Laser in Dermatology

Laser Hair Removal

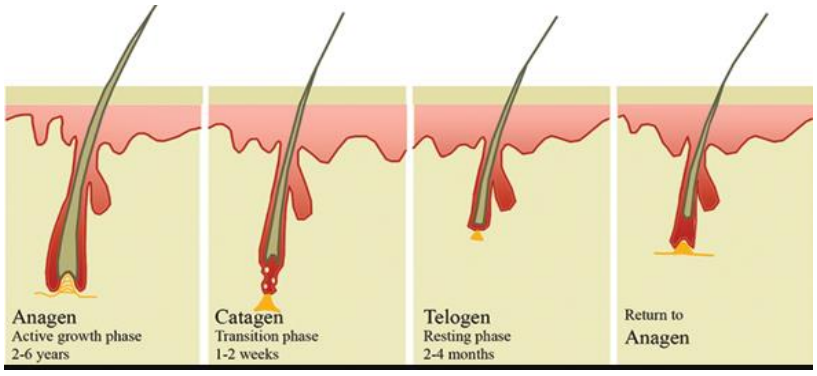
Laser hair removal is the process of removing unwanted hair by means of exposure to pulses of laser light that destroy the hair follicle. It had been performed experimentally for about twenty years before becoming commercially available in the mid-1990s. The efficacy of laser hair removal is now generally accepted in the dermatology community. Laser hair removal is one of the most commonly done cosmetic procedures. It beams highly concentrated light into hair follicles, pigment in the follicles absorb the light that destroys the hair.

A **hair follicle** is a mammalian skin organ that produces hair. Hair production occurs in phases, including growth (anagen), cessation (catagen), and rest (telogen) phases. Stem cells are responsible for hair production.

Hair-follicle cycling

Hair grows in cycles of various phases: anagen is the growth phase; catagen is the involuting or regressing phase; and telogen, the resting or quiescent phase.

- anagen phase, 2–6 years
- catagen phase, 1–2 weeks
- telogen phase, around 3 months

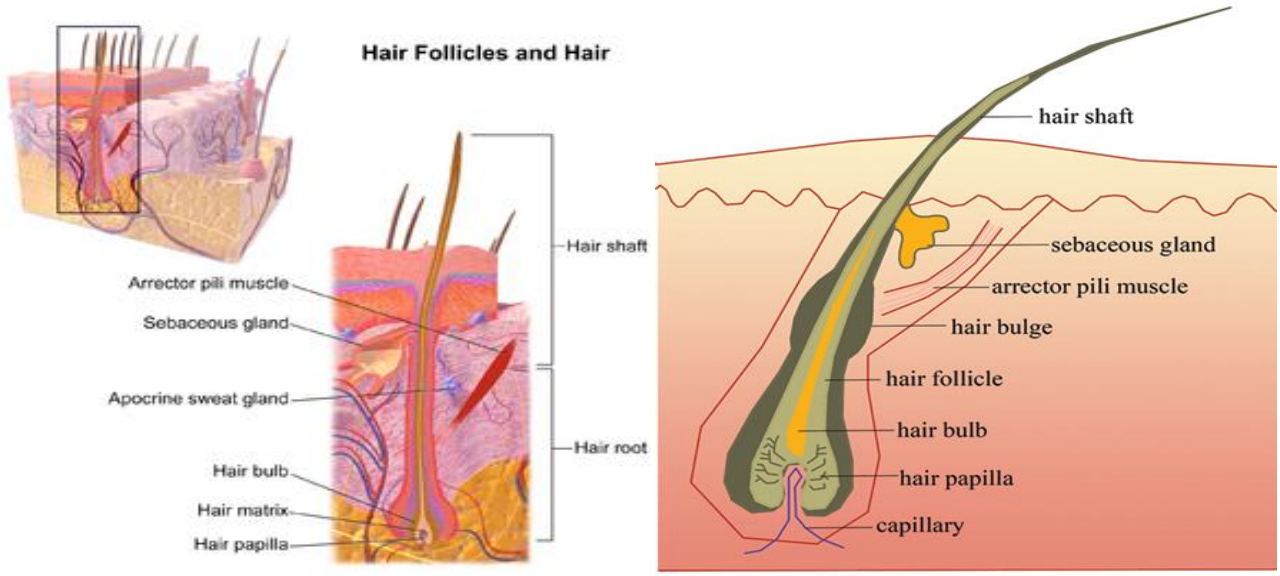


Papilla

The papilla is a large structure at the base of the hair follicle. The papilla is made up mainly of connective tissue and a capillary loop. Cell division in the papilla is either rare or non-existent.

Matrix

Around the papilla is the hair matrix, a collection of epithelial cells often interspersed with the pigment-producing cells, melanocytes. Cell division in the hair matrix produces the cells that form the major structures of the hair fiber and the inner root sheath. The hair matrix epithelium is one of the fastest growing cell populations in the human body, which is why some forms of chemotherapy or radiotherapy, that kill dividing cells, may lead to temporary hair loss. The papilla is usually ovoid or pear shaped. The matrix wraps completely around it, except for a short stalk-like connection to the surrounding connective tissue.



Bulge

The bulge is located in the outer root sheath at the insertion point of the arrector pili muscle. It houses several types of stem cells, which supply the entire hair follicle with new cells, and take part in healing the epidermis after a wound.

Mechanism of action

The primary principle behind laser hair removal is ***selective photothermolysis*** (SPTL), the matching of a specific wavelength of light and pulse duration to obtain optimal effect on a targeted tissue with minimal effect on surrounding tissue. Lasers can cause localized damage by selectively heating dark target matter, melanin, in the area that causes hair growth, the follicle, while not heating the rest of the skin. Light is absorbed by dark objects, so laser energy can be absorbed by dark material in the skin, but with much more speed and intensity.

Because of the selective absorption of photons of laser light, only black or brown hair can be removed. Laser works best with dark coarse hair. Light skin and dark hair are an ideal combination, being most effective and producing the best results, but new lasers are now able to target black hair in patients with dark skin with some success.

Many patients experience complete regrowth of hair on their treated areas in the years following their last treatment. This means that although laser treatments with these devices will permanently reduce the total number of body hairs, they will not result in a permanent removal of all hair.

Laser parameters that affect results

Several wavelengths of laser energy have been used for hair removal, from visible light to near-infrared radiation. These lasers are characterized by their wavelength, measured in nanometers (nm):

Argon: 488 nm (Turquoise/Cyan) or 514.5 nm (Green) (no longer used for hair removal).

Ruby laser: 694.3 nm (Deep Red) (only safe for patients with very pale skin).

Alexandrite: 755 nm (Near-Infrared) (safe and effective on all skin types).

Pulsed diode array: 810 nm (Near-Infrared) (for pale to medium type skin).

Nd:YAG laser: 1064 nm (Near-Infrared) (made for treating darker skin types, though effective on all skin types).

IPL or Intense pulsed light: 810 nm (Not a laser but used for hair removal) (for pale to medium type skin).

- **Pulse width** (or duration) is one of the most important considerations. The length of the heating pulse relates directly to the damage achieved in the follicle. When attempting to destroy hair follicles the light energy is absorbed by the melanin within the hair and heat is generated. The heat then conducts out towards the germ cells. As long as a sufficient temperature is maintained for the required time then these cells will be successfully destroyed. This is absolutely critical - attaining the require temperature is not sufficient unless it is kept at that temperature for the corresponding time.

- **Spot size**, or the width of the laser beam, directly affects the depth of penetration of the light energy due to scattering effects in the dermal layer. Larger beam diameters result in deeper deposition of energy and hence can induce higher temperatures in deeper follicles. Hair removal lasers have a spot size about the size of a fingertip (3-18mm).

- **Fluence** or energy density is another important consideration. Fluence is measured in joules per square centimeter (J/cm^2). It's important to get treated at high enough settings to heat up the follicles enough to disable them from producing hair.

Epidermal cooling has been determined to allow higher fluences and reduce pain and side effects, especially in darker skin. Three types of cooling have been developed:

- Contact cooling: through a window cooled by circulating water or other internal coolant. This type of cooling is by far the most efficient method of keeping the epidermis protected since it provides a constant heat sink at the skin surface.
- Cryogen spray: sprayed directly onto the skin immediately before and/or after the laser pulse
- Air cooling: forced cold air at -34 degrees C

In essence, the important output parameter when treating hair (and other skin conditions) is power density - this is a combination of energy, spot diameter and pulse duration. These three parameters determine what actually happens when the light energy is absorbed by the tissue chromophore be it melanin, haemoglobin or water, with the amount of tissue damaged being determined by the temperature/time combination.

Comparisons with other removal techniques (IPL)

IPL, though technically not containing a laser, use xenon flash lamps that emit full spectrum light. IPL-based methods, are now commonly (but incorrectly) referred to as "laser hair removal". IPL systems typically output wavelengths between 400 nm and 1200 nm. Filters are applied to block shorter wavelengths, thereby only utilizing the longer, "redder" wavelengths for clinical applications. IPLs offer certain advantages over laser, principally in the pulse duration. While lasers may output trains of short pulses to simulate a longer pulse, IPL systems can generate pulse widths up to 250 ms which is useful for larger diameter targets. Some current IPL systems have proven to be more successful in the removal of hair and blood vessels than many lasers.

Benefits of Laser Hair Removal: benefits of laser hair removal include:

- **Precision.** Lasers can selectively target dark, coarse hairs while leaving the surrounding skin undamaged.
- **Speed.** Each pulse of the laser takes a fraction of a second and can treat many hairs at the same time. The laser can treat an area approximately the size of a quarter every second. Small areas such as the upper lip can be treated in less than a minute, and large areas, such as the back or legs, may take up to an hour.
- **Predictability.** Most patients have permanent hair loss after an average of three to seven sessions.

How to Prepare the patient for Laser Hair Removal session

The patient should limit plucking, waxing, and electrolysis for six weeks before treatment. That's because the laser targets the hairs' roots, which are temporarily removed by waxing or plucking. The sun exposure should be avoided for six weeks before and after treatment. Sun exposure makes laser hair removal less effective and makes complications after treatment more likely.

Number of sessions

Hair grows in several phases (anagen, telogen, catagen) and a laser can only affect the currently active growing hair follicles (early anagen). Hence, several sessions are needed to kill hair in all phases of growth.

Multiple treatments depending on the type of hair and skin color have been shown to provide long-term reduction of hair. Most patients need a minimum of seven treatments. Current parameters differ from device to device but manufacturers and clinicians generally recommend waiting from three to eight weeks between sessions, depending on the area being treated. The number of sessions depends on various parameters, including the area of the body being treated, skin color, coarseness of hair, reason for hirsutism, and sex. Coarse dark hair on light skin is easiest to treat. Certain areas (notably men's faces) may require considerably more treatments to achieve desired results.

Laser does not work well on light-colored hair, red hair, grey hair, white hair, as well as fine hair of any color. For darker skin patients with black hair, the long-pulsed Nd:YAG laser with a cooling tip can be safe and effective when used by an experienced practitioner.

Typically the shedding of the treated hairs takes about two to three weeks. These hairs should be allowed to fall out on their own and should not be manipulated by the patient for certain reasons, chiefly to avoid infections. Pulling hairs after a session can be more painful as well as counteract the effects of the treatment.

Side effects and risks

Some normal side effects may occur after laser hair removal treatments, including itching, pink skin, redness, and swelling around the treatment area or swelling of the follicles (follicular edema). These side effects rarely last more than two or three days. The two most common serious side effects are acne and skin discoloration.

Unwanted side effects such as hypo- or hyper-pigmentation or, in extreme cases, burning of the skin call for an adjustment in laser selection or settings. Risks include the chance of burning the skin or discoloration of the skin, hypopigmentation (white spots), flare of acne, swelling around the hair follicle (considered a normal reaction), scab formation, purpura, and infection. These risks can be reduced by treatment with an appropriate laser type used at appropriate settings for the individual's skin type and treatment area.

Some level of pain should also be expected during treatments. Numbing creams are available at most clinics, sometimes for an additional cost. Typically, the cream should be applied about 30 minutes before the procedure. Icing the area after the treatment helps relieve the side effects faster.