skin types.

Various methods for **filtering wavelengths** are used in IPL devices, which vary by manufacturer. Lumenis' IPL devices use cutoff filters to eliminate undesired short wavelengths. The filter's value indicates the shortest wavelength that is emitted to the skin. Common cutoff filters are 515, 550, 560, 570, 590, 615, 645, 690, 695 and 755 nm. These IPL devices utilize one handpiece for all treatments and have removable cutoff filters that slide into the handpiece. For example, a 515 nm cutoff filter eliminates all wavelengths shorter than 515 nm and is used to treat epidermal lesions; a 590 nm filter is used to treat deeper vascular lesions; and 695 nm is used for hair removal. Other manufacturer's such as Palomar/Cynosure use a combination of filters inside their IPL handpieces to generate emission peaks at desired wavelengths and remove short undesired wavelengths. For example, the IPL handpiece used for treatment of pigmented and vascular lesions (MaxG) has two output peaks at 500–670 nm and 870–1200 nm to target oxyhemoglobin and

melanin chromophores respectively (Fig. 2, Chapter 2). The handpiece for hair removal (MaxRs) has different internal filters that create one emission peak at 600–800 nm to target melanin (Fig. 3, Chapter 1). The entire handpiece must be changed when treating different conditions. Another IPL manufacturer, Cutera, selects for certain emission wavelengths using a variable current that allows changes to be made electronically, avoiding the need for connecting different handpieces or filters.

Like lasers, IPLs have **variable fluences and pulse widths**, which aid in targeting specific lesions in the skin. For example, treatment of a patient with Fitzpatrick skin type II with large, deep telangiectasias may use a pulse width of 100 ms and fluence of 50 J/cm^2. Treatment of the same patient with background erythema, which represents fine vessels located superficially in the skin, may use a pulse width of 10 ms and fluence of 34 J/cm^2. Some IPL devices have **variable pulse sequencing**, where one output pulse is delivered as single, double, or triple pulses. Multipulse modes (e.g., triple pulses) have greater dissipation of heat, are safer for the epidermis and used in darker skin types. In addition, the overall pulse width is lengthened with multipulse modes; they penetrate deeper and are preferable for treatment of deeper dermal targets such as large caliber telangiectasias.

IPLs have **large spot sizes** (e.g., 1.6 × 4.6 cm) and consequently cover a larger area with each pulse. While large spot sizes typically translate into faster treatment times, this is offset by low repetition rates (e.g., 0.3–1 Hz) when high fluences are used. For precise treatment of small lesions, the spot size may be reduced by covering a portion of the treatment tip with an opaque paper (Fig. 8, Chapter 3). Some IPL devices have adaptors that can be attached to the treatment tip to reduce the spot size to 4 or 6 mm. High quality devices use **built-in cooling** for epidermal protection which also provides some anesthesia.

Very Short Pulse Lasers (Q-switched and Mode-locking)

Lasers with Q-switching (or quality-switching) and mode-locking capabilities generate very short pulse widths, in the nanosecond and picosecond range respectively. These very short pulse lasers are used for tattoo removal and treatment of pigmented lesions. They operate under the principles of selective photothermolysis and photoacoustic vibration. **Photoacoustic vibration** results from rapid, high-energy pulses with short pulse widths that oscillate and fragment targeted lesions into smaller particles, thereby enhancing elimination. Tattoo ink particles and melanosomes are very small in size with short thermal relaxation times and therefore, respond well to extremely short pulse widths. While most short pulse lasers treat epidermal pigmented lesions, QS 1064 nm lasers have deeper penetration due to their longer wavelength and are used to treat dermal pigmentation such as melasma. Q-switched (QS) lasers commonly used include 532, 585, 650, 694, 755 and 1064 nm; picosecond lasers include 532 and 755 nm.

Neodymium-doped Yttrium Aluminum Garnet Laser

Neodymium-doped yttrium aluminum garnet (Nd:YAG) can produce many different wavelengths. Nd:YAG is a crystal that has a small fraction of the yttrium replaced by neodymium (i.e., it is doped with neodymium), which provides the lasing activity for the crystal. Nd:YAG typically emits light with a wavelength of 1064 nm. However, based on

how it is pumped from an external energy source, it can emit either 940 nm, 1320 nm, or 1440 nm. These are not interchangeable, and a given Nd:YAG laser only emits one of these wavelengths.

Potassium Titanyl Phosphate Laser

Potassium titanyl phosphate (KTP) laser is actually a misnomer. The primary lasing medium in a KTP laser is neodymium-doped yttrium aluminum garnet (Nd:YAG) and the primary wavelength is 1064 nm. The 532 nm wavelength is produced by passing the 1064 nm wavelength through a frequency doubling potassium titanyl phosphate (KTP) crystal. So, a KTP laser is actually a frequency doubled Nd:YAG laser.

Radiofrequency Devices

Radiofrequency (RF) devices are nonlaser, non–light-based devices. They employ **rapidly alternating current** that creates heat when applied to the skin, due to the skin's resistance to current flow (impedance). RF energy is concentrated in the dermis. Heating tissue with RF is controlled by several factors, including the type of electrodes used (e.g., monopolar, bipolar, tripolar), amount of current, duration of current, and cooling times. Newer RF devices utilize fractional methods for delivering current that create microwounds below the skin surface. RF devices are used primarily for reduction of skin laxity and have shown benefits in areas such as the periocular region, nasolabial folds, jowls, neck and abdomen, and for reduction of cellulite, which is outside the scope of this book.

Light-Emitting Diodes

Light-emitting diodes (LEDs) are nonlaser, light-based devices that emit a narrow range of low-intensity wavelengths. Red LED devices (570–670 nm) are used for mild wrinkle reduction and blue LED devices (400–500 nm) for acne. They do not operate based on the theory of selective photothermolysis but rather are based on the principle of **photomodulation**, where cellular activity is modulated through illumination by particular wavelengths of light. While devices have similarities to lasers and other light-based technologies, their histologic effects on skin and clinical results are extremely modest. The main advantage of LEDs is their ease of use.

Photodynamic Therapy

Photodynamic therapy (PDT) involves the use of a topical **photosensitizing medication** activated by a light source such as an LED, IPL or laser (e.g., 595 nm). Commonly used photosensitizers include 5-aminolevulanic acid (ALA) and methyl ALA. ALA (e.g., Levulan™) is selectively absorbed and concentrated in proliferating cells and pilosebaceous units where it is converted to protoporphyrin. Upon activation with a light source, protoporphyrin forms free radicals that selectively destroy the target. PDT is used off-label for photorejuvenation of pigmented lesions and photodamage, and is FDA approved for treatment of nonhyperkeratotic actinic keratoses on the face. While PDT has impressive results, there is significant postprocedural erythema and crusting, strict patient avoidance

of ambient sunlight for 48 hours is necessary as exposure can lead to extended photosensitizer activation and associated complications, and treatment cost is higher than with laser alone due to the medications used.

Laser Devices by Indication

Skin Resurfacing

Wrinkle reduction with lasers, also referred to as laser skin resurfacing, is based on the principle of creating a controlled wound in the skin using heat and evoking a healing response. The healing process stimulates collagen remodeling with fibroblast production of new collagen, elastin, and other extracellular matrix components that thickens the dermis. In addition to wrinkle reduction, dermal remodeling also improves rough skin texture, pore size, and scars. Lasers are not the only means by which the skin can be resurfaced; other modalities include mechanical resurfacing with microdermabrasion and chemical resurfacing with chemical peels. Regardless of the method used, skin resurfacing can be performed to varying degrees of aggressiveness, based on the depth of skin penetration. Greater depths of wounding produce more dramatic results but require longer recovery times, more intensive postprocedure care, and have greater risks of complications. Figure 9 shows the standard depths associated with very superficial, superficial, medium, and deep skin resurfacing procedures. Skin resurfacing with lasers can be achieved using ablative and nonablative lasers. Selecting the appropriate laser resurfacing procedure depends on a combination of factors including wrinkle severity, patient expectations for results, number of treatments needed to achieve results, tolerance for postprocedure downtime, and complication risks (Table 3).

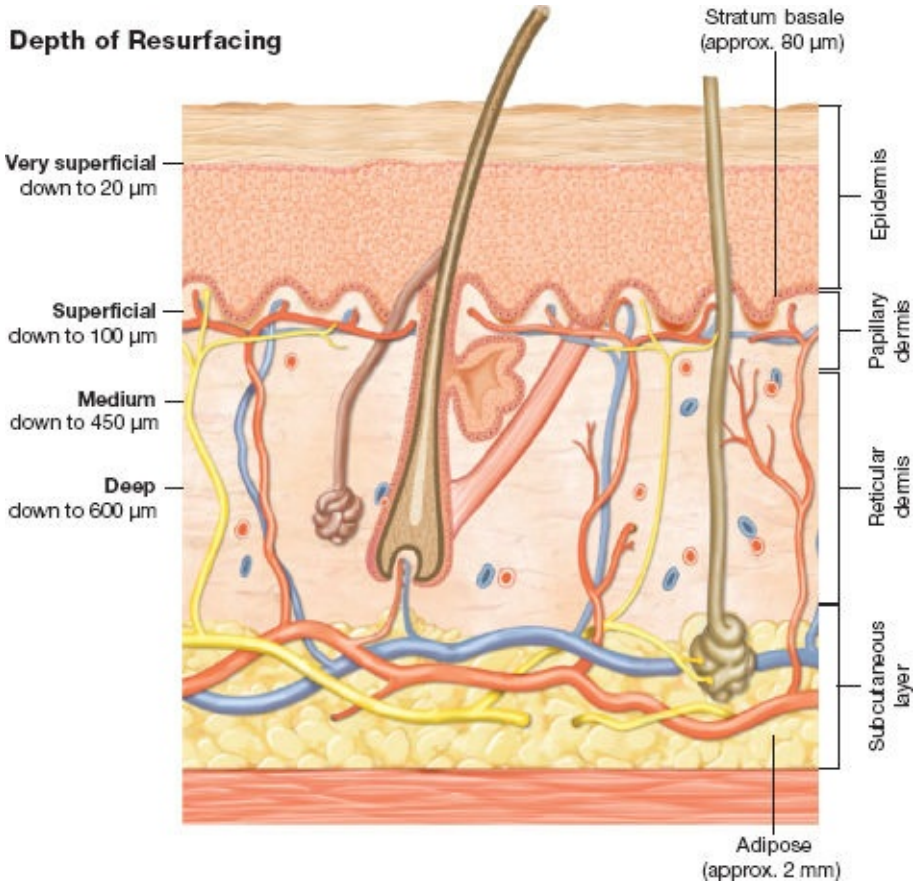


FIGURE 9 Skin resurfacing terminology and cutaneous depth of penetration.

TABLE 3

Laser Resurfacing Treatments for Wrinkle Reduction

	Patient Presentation and Treatment Characteristics				
Resurfacing Lasers	Wrinkle Severity	Results	# Treatments	Recovery Time	Complication Risk
Nonablative	+	+	6–8	+	+
Fractional nonablative	++	++	4–6	++	++
Fractional ablative	+++	+++	1	+++	+++
Ablative	++++	++++	1	++++	++++

Nonablative = 532 nm, 585 nm, 595 nm, 755 nm, 1064 nm, 1320 nm, 1450 nm, and IPL (500–1200 nm).
Fractional nonablative = 1410 nm, 1440 nm, 1540 nm, 1550 nm, 1565 nm, and 1927 nm.
Fractional ablative and ablative = 2790 nm, 2940 nm, and 10600 nm.
+ mild; ++ moderate; +++ significant; ++++ very significant.

Ablative skin resurfacing lasers vaporize and remove skin. They can achieve profound wrinkle reduction results but have longer recovery times and greater risks of complications such as pigmentary alterations, infection, and scarring compared to nonablative treatments. Ablative lasers wavelengths are highly absorbed by the water chromophore and they vaporize tissue by raising the skin temperature to over 100°C. The two wavelengths used most often for ablative resurfacing are: 2940 nm (erbium:yttrium-aluminum-garnet or Er:YAG) and 10600 nm (carbon dioxide). Treatments with ablative lasers also improve epidermal pigmented lesions such as freckles and lentigines as a result of epidermal tissue removal. Ablative skin resurfacing is most commonly performed using fractional devices as they offer more rapid recovery times and significantly decreased risks of complications compared to nonfractional ablative lasers. Ablative skin resurfacing treatments are discussed in detail in Chapter 6.

Nonablative skin resurfacing lasers provide milder treatments compared to ablative lasers, gently heating the skin (to approximately 60°C) without removing tissue. Results are much less significant, but recovery times are shorter, and complications are less common and less severe relative to ablative lasers. They appeal to patients who desire to continue daily activities with minimal to no disruption. Some nonablative skin resurfacing lasers target the water chromophore and others target colored chromophores (melanin and oxyhemoglobin). Out of all nonablative skin resurfacing lasers, fractional lasers that target water (1410 nm, 1440 nm, 1540 nm, 1550 nm, 1565 nm, 1927 nm) offer the most impressive wrinkle reduction results. Nonablative skin resurfacing treatments are discussed in Chapter 5.

Pigmented Lesions

Lasers used for benign pigmented lesions such as lentigines and ephelides work by either specifically targeting melanin, or by targeting water and non-specifically removing pigmentation through skin resurfacing. Lasers used for treatment of pigmented lesions that target melanin include: 532 nm, 694 nm, 755 nm, 810 nm, and 1064 nm. These

wavelengths are effective for treatment of pigmented lesions when used as long-pulse lasers and are even more effective when used as QS lasers (QS 532 nm, QS 694 nm, QS 755 nm, QS 1064 nm). Some wavelengths are well absorbed by both melanin and oxyhemoglobin such as 532 nm and IPL (500–1200 nm). They are commonly used to treat both pigmented and red vascular lesions. Skin resurfacing lasers that target water, while commonly used for wrinkle reduction, can also be used to remove pigmented lesions in a nonspecific manner. Ablative lasers remove pigmented lesions through vaporizing melanin in epidermal tissue. Nonablative fractional lasers remove pigmented lesions through extruding melanin from MTZs along with other epidermal and dermal necrotic debris. Treatment of pigmented lesions is discussed in Chapter 2.

Hair Removal

Lasers used for hair removal target melanin, which damages follicular structures necessary for hair growth. Wavelengths that penetrate deeply into the skin and do not target red vascular chromophores are used for laser hair removal; they include: 755 nm, 810 nm, 1064 nm, and IPLs with filters that remove short wavelengths. Epidermal melanin serves as a competing chromophore for short wavelengths and use of cooling methods and short wavelength cutoff filters with IPLs is important to prevent epidermal thermal injury. The 1064 nm laser has poor epidermal melanin absorption and is safe for hair removal in dark skin types such as Fitzpatrick type VI. Laser hair removal is reviewed in Chapter 1.

Vascular Lesions

Lasers used for red vascular lesions such as telangiectasias, erythema, and cherry angiomas target oxyhemoglobin. These lasers include: 532 nm, pulsed-dye lasers (585 nm, 590 nm, 595 nm, 600 nm), and IPL (500–1200 nm). Epidermal melanin is a competing chromophore for these wavelengths; therefore, lasers used for treatment of red vascular lesions typically employ a method for epidermal cooling to protect the epidermis from thermal injury. Blue vascular lesions such as reticular leg veins contain deoxyhemoglobin and are more effectively treated with wavelengths that are well absorbed by deoxyhemoglobin and penetrate deeply such as 755 and 1064 nm. Blue vascular lesions are not typically part of photoaging presentations and are excluded from the discussions in this book, which focus on rejuvenation of photoaged skin. Treatment of red vascular lesions is discussed in Chapter 3.

Tattoo Removal

Lasers used for tattoo removal target exogenous ink chromophores. These treatments are performed with Q-switched (nanosecond) and mode-locking (picosecond) lasers that emit rapid, high-energy pulses with very short pulse widths. These lasers operate under the principles of selective photothermolysis and photoacoustic vibration. Wavelengths used for treatment of tattoos include: QS 1064 nm, QS 755 nm, QS 694 nm, QS 650 nm, QS 585 nm, QS 532 nm, picosecond 532 nm and picosecond 755 nm. Laser tattoo removal is discussed in the Very Short Pulse Lasers section and in Chapter 4.

Laser Maintenance

The output of a laser may vary slightly over time and with extended use. Periodic servicing and annual maintenance can help ensure consistent performance. After servicing, it is advisable to use caution with initial treatments and pay close attention to clinical endpoints as lasers may have higher outputs than anticipated. For example, a patient's tattoo treated using a QS 1064 nm laser with a spot size of 6 mm and fluence of 3.5 J/cm^2 before servicing may require lower settings such as 1064 nm with a 6 mm and lower fluence of 3.0 J/cm^2 after servicing to achieve desireable clinical endpoints.

Laser Safety

The **American National Standards Institute (ANSI)** laser safety requirements have established guidelines to assist with safety for both patients and providers. Specific manufacturer guidelines for safety and maintenance for the device used should also be followed. Written **laser safety policies and procedures** are established in practices using lasers, and a Laser Safety Officer designated who is responsible for ensuring proper maintenance and functioning of laser equipment and adherence to standards for laser operation. It is advisable to perform a **laser safety check list** prior to treatment, which includes covering reflective surfaces such as mirrors and windows in the treatment room, posting laser warning signs outside the treatment room, providing patients and providers with wavelength-specific eyewear to protect from ocular injury, and stowing the foot pedal out of the way when the laser is not in use. All lasers are equipped with an emergency shut-off button that may be depressed if the device needs to be rapidly turned off (Fig. 10). For example, if someone unintentionally walks into a treatment room without eye protection.

Ocular safety is paramount with laser treatments. Lasers produce high-intensity beams that can travel long distances and reflect off surfaces without loss of intensity, unlike IPLs, which lose intensity over distance. Due to the beam characteristics, IPLs are more ocular safe than lasers. Both lasers and IPLs can cause ocular injury and require protective eyewear for the provider operating the device, patient, and all people in the treatment room. Protective eyewear indicates the wavelengths protected against and the optical density (OD) of the lens. An OD of at least 4 for the wavelength being used is recommended for adequate eye protection. Provider goggles with clear, light-colored lenses (with appropriate OD for the wavelength used) offer the best visualization. Goggles should fit snugly to the face without big gaps, particularly if glasses are worn underneath. When working on a patient's face, extraocular lead eye shields, either goggles or adhesive pads, are used for the patient. When working on the eyelids, intraocular lead eye shields are used. Figure 11 shows a variety of protective eyewear used for laser and IPL treatments. Even with protective eyewear, the operator should never look directly into the laser tip while the laser is connected to a power source. There are reported cases of experienced laser operators doing so using 1064 nm lasers with resultant permanent visual field deficits. **Plumes** of aerosolized tissue are created with ablative lasers, and tattoo lasers may **splatter blood or tissue,** which poses risks of airborne and contact exposure to bacteria and viruses. Use of a smoke evacuator and mask is necessary with ablative lasers. Distance guide cones fitted to the tip of tattoo lasers may reduce exposure to tissue debris (Fig. 10). Lasers

present a **fire hazard** and a fire extinguisher should be readily available. Use of flammable products such as alcohol is avoided immediately prior to pulsing the laser.

FIGURE 10 Laser parts (RevLite™, Courtesy of Cynosure/ConBio).

FIGURE 11 Protective eye wear used for laser or IPL treatments including provider goggles, small lead goggles and adhesive lead eye shields for patients. (Courtesy of R. Small, MD.)

Aesthetic Consultation

Aesthetic consultation is an important part of successfully performing laser treatments. In addition to identifying the patients' concerns and clarifying their specific goals, consultation provides the physician with the opportunity to establish realistic expectations for treatment results and discuss possible complications.

The patient's **medical history** is reviewed including: medications, allergies, past medical history, contraindications to treatment (see General Laser Contraindications section below), pigmentary changes (either hormonally induced or postinflammatory), and history of herpes in the treatment area. Cosmetic history is also reviewed including: previous aesthetic procedures and surgeries (modality, frequency, date of treatments, response, satisfaction with results, and complications). Identifying activities that can interfere with treatments is important such as routine sun exposure and water-related activities (e.g., surfing, swimming). An example of an aesthetic intake form that may be used is shown in Appendix 1.

A focused **physical examination** is performed and the main areas of concern determined. It is recommended that the provider and patient simultaneously examine the

desired treatment areas using a handheld mirror. Lesions indicated for treatment are identified such as lentigines, freckles, erythema, and telangiectasias as well as lesions suspicious for skin cancers, and it is documented in the chart. Lesions suspicious for melanoma or other skin cancer are biopsied or referred, and benign results confirmed prior to proceeding with laser treatments. Pigmented lesions suspicious for melanoma can be screened using the "ABCDE" criteria: asymmetry, borders are irregular, color is variegated, diameter is greater than 6 mm, evolving with new characteristics such as enlargement, bleeding, or is elevated. Note that basal cell carcinomas can also be pigmented. Patients considering aesthetic treatments are advised to avoid direct sun exposure and use a broad-spectrum sunscreen with sun protection factor (SPF) 30 containing zinc oxide or titanium dioxide daily prior to and throughout the course of treatment. Baseline assessments of the patient's skin type (Fitzpatrick Skin Type) and severity of photoaging (Glogau Classification of Photoaging) are also typically performed at the time of consultation (see respective sections below).

Early on in the consultation process, it is advisable to assess whether patients will derive adequate benefit from minimally invasive treatments or require surgical intervention. Patients presenting with severe wrinkles and excessive skin laxity may not have significant improvements from minimally invasive treatments and may be better served by surgery. For patients who are candidates for minimally invasive procedures, treatment options and recommendations are reviewed including the expected degree of improvement and anticipated number of treatments. It is important to note that treatment outcomes vary from person to person and a specific percentage of improvement cannot be guaranteed for a given patient. Using terms such as "significantly improve" rather than "remove" can help set realistic expectations. Meeting or exceeding patients' expectations contributes to patient satisfaction. Patients with unrealistic expectations or body dysmorphic disorder may have a history of repeated dissatisfaction with prior aesthetic treatments and these are contraindications for aesthetic procedures. An individualized aesthetic treatment plan is created and recorded in the chart. The risks of complications, recovery time, and costs for the proposed procedures are discussed. The informed consent process is followed for each procedure with inclusion of a signed consent form in the chart (see Informed Consent section below). Photographic documentation of conditions and lesions indicated for treatment and results are recommended (see Photodocumentation section below).

Fitzpatrick Skin Type

Fitzpatrick skin type classification is used to describe background skin coloration and the skin's response to sun exposure (Table 4). In general, individuals with more melanin in their skin have a darker baseline skin color, are more resistant to sunburn, and are classified as a high Fitzpatrick skin type. Skin types I–III are Caucasian, IV–V have olive or light brown skin tones such as people of Mediterranean, Asian, and Latin descent, and VI are black, typically of African-American descent. Fitzpatrick skin type may grossly predict complication risks with treatments and can be used as a guide to selecting the type of aesthetic treatment most appropriate for a patient and the aggressiveness of that treatment. For example, patients with light Fitzpatrick skin types (I–III) have low risks of pigmentary

changes and can generally tolerate aggressive treatments. Patients with dark Fitzpatrick skin types (IV–VI) have greater risks of pigmentary changes, such as hyperpigmentation and hypopigmentation, and require more conservative treatments to minimize the likelihood of these complications. An example of a form that may be used to determine Fitzpatrick skin type is provided in Appendix 2.

TABLE 4

Fitzpatrick Skin Types

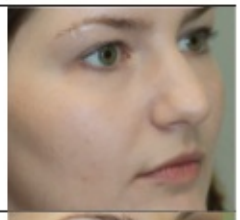
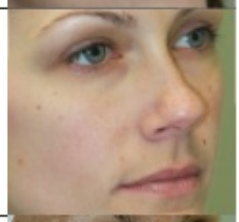
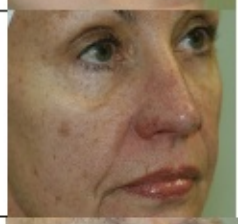
Fitzpatrick Skin Type	Skin Color	Reaction to Sun	
I	Very white or freckled	Always burns	
II	White	Usually burns	
III	White to olive	Sometimes burns	
IV	Brown	Rarely burns	
V	Dark brown	Very rarely burns	
VI	Black	Never burns	

Glogau Classification of Photoaging

Glogau classification is used to assess the severity of photoaging (Table 5), especially with regard to wrinkles. It is a baseline measure performed at the time of aesthetic consultation and may also be used to grossly guide treatment selection and the aggressiveness of treatment. Glogau types I–III have less severe wrinkling and tend to show the most noticeable improvements with aesthetic treatments such as botulinum toxin and dermal filler injections, nonablative lasers, superficial and fractional ablative lasers, and superficial skin resurfacing procedures such as light chemical peels and microdermabrasion. Glogau type IV patients have severe photoaging and often require deep ablative laser treatments and/or surgery for significant skin rejuvenation.

TABLE 5

Glogau Classification of Photoaging

Glogau Type	Photoaging	Typical Age	Skin Characteristics	
I	Mild	20s to 30s	Minimal wrinkles No lentigines No keratoses	
II	Moderate	30s to 40s	Wrinkles in motion Rare, faint lentigines Skin pores more prominent Keratosis palpable but not visible	
III	Advanced	50s to 60s	Wrinkles at rest Prominent lentigines Telangiectasias Visible keratosis	
IV	Severe	60s and older	Wrinkles throughout Numerous lentigines Elastosis, coarse pores Yellowish skin color Skin malignancies and premalignant lesions	

Informed Consent

Patients seeking elective aesthetic treatments typically have high expectations for results and low tolerance for side effects. All aspects of the informed consent process are covered prior to performing procedures, and this consist of: (i) discussing the risks, benefits (with emphasis on realistic expectations), alternatives, and complications of the procedure; (ii) providing adequate opportunity for all questions to be asked and answered; (iii) educating the patient about the nature of their aesthetic issue and procedure details; (iv) signing the consent form; and (v) documenting the informed consent process in the chart. Examples of consent forms for the laser procedures in this book are shown in Appendix 4.

Photodocumentation

Photographs that are used to document clinical findings and incorporated into the medical record are referred to as photodocumentation. Taking photographs is recommended prior to treatment, midway through a series of treatments, and posttreatment. Consent for photographs is typically included in the procedure consent form and obtained prior to taking photographs. Consistent lighting and positioning is important, particularly with wrinkle reduction treatments as results can be subtle and challenging to capture photographically. Patients are usually positioned for photographs fully upright looking straight ahead. Photographs are taken of the full face and zoomed in to specific treatment areas from the front, 45 and 90 degrees.

Selecting the Appropriate Laser Procedure for Photoaged Skin

Skin rejuvenation involves optimizing treatment efficacy while minimizing recovery time and procedural risks. There is no right or wrong approach to treatment of photoaged skin, and the approach taken largely depends on the devices available to the provider and balancing the patient's expectations for results with tolerance for downtime and risks. As a general rule, it is prudent to use the least aggressive and least painful laser initially such as nonablative lasers, and progress to more aggressive laser treatments such as ablative lasers when less invasive modalities will not achieve desired results.

Treatment of photoaged skin usually requires addressing multiple issues including dyschromia, vascular ectasias, skin texture and wrinkles. Providers can approach treatment of multiple issues sequentially by addressing dyschromia and vascular ectasias first and then addressing texture and wrinkles afterward. Treating in this order is advisable as improvements in texture are more apparent once dyschromia and vascularities are improved. For example, a patient presenting with photoaging might initially receive IPL treatments to address lentigines and telangiectasias and then receive nonablative skin resurfacing treatments (e.g., fractional 1550 nm) for wrinkle reduction. Another approach is to use a more aggressive laser that addresses multiple aspects of photoaging at once such as fractional ablative skin resurfacing. These lasers can treat pigmented lesions and wrinkles simultaneously but require more downtime and have more risks than nonablative lasers. Assuming a variety of laser devices are on-hand for treatment, the approach used is often determined by patient preference. Some patients prefer a less aggressive approach with a greater number of treatments, others, particularly those with advanced photoaging changes, desire the more aggressive approach.

Laser Treatments in Patients with Dark Background Skin

Dark background skin color is associated with increased epidermal melanin concentration. Dark Fitzpatrick skin types (IV–VI) have dark background skin color as they inherently have higher epidermal melanin content. Light skin types (I–III) have lower epidermal melanin. However, light skin types can develop darkened background skin color as a result of UV exposure and formation of diffuse dyschromia (i.e. tanned skin, actinic bronzing, extensive lentigines). Epidermal melanin serves as a competing chromophore with cutaneous lesions for laser absorption during treatment, and can reduce treatment efficacy and increase risks of epidermal thermal injury. Complications such as postinflammatory hyperpigmentation, hypopigmentation, and burns are more likely to occur in patients with dark background skin color. Treatments in patients with dark background skin are performed using conservative laser parameters: long wavelengths (the safest of which is 1064 nm), long pulse widths, large spot sizes, and low fluences. These parameters allow for deep cutaneous penetration that decreases absorption by epidermal melanin, reducing the risk of complications.

Alternative Therapies

Other aesthetic procedures that treat facial lines and wrinkles include: botulinum toxin for dynamic wrinkles, nonlaser skin resurfacing procedures such as microdermabrasion and dermabrasion (rarely used today due to risks of pigmentary changes and scarring), and chemical peels for treatment of static wrinkles. Dermal fillers are also used for static wrinkles and to improve facial contours. For severe wrinkling with redundant lax skin, surgery is an option. Pigmented lesions can be treated with liquid nitrogen and topical skin care products. Red vascularities can be treated with electrocautery (though not recommended due to scarring risks). Hair can be permanently removed with electrolysis, and tattoos can be minimized with topical caustic agents (also not recommended due to risks of scarring). Further discussion of alternative therapies to particular laser treatments are discussed in each chapter.

Advantages of Laser Treatment

- Lesion specificity
- Short treatment times
- High efficacy when appropriate device is selected

Disadvantages of Laser Treatment

- Expensive relative to most other procedures (except surgery)
- Risks of cutaneous thermal injury
- Risks of ocular injury
- Typically require multiple treatments, and if not, then singular aggressive treatments are associated with procedural discomfort, have longer recovery times and higher risks of complications

General Laser Contraindications

- Active infection in the treatment area (e.g., herpes simplex, pustular acne, cellulitis)
- Dermatoses in the treatment area (e.g., vitiligo, psoriasis, atopic dermatitis)
- Melanoma, or lesions suspected for melanoma in the treatment area
- Deep chemical peel, dermabrasion or radiation therapy in the treatment area within the preceding 6 months
- Keloidal scarring*
- Impaired healing (e.g., immunosuppressive medications, collagen vascular diseases such as scleroderma, poorly controlled diabetes mellitus)
- Peripheral vascular disease
- Bleeding abnormality (e.g., thrombocytopenia, anticoagulant use)
- Seizure disorder
- Uncontrolled systemic condition
- Cardiac pacemaker
- Skin atrophy (e.g., chronic oral steroid use, genetic syndromes such as Ehlers–Danlos

syndrome)
- Livedo reticularis, a vascular disease associated with mottled skin discoloration of the arms or legs exacerbated by heat exposure
- Erythema ab igne, a rare acquired reticular erythematous or pigmented rash exacerbated by heat exposure
- Direct sun exposure or tanning bed use within the preceding 2 weeks resulting in reddened or sunburned skin
- Tanned skin
- Self-tanning product within the preceding 2 weeks
- Topical prescription retinoid within the preceding week
- Isotretinoin (Accutane™) within the preceding 6 months
- Gold therapy (e.g., used for treatment of arthritis)
- Photosensitizing medications (e.g., tetracyclines, St. John's wort, thiazides)
- Photosensitive disorder (e.g., systemic lupus erythematosus, polymorphous light eruption)
- Pregnant or nursing
- Unrealistic patient expectations
- Body dysmorphic disorder
- Treatment inside the eye orbit (i.e., without intraocular eye shields)

Certain dermatoses such as **vitiligo, psoriasis,** and **atopic dermatitis** can erupt at sites of trauma (referred to as koebnerization) and occurrence in the treatment area is a contraindication; the risk is greatest with lasers that cause the most trauma such as ablative skin resurfacing and tattoo removal lasers. **Oral retinoids** (isotretinoin) within the prior 6–12 months are associated with increased risks of scarring and poor healing due to impaired sebaceous gland function. Although these risks are clearly associated with ablative laser treatments, some recent studies show no adverse effects in patients undergoing nonablative laser treatments while using oral retinoids. Other conditions may also impair healing such as **collagen vascular diseases, poorly controlled diabetes mellitus,** and use of **immunosuppressive drugs** as well as prior procedures that reduce adnexal structures in the treatment area such as **deep chemical peels, dermabrasion, radiation therapy,** and **extensive electrolysis**. Patients with poorly controlled diabetes and those using immunosuppressive medications are also at increased risk of infection. **Tanned skin** has increased risks of hyperpigmentation, hypopigmentation, and burns. Laser treatment (particularly with QS lasers) is contraindicated in patients with a history of taking **gold therapy** due to the risk of inducing permanent dark blue dyspigmentation known as chrysiasis. Additional treatment-specific contraindications are listed in individual chapters.

Indications

The chapters in this book are organized by treatment indication: hair removal, pigmented lesions, vascular lesions, tattoo removal, nonablative skin resurfacing for wrinkle reduction, and ablative skin resurfacing for wrinkle reduction. Individual lasers typically have multiple applications. Each chapter has a section on Devices Currently Available where the devices used for the chapter's indication and other common applications for those devices are discussed.

Preprocedure Checklist

- Aesthetic consultation
- Fitzpatrick skin type
- Examination of treatment area
- Informed consent
- Pretreatment photographs
- Sun protection
- Antiviral and other pretreatment medications

A preprocedure checklist is performed prior to treatment to help ensure safety and maximize results, and each chapter includes a checklist specific to that procedure. Ablative laser treatments require more advanced preprocedure planning and the preprocedure checklist is usually started 4–6 weeks prior to treatment. The checklist for laser hair removal treatments is begun 4 weeks prior to treatment to ensure patients discontinue certain methods of hair removal. The checklist for other laser treatments can be performed on the day of treatment.

Prophylactic antiviral medications may be given for a history of herpes in or near the treatment area 2 days prior to the procedure and continued for 3 days postprocedure (e.g., valacyclovir/famciclovir 500 mg 1 tablet twice daily). If there is a remote history and the patient is low risk, an antiviral medication may instead be started on the day of treatment and continued for 5 days. Some patients require other oral or topical medications such as analgesics prior to treatment and pretreatment medications commonly used for specific procedures are discussed in each chapter.

Preprocedure Skin Care Products for Laser Treatments

- **Sunscreen.** All patients are started on a daily broad-spectrum sunscreen with an SPF of at least 30 containing zinc oxide or titanium dioxide at the time of consultation. SPF values greater than 30 do not correlate with significantly increased protection from the sun. Broad-spectrum sunscreens protect from both UVA and UVB rays.
- **Skin lightening product.** Patients prone to hyperpigmentation and dark Fitzpatrick skin types (IV–VI) can use a topical lightening agent such as hydroquinone cream 2–8%, as it may reduce the risk of postinflammatory hyperpigmentation (PIH) with laser procedures. Cosmeceutical hydroquinone alternatives include kojic acid, arbutin, niacinamide, and azelaic acid. Ideally, a lightening product is begun 1 month prior to procedure.
- **Discontinuation of active products.** If patients are using active products such as retinoids (e.g., tretinoin) and hydroxy acids (e.g., glycolic acid), it is advisable to discontinue use 1–2 weeks prior to laser procedures to ensure the epidermis is intact at the time of treatment and reduce skin sensitivity.

Preprocedure patient instructions for each procedure are provided in Appendix 3.

Anesthesia for Laser Procedures

Providing adequate anesthesia for laser procedures reduces anxiety, offers the patient a more tolerable experience and can facilitate greater treatment precision and optimal technique to improve outcomes. The most common anesthetic modalities used with cosmetic laser procedures are epidermal cooling and topical anesthetics. The anesthetic modality chosen is dependent on the discomfort level associated with the procedure, procedure duration, and patient tolerance for pain. Anesthesia for less painful procedures, such as laser hair removal, can usually be accomplished with contact cooling using ice and/or topical anesthetic. More painful procedures such as ablative laser resurfacing often require a combination of modalities such as topical anesthetic, oral analgesic, and forced air cooling (Table 6).

TABLE 6

Anesthesia for Laser Treatments

Laser Treatment	Topical Anesthetics	Contact Cooling	Forced Air Cooling	Anxiolytic and Analgesic Medications	Injectable Anesthetics
Hair removal	X	X		X	
Pigmented lesions	X	X			
Vascular lesions				X	
Tattoo removal	X			X	Local
Fractional nonablative resurfacing	X		X	X	
Ablative resurfacing	X		X	X	Regional

Epidermal Cooling

Epidermal cooling is a commonly used method for achieving anesthesia with laser treatments. In addition to reducing discomfort, it also improves safety by protecting the epidermis from thermal injury. Epidermal cooling can be achieved by directly applying ice, a chilled roller, or a cool laser tip to the skin, referred to as contact cooling (Fig. 12). Many lasers have built-in **contact cooling** mechanisms that maintain the laser tip at a constant safe temperature during pulsing. Built-in cooling methods can be synchronized with the laser pulse or released a few milliseconds before or after the pulse. IPLs, for example, have integrated contact cooling typically consisting of a chilled sapphire window in the treatment tip that provides epidermal cooling through continuous contact with the skin during treatment. Other cooling methods include cryogen spray and forced air cooling. **Cryogen sprays** are released immediately before and/or after laser pulses and are an integrated component of the laser handpiece. Sprays are a consumable requiring replacement fairly often. **Forced air cooling** involves directing air through a hose that is aimed at the treatment area. Forced air cooling is provided by stand-alone devices (e.g., ArTek Air™ and Zimmer Cryo 6™). This noncontact method of cooling is particularly useful with ablative laser treatments.

Adequate epidermal cooling with any method is indicated by skin erythema or brief

blanching. Excessive cooling is indicated by prolonged blanching of the skin and can reduce treatment efficacy and cause epidermal injury. Dark skin types (IV–VI) have a greater risk of pigmentary changes such as hyperpigmentation and hypopigmentation due to cold injury. Cooling may be used alone or adjunctively with most other anesthetic modalities for laser treatments.

FIGURE 12 Ice packs and chilled roller.

Topical Anesthetics

Topical anesthetics are often used for laser procedures due to their effectiveness and ease of application. Commonly used topical anesthetic products include: L.M.X. (lidocaine 4–5%) available over the counter, EMLA (lidocaine 2.5%:prilocaine 2.5%) available by prescription, and lidocaine 30% and BLT (benzocaine 20%:lidocaine 6%:tetracaine 4%), which require compounding by a pharmacy.

The skin is degreased with alcohol prior to application, the product rubbed gently onto the treatment area, and then occluded with plastic wrap. The degree of anesthesia achieved with a topical anesthetic is related to the strength of the product and the duration and method of application. For less painful procedures, such as laser hair removal, an application of BLT for 15 minutes is adequate for most patients. More painful procedures, such as tattoo removal and ablative resurfacing, require an application of BLT for 45 minutes under occlusion. Due to the time required for topical anesthetics to take effect, procedure times are significantly increased.

Toxicity of topical anesthetics is related to systemic absorption of the product. Several factors affect systemic absorption including surface area covered, duration of application, and the presence of an intact skin barrier. Most topical anesthetics are safe with proper use as the systemic blood levels reached are usually only a small fraction of the toxicity level. For example, 60 gm of EMLA cream placed on a 400 cm^2 area (equivalent to half a back) for 4 hours produces peak blood levels of lidocaine that are 1/20th the systemic toxic level of lidocaine and 1/36th the toxic level of prilocaine. Cases where topical anesthetic use has resulted in toxicity are associated with patient self-application of large quantities to large surface areas (e.g., full legs) or with procedures that disrupt the skin barrier such as fractional laser resurfacing. Signs and symptoms of systemic lidocaine toxicity range from

mild dizziness to respiratory depression, hypotension, seizure, and death. To minimize the risk of systemic toxicity application to areas no greater than 400 cm^2 for most topical anesthetics is recommended at each treatment. It is also advisable to apply higher strength topical anesthetics such as BLT in the office under supervision.

Methemoglobinemia has been reported with anesthetics, primarily topical prilocaine and benzocaine. Metabolites of these medications can increase methemoglobin in the blood, which creates a functional anemia resulting in impaired oxygen carrying capacity of blood. Patients present with shortness of breath, cyanosis, mental status changes, headache, fatigue, dizziness, loss of consciousness, and with severe methemoglobinemia may exhibit seizures, coma, and death. They usually have low oxygen saturation as measured by pulse oximetry, and normal oxygen saturation calculated from arterial blood gas analysis. Blood with methemoglobinemia appears chocolate-brown in color and does not change color with the addition of oxygen. Methemoglobinemia is treated with supplemental oxygen and methylene blue 1% solution (10 mg/mL) 1–2 mg/kg administered intravenously slowly over 5 minutes. Methylene blue converts iron in hemoglobin to its normal state and restores the blood's oxygen carrying capacity.

Injectable Anesthetics

Injectable anesthetics are rarely used for aesthetic laser treatments. Local infiltration may be used with laser tattoo removal treatments for patients intolerant of treatment using topical anesthetics and oral analgesics. Occasionally, a perioral regional nerve block may be necessary for ablative laser treatments. The most commonly used injectable anesthetic preparation for laser procedures is 1–2% lidocaine (10 mg/mL) with 1:100000 of epinephrine. This has a rapid onset of anesthesia within a few minutes and wears off within a few hours. Epinephrine is associated with vasoconstriction, which keeps the lidocaine in the area where it was injected, thereby decreasing systemic absorption and toxicity. Lidocaine may be buffered with sodium bicarbonate in a 1:8 or 1:10 ratio to reduce the burning sensation upon injection. When performing local infiltration, care should be taken to inject the smallest possible anesthetic volumes necessary to minimize the risk of lidocaine toxicity.

Maximal safe doses of 2% lidocaine with and without epinephrine are listed below. Above these doses there is an increased risk of neurotoxicity and seizures.

Lidocaine Solution	Maximum Adult Dose by Body Weight (mg/kg)	Maximum Injection Volume for 140 lb Adult (mL)
2% lidocaine without epinephrine	4	13
2% lidocaine with epinephrine	7	22

Anxiolytic and Analgesic Medications

Anxiolytic and analgesic medications may be required by a small number of patients who are intolerant of laser procedures using other anesthetic modalities. These medications are typically administered in-office 1 hour prior to the procedure. Patients taking anxiolytics or opioids such as hydrocodone require a driver to take them home after their procedure. Common in-office anxiolytic and analgesic medications include the following:

Anxiolytic

• Diazepam (Valium®) 5–10 mg orally

Analgesics

• Tramadol (Ultram®) 50–100 mg orally
• Ketorolac (Toradol®)10–20 mg orally or 30–60 mg IM
• Hydrocodone with acetaminophen (Vicodin® 5/500) 1–2 tablets orally

Pneumatic Skin Flattening

Pneumatic skin flattening devices utilize negative pressure to elevate and flatten skin against the laser window, which reduces pain. The mechanism of action of these devices is based on the gate theory of pain, whereby the pressure generated by pneumatic flattening inhibits pain sensation by overwhelming and blocking the pain pathways. Pneumatic skin flattening has been used to provide anesthesia with hair removal, and it may also increase treatment efficacy by bringing the hair bulb closer to the skin surface. Some laser devices have pneumatic skin flattening incorporated into the laser and others have a separate external device that attaches to the treatment tip.

Laser Procedure

Procedural recommendations are provided in each chapter and include: guidelines for selecting initial laser parameters, technique recommendations, desirable and undesirable clinical endpoints, aftercare, treatment intervals, parameter modifications for subsequent treatments, follow-up issues, and complications and their management. While the general principles discussed apply to most lasers used for a particular indication, it is advisable to follow manufacturer recommendations for the specific device used at the time of treatment.

Aggressive Versus Conservative Laser Parameters

Laser parameters used for treatments are often described as aggressive or conservative. **Aggressive** laser parameters refer to the use of short wavelengths, short pulse widths, small spot sizes, and high fluences. **Conservative** laser parameters refer to the use of long wavelengths, long pulse widths, large spot sizes, and low fluences (Fig. 3, Key References).

Selecting Initial Laser Parameters for Treatment

Laser parameters of wavelength, fluence, pulse width, spot size, and repetition rate can be selected at the time of treatment. **Patient characteristics** and **lesion characteristics** are both considered when selecting laser parameters for treatment and each chapter discusses how these factors are taken into consideration.

Patient Characteristics

• **Fitzpatrick skin type.** Patients with dark Fitzpatrick skin types (IV–VI) have high

epidermal melanin. These patients have greater risks of epidermal injury and associated complications of hyperpigmentation, hypopigmentation, and burns. It is advisable to use conservative laser parameters of long wavelengths, long pulse widths, large spot sizes, and low fluences when treating these patients (Fig. 3, Key References). Patients with light Fitzpatrick skin types (I–III) can tolerate more aggressive parameters of short wavelengths, short pulse widths, small spot sizes, and high fluences.

- **Anatomic location.** Nonfacial areas such as the neck, chest, and extremities have decreased healing capacity and delayed healing, due to fewer adnexal structures. Relative to the face, these areas have a greater risk of complications such as scarring and it is advisable to use more conservative parameters when treating nonfacial areas (Fig. 3, Key References). Slow repetition rates are also used for treatment of discrete lesions to aid in precise laser pulsing; fast repetition rates are used for confluent treatment of large areas.
- **Treatment area contour.** The contour of the treatment area often determines the repetition rate selected. Flat areas such as the chest and back can be treated with fast repetition rates, which shorten treatment times. Contoured areas such as the face usually require slow rates to help ensure careful placement and complete contact between the skin and laser tip.

Lesion Characteristics

- **Target lesion chromophore.** Treatment areas that contain a lot of target chromophore such as high density of lesions (e.g., numerous lentigines) or intensely colored lesions (e.g., dark brown lentigines) require conservative parameters. Treatment areas that contain less target chromophore such as low density of lesions (e.g., sparse lentigines) or faintly colored lesions (e.g., light brown lentigines) require more aggressive parameters (Fig. 3, Key References).
- **Other chromophores.** In addition to the lesions targeted, the treatment area is assessed for the presence of other chromophores that are targets for the wavelength being used. Photodamaged skin often has both vascular and pigmented lesions, particularly on the face and chest. Treatment areas may also have dark hair present, which is a chromophore for many wavelengths used to treat photoaging. These lesions often overlie one another and lasers cannot discriminate between desirable targets or otherwise. Therefore, conservative treatment parameters are used when multiple chromophore targets are present. For example, if a patient presents for treatment of sparse, faintly colored lentigines but these lesions overlie intense erythema, then based on having a lot of target, conservative laser parameters are used. Similarly, if a patient presents for treatment of lentigines that overlie dark hair, conservative parameters are used.

General Treatment Technique

- The provider is comfortably positioned (usually seated) at the head of the treatment table (Fig. 13). It is helpful to tuck elbows into the body at 90 degrees to alleviate upper back strain and repetitive motion injury.
- Snugly fitted laser-safe eye protection that corresponds to the wavelengths used (with an OD greater than or equal to 4) is worn by the provider, patient, and all people in the treatment room. When working on the face, patient contact lenses are removed and