

The versatility of diode lasers in aesthetic dermatology

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Abstract

Diode lasers are one of the most used techniques among energy-based devices due to their efficacy and wide applicability in cosmetic procedures. Best known and used application is permanent hair reduction, however they are also suitable for rejuvenation, treating scars, small vessels and pigmented lesions with a favorable safety

profile. The variety of indications increases the favorable marketability of these processes and equipment. In this review article, we summarize the indications, contraindications, possible side effects, efficacy, cost effectiveness of diode laser procedures.

Introduction

Based on the statistics of the American Society of Plastic Surgeons from 2019, laser hair removal was the most popular minimally invasive procedure performed with energy-based devices (EBD) (Table I). Besides that, other laser applications, as skin resurfacing, tattoo removal, treatment of veins also represent significant procedural numbers on the list. The total number of interventions with EBD's even exceeds the number of treatments

with soft tissue fillers (1). The latter highlights the importance of the versatility of energy-based devices. Diode lasers fulfill this requirement since they offer versatile aesthetic treatment options for multiple indications. They provide effective solution for various problems in many fields of cosmetic dermatology. The most used application is permanent hair reduction, however it provides favorable cosmetic outcomes for the treatment of

pigmented lesions, keloid and hypertrophic scars or vascular malformations (2-4). Furthermore, promising results were published regarding skin rejuvenation, that makes specific devices suitable to meet common patient needs with treating skin

aging (5). Also, in the terms of European skin type distribution, it is the most optimal procedure covering the largest treatable population (Fig. 1). Thus, investing in such a device is economical because its field of application is growing.

Cosmetic minimally invasive procedures	2019
Botulinum toxin	7,697,798
Soft tissue fillers	2, 721,469
Chemical peel	1,387,607
Laser hair removal	1,055,456
Laser skin resurfacing	596,755
-Ablative	160,893
-Non-ablative	435,862
Laser tattoo removal	166,019
Laser treatment of leg varicose veins	214,800

Table 1. Statistics report show that laser hair removal is one of the most common minimally invasive treatment in the population, based on the American Society of Plastic Surgeons statistics report (1).

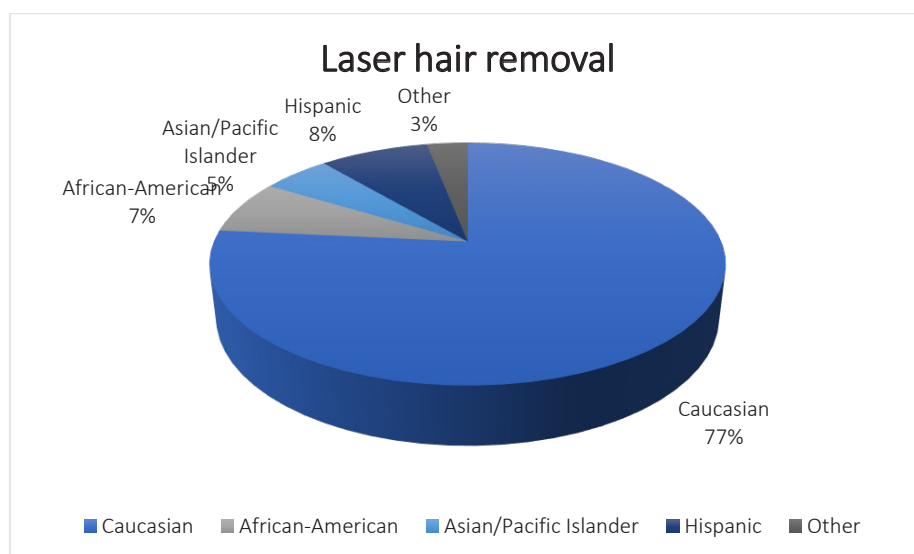


Fig. 1. Considering the ethnicity the most common group treated by laser for the purpose of hair removal is Caucasian population (1).

Basic principles of lasers

Lasers use stimulated amplified lights and transfer them to an extremely intense coherent, monochromatic, collimated electromagnetic radiation in the visible and invisible spectrum. Lasers consist of an energy source which excites the electrons, a resonant chamber which contains reflective mirrors and an active medium. Lasers are named based on the type of their active medium. The active medium can be gas - carbon dioxide, argon, helium -, or solid material, like diode lasers. Most of the cases the solid material is made of glass or crystalline material which can be doped with different ions. Diode lasers are usually made of a crystal wafer with a thin layer on the surface. Depending on the emitted ranges of light, lasers are capable to act on the tissues by photodisruption and photocoagulation. Medical lasers are widely used devices with multiple clinical applications. Practitioners can cut, coagulate, or ablate tissue due to thermal effects. Thus, they are commonly used in many fields of medicine – e.g laser-assisted in-situ keratomileusis in ophthalmology, cutting and coagulating during surgery, laparoscopy, endoscopy, and bronchoscopy. Nevertheless, one of the largest markets of laser treatments are aesthetic medicine and dermatology. The following parameters are affecting the laser - tissue interactions: wavelength, fluence, pulse duration and spot size. Wavelength is affecting the absorption of the chromophores and the penetration of the skin. Chromophores absorb light on specific wavelengths (6). Dermatological application is mainly based on the theory of selective photothermolysis (7). Selective absorption of the light in different chromophores

destroy certain specific targets in the skin (Table II). The fluence we use during the treatment is equal with the energy input. Pulse duration is defined by the thermal relaxation time of the targeted chromophore. Thermal relaxation time means the time necessary for the target to cool down 50% through the transfer of its heat to surrounding tissue via thermal diffusion. For example, the ideal range for laser hair removal is 10-40 milliseconds (ms) (8). In this way, lasers can treat various skin disorders and aesthetic problems without causing unwanted damages to the healthy skin tissues. The effect to the skin and the application in aesthetic dermatology is depending on which wavelength we use for the treatment.

Diode lasers can emit light on a variety of wavelength, most usually these devices are used between 800-900 nm (9). However, the field of the usage is getting wider by changing the diode lasers wavelength, depending on the purpose of the treatment. Different wavelengths are suitable to achieve the best results in the treatment of vascular malformations, pigmented lesions, laser hair removal and skin rejuvenation. Some manufacturers provide interchangeable headpiece to ensure that the diode laser can be used at different wavelengths. The headpiece can emit on 810, 940 and 1060 nm wavelengths with diode technology that delivers three wavelengths simultaneously for effective treatment on tanned and dark skin. This method provides a safe and effective treatment throughout the whole year. When used for hair reduction 810 nm is optimal for all types of hair (10). 940 nm has a better absorption in oxyhemoglobin, which provides

an effective method to coagulate micro vessels that feed the hair bulb. 1060 nm provides a very high penetration and low impact on epidermal

melanin, so it is a very safe for patients with more tanned or darker skin.

Laser- wavelength (nm)	Chromophore
Long-pulsed ruby 694 nm	Melanin
Long-pulsed Alexandrite 755 nm	Melanin
Diode-810 nm	Melanin
Diode-940 nm	1,055,456
Diode-980 nm	Melanin
Diode-1060 nm	Melanin
Long-pulsed Nd:YAG 1064 nm	Water
Long-pulsed Nd:YAG 1320nm	Water
Diode 1450 nm	Water

Table II. Chromophores on specific wavelengths. Based on Carroll L. et al. with modifications (10).

Different applications of diode lasers

The most widely used application of diode lasers is permanent hair reduction, that is discussed in detail in the following chapters. However, based on the literature, this technique may be advantageous

in other fields of aesthetic dermatology as well, depending on the wavelength of the diode laser that is used.

Pigmented lesions

The treatment of pigmented lesions with laser therapy is controversial. There are several studies that examine the effect of laser for pigmented lesions. There are reports of clinical, dermoscopic and histological results which shows regression of pigmented melanocytic lesions after hair

removal (11). Due to the fact that absorption in the wavelength range of diode lasers is dominated by melanin, choosing the right parameter is essential to avoid unnecessary risk (12). Moreover, it is important to consult an expert dermatologist to identify the possibly treatable lesions. It was

reported that using high-power diode laser at 755 nm can be useful to treat benign pigmented lesions especially solar lentigines (13). According to this study high power diode laser can eliminate certain aesthetically unpleasant pigmented lesions. The treatment was applied for a Caucasian woman with Fitzpatrick IV phototype. The parameters for the procedure were 755 nm wavelength, 21 ms with long pulse duration, 25 J/cm² fluence. After 10 days a complete remission of the solar lentigines was detected. It is an effective treatment option not only for solar lentigines but also for hyperpigmentation of the skin, including melasma, which may cause persistent psychosocial problems for the patient and effective treatment options are limited (2). Previously a research group investigated the effect of fractionated non-ablative diode laser treatment at 1955 nm wavelength for melasma amongst patients with darker skin type. In the research they separated a group for patients with Hidroquinon use and patients with moisturizer. After a therapy

Rejuvenation and scar treatment

High power diode laser at 1060 nm proved to be an effective rejuvenating procedure, it can reach the efficacy and safety of neodymium:yttrium-aluminum-garnet (Nd:YAG 1064 nm) solid state laser that is a commonly used rejuvenating procedure. It was reported that facial sagginess and nasolabial fold wrinkles were successfully treated in only four sessions with a high-power diode laser at 1060 nm, 10J/cm² fluence and 400ms pulse duration. As a result remarkable improvement was shown in the nasolabial fold wrinkles volume and depth analyzed by 3D measurements (5). In this setting the target chromophore is mostly water. Absorption in

session which included 4 treatment with 2 weeks pause between the sessions results were compared. There was significant improvement in hyperpigmentation after the therapy both groups. The patients in both groups had a darker skin type between Fitzpatrick III-V (14). Ephelides is an epidermal pigmented lesion which is very difficult to treat with laser therapy and its usually returns back after therapy sessions, Hidroquinon usage may be required during the treatments (15). Treating pigmented lesions is a question which must be wisely considered. Treating epidermal lesions including Ephelides, lentigines, Café au lait macules may provide satisfying results, while treating dermal pigmented lesions is a difficult and controversial question. In dermal pigmented lesions the first treatment option must be surgical excision, however there are some cases when after a detailed examination by an expert dermatologist laser removal may be considered (15).

water and heat production lead to activation of Heat shock protein 47 (Hsp47), which has an important role in collagen production and skin rejuvenation (16).

Besides rejuvenation pathological scar formation could be also treated with diode lasers. Keloid and hypertrophic scars are caused by an excessive tissue response to skin injury, which triggers fibroblast proliferation and collagen overproduction. Ablative and non-ablative laser therapy is an efficient way to treat keloid and hypertrophic scars (17, 18). Non-ablative treatment including diode laser on 980-nm targets mainly oxyhemoglobin that selectively

damages blood vessels that supply the scar tissue (19). Good results were shown in treating acne keloidalis nuchae (AKN), which is a chronic inflammation that involves hair follicles and causes scarring alopecia (20). It is usually treated with oral antibiotics, steroids or retinoids, however usually only limited success can be achieved (21). AKN is often cosmetically disfiguring and have a negative impact of life quality. In a recent report, with 4 sessions of diode laser treatment during 6 months on the affected skin area, 95% clearance was achieved and also no new lesions were observed during the treatment period (21). Also, light based therapies had a good effect on treating acne vulgaris, which is a common dermatological problem and its treatment is difficult, but for those patients who suffers from acne vulgaris, it can cause an emotional distress. Using diode laser on 1450-nm showed to be useful for treating

the underlying pathogenic factors, including excessive sebaceous gland activity, increased inflammation and bacterial colonization. Moreover, it has a significant effect for acne scarring (22, 23). Another form of scarring is the development of striae distensae (SD), which is a very common and frustrating problem amongst women. Several procedures have been developed to alleviate this stubborn condition, including ablative and non-ablative lasers. Targeting water, melanin and hemoglobin to trigger collagen and melanin production, along with decreasing vascularity may lead to cosmetic benefits (24). Diode laser was successfully used for treatment of atrophic scars and striae at 1450 nm with 4, 8 and 12 J/cm² fluence over three sessions in six-week intervals. However, it was revealed that it is not effective in the treatment of striae in patients with skin type IV, V and VI (25).

Vascular lesions

Nd:YAG (1064 nm) and Alexandrite lasers (755 nm) are recommended for treating vascular malformations. Studies even proved that long-pulsed Alexandrite laser was effective for treatment of resistant and hypertrophic port wine stains (3, 26). Based on previous studies, 1060-nm high-power diode laser can be an alternative solution for treating vascular malformations, since the 1060 nm range has a better oxyhemoglobin absorption compared to melanin absorption. Better oxyhemoglobin absorption makes the photothermolysis in microvessels more effective. Furthermore, the deeper penetration of 1060 nm compared to 755 nm results in a better effect on deeper vascular malformations. For this reason, diode lasers operating at 1060 nm wavelength may be superior to Alexandrite laser (26). Laser can be

used not only for small varicose veins but also to treat telangiectasias and reticular veins (27). Based on a clinical study, 800 nm high power diode laser is an effective method to treat patients presenting with leg vessels between 0.4 and 1 mm. The target chromophores for diode laser is oxyhemoglobin. During the sessions, oxyhemoglobin absorbs the energy of the laser, transferring heat to the vascular epithelium, and causing a denaturation of the vessel wall. At 800 nm wavelength, less energy is absorbed by the melanin, which acts as a competing chromophore, than when shorter wavelengths are used. As a result, it is possible to reduce side effects caused by interaction with the melanin in the epidermis (28). In this study it was shown that optimal treatment parameter is a fluence of 40 J/cm² at a 30 ms pulse width.

Body contouring

Body contouring has become increasingly popular and wide ranges of possibilities are available to achieve the results. It was shown that 1060 nm diode laser has high efficacy on non-invasive body contouring, using the mechanism of hyperthermic lipolysis (29, 30). This wavelength provides a safe method by achieving hyperthermic temperatures in adipose tissues. It

Laser hair removal

As the cited survey (Table I) shows hair removal is the most popular EBD procedure. Both women and men are looking for an optimal solution to remove the unwanted hair. There are many options including waxing, shaving, epilating, being treated by Intense Pulsed Light (IPL), but none of them are as effective as laser hair removal. The application of IPL technology (400-1400 nm) is still a popular choice, because of its lower expenses compared to lasers. Additionally, it has a large spot size and it can be suitable for Fitzpatrick skin types I and II (32). However, IPL treatment takes more time and it is more painful for patients and the result does not approach the efficiency of the diode laser either (33). Using lasers is not only beneficial because of its convenience for hair removal, but also because there is currently no other method on the market that is capable of permanent hair removal with such efficiency. During procedure the target chromophore is melanin in the hair shafts that absorbs light in the range of 300-1200 nm. Consequently, this range of wavelength is applicable for hair reduction. The laser energy of the diode is converted into heat and destroys the highly absorbing targets according to the principle of selective photo thermolysis (34). Also, there is

effectively targets unwanted adipocytes without making any harm to the skin and appendages. Also, it was shown, that a combined topical skin tightening concentrate with a hyperthermic laser lipolysis device may achieve improved aesthetic outcomes without any notable adverse events (31).

an extended theory about the destruction of the weakly absorbing parts, which is based on heat diffusion caused by the highly absorbing targets. The hair matrix and the stem cells in the bulge are containing high concentration of melanin. Melanin absorbs and collects the energy causing a high temperature locally which distributes to the surrounding follicular structures and destroys them. Given the damage of the follicular structure, the hair is unable to grow in the future (7). When comparing different methods, it can be seen, that there are a lot of procedures and devices on the market, that are suitable for permanent hair reduction. Although not all of them are painless, and neither of them can be as effective as laser hair removal. Ruby laser operates on 694 nm wavelength and it can be suitable for treating fair type of skin, Fitzpatrick I-III. However, it is not a good option for darker skin as it is absorbed in the surface layers, so epidermal interference can cause skin burning (35). Alexandrite laser uses 755 nm wavelength. Similar to Ruby laser, it can also be used to treat light skin types, however, it is not a safe to treat darker skin due to the melanin content of the epidermis (36). The Nd:YAG laser (1064nm) can be used up to Fitzpatrick VI, that makes it the most suitable for dark skin types.

The Diode laser on 810 nm is providing a good solution for the treatment of all Fitzpatrick skin types I, II, III, IV and V. Due to its longer wavelength, it is absorbed in the deeper layers of the skin, so it can destroy hair follicles more selectively. In terms of the ethnic composition of the European population, the use of the Diode laser is the most advantageous in terms of cost-benefit (Table II).

All the manufacturers are trying to develop devices that can reach the optimal temperature to destroy the hair follicle without affecting the skin. During laser hair removal, diode lasers can be used on different wavelengths. The longer the wavelength is, the deeper it can

penetrate to the skin. It is important to choose the correct wavelength suitable for the patient's skin pigmentation. In this way it is possible to increase the selectivity and to reduce the chance to make any damage to the skin. Using the 755 nm wavelength is optimal for individuals in Fitzpatrick categories I and II, while the 810 nm application is the safest for phototype II, III, IV. The 1060 nm range can be safely applied to phototypes IV, V and VI. Nowadays and in future all these benefits are going to be available in one device thanks to the so-called combined heads that operate simultaneously on different wavelengths (Table III, IV).

Type of laser	Wavelength	Suitable for	
RUBY LASER	694 nm	Fitzpatrick I- III	lighter skin types with dark hair
ALEXANDRITE LASER	755 nm	Fitzpatrick I- III	better penetrance than ruby laser, suitable for lighter hair
DIODE LASER	810 nm	Fitzpatrick I-V	penetrates deeper, less epidermal damage, safer in darker skin
Nd:YAG laser	1064 nm	Fitzpatrick I- VI	better penetration, less epidermal damage, less melanin absorption
Intense Pulse Light (IPL)	400-1400 nm	Fitzpatrick I-II	high intensity pulses of polychromatic, non-coherent light, less expensive than a true laser, but not as effective

Table III. *Different type of lasers and their usability.*

Using diode laser on different wavelengths		
755 nm	810 nm	1060 nm
◦ laser hair removal, better efficacy on fair skin types ◦ pigmented lesions such as lentigines	◦ laser hair removal for a wide range of skin types	◦ laser hair removal, better efficacy on darker skin types ◦ body contouring-hypertermic laser lipolysis ◦ skin rejuvenation ◦ acne treatment ◦ venous malformations: hypertrophic capillary malformations, cherry angiomas

Table III. Using diode lasers on different wavelengths.

Indications for hair reduction

The purpose of laser hair removal is to reduce the unpleasant hair in the areas such as legs, arms, armpits, around genitals, face. It is not only an aesthetic problem but for those who suffer from extreme hair growing conditions such as hormonal problems, it can seriously damage self-confidence, leading to deprivation and depression. There are certain conditions that must be met for the procedure to be successful. Laser light is absorbed in melanin chromophores, because of that it is necessary that the hair should be pigmented in the area to be treated. Not only is the pigmentation of the hair being essential,

but also the contrast between the skin and hair color. The higher the contrast, the better the efficacy of the treatment is, and the lower the risk of unwanted side effects are. Blond, white, red and gray hair cannot be treated in the absence of enough pigment. Laser hair removal can be done on all Fitzpatrick skin types; however, the most remarkable result can be achieved on skin type II and III. Effective laser treatment methods have also been developed for skin type V to VI by changing the wavelength of the laser applied for the more pigmented skin.

Contraindications of hair reduction

Diode laser procedures are safe and effective in general, but for all laser treatments there are certain medical conditions and contraindications that needs to be considered for safety. Certain

medical conditions including psoriasis, bleeding disorders, vitiligo, history of melanoma, raised naevi, suspicious lesions, wound healing problems -e.g. history of keloid, diabetes- not

recommended to treat. Having metal implants in the treated area is a contraindication as well. Also, it is contraindicated to treat patients with autoimmune diseases such as vitiligo, scleroderma and systemic lupus erythematosus (SLE), since laser treatment can lead to a flare up. In patients with history of light triggered epilepsy laser hair removal should be avoided. Furthermore, in conditions with unstable hormone levels, such as pregnancy, breastfeeding, thyroid problems and hirsutism can affect the procedure's effectiveness, because these conditions can cause an excessive hair growth. Thus, it is uncertain if that the treatment will succeed, or more sessions will be needed during the procedure. Also, if there are active infections, herpetic lesions, cold sores,

tattoos or permanent make-up, previous surgery, chemical peels or laser resurfacing in the area to be treated it is not recommended to apply the procedure. Taking medications that cause photosensitivity including certain antibiotics especially tetracycline, dapsone, fluoroquinolone, sulfonamides, quinolones acne medications such as isotretinoin, anti-inflammatory medications, steroids, chemotherapy medications also contraindicate the treatment. Treating patients who were exposed to severe sun burning should be avoided, because the skin is sensitized and also it is not allowed to treat the area if the skin color is darker than the hair wished to be removed, because it has a higher chance to burn the skin during the procedure.

Laser hair removal with diode laser on 855nm

Preparation

Before every treatment it is needed to consult with an expert physician. It is important to discuss every medical condition that can affect the treatment. Besides patients should inform the practitioner about the current medicines and health condition. Patients are instructed by the practitioner not to use any kind of body care product on the treatment area, not to use tanning bed or take any medicine which can cause photo sensibility. Permanent laser hair removal can only be effective, if the treated area is only shaved during the sessions and no other depilation method like wax, epilation, shaving

cream is used. Patients are instructed to shave the area the night before the treatment. The previous information has a key importance, because during shaving the connection between the hair and the hair follicle remains continuous. So, the laser light can be easily absorbed by both the hair's and the follicle's melanin pigment. A successful treatment requires individual settings, based on the skin type. Choosing the right laser is important to reach our aim, also it is extremely important to set the adequate fluence and pulse duration.

Procedure

First step of the treatment is to clean the area, remove make up, and contamination as much as it is possible. After the decontamination process, we should examine the area of the skin if there are

any pigmented naevi on the area or any specific dermatological problem including different skin lesions, scars and tattoos. The practitioner applies white marker or paint on the surface of

the specific lesions or tattoos, since laser light cannot target white color spots. Although if there are a lot of moles in the area, it is better to avoid treating that area for the patient's safety (Fig. 2).



Fig. 2. Treating with diode laser (810 nm). Using an ultrasound contact gel is useful for cooling the treated area.

Depending on which manufacturer's product is used for the treatment, certain devices may require the use of a contact gel. The main role of contact gel is to slide the probe easily on the surface, and on the other hand it is also used as a cooling medium during treatment. There are two methods of the treatment depending on the type of the device which we use during the sessions. The parameters are being controlled by the practitioner. The actual settings are based on the skin type, hair color, localization, and treatment numbers. Generally, we can say that on the face,

with the adequate parameters 8-10 sessions are required, the time between the sessions should be 4-6 weeks. On the other hand, if the treated area is localized to other body parts generally 6-8 session is needed, the time between the sessions should be at least 6-8 weeks. In the genital area usually more sessions are required, than on the other parts of the body. Session numbers can vary by person to person, and it is depending on which manufacturer's product we use during the treatment.

Aftercare

To avoid any unpleasant side effects after the procedure, it is important to avoid tanning bed usage for 2 weeks before and after the procedure.

Adverse effects

Although laser hair removal is generally a safe procedure, it is important that the personnel should be familiar with the indications, contraindications and fine-tuning of the settings. It is important to be able to confidently differentiate between cases in which you prefer to stop treatment to avoid causing unwanted side effects. Ocular injury, more frequently retina injury can occur if eye protection was not adequately used during the procedure. The severity of the injury depends on the duration and amount of energy delivered

Sun protection is also highly recommended for this period along with using emollients on the treated areas.

(42). Infection can occur after almost any laser therapy. Side effects can occur more often if the treated patient has taken photosensitizing medicines. Having deep vein thrombosis in the history or thrombophlebitis or any vascular problems may predispose for a thrombosis (43). The most common side effects are usually mild and transient. After treatment, the treated area may be sensitive and painful for a few days. Most common skin reactions are transient erythema and perifollicular edema (Figure 3-6).



Fig. 3. *Transient erythema and perifollicular edema on the treated area.*



Fig. 4. *kin reaction after the treatment on knee area.*



Fig. 5. *Skin reactions after the treatment.*



Fig. 6. Erythema and perifollicular edema on a lighter skin type. Pictures belong to the author and they were taken and published with the written permission of the patients. The pictures were taken right after the treatment. Acute reaction to the treatment is clearly visible. The following reactions are only transient.

In rare cases, adverse effects can occur like burns, hyperpigmentation, blister, persistent hypopigmentation and permanent scarring (44, 45). Rare adverse effects can also occur including, persistent urticaria, inflammatory and pigmentary changes of preexisting nevi. Ocular damage can cause by the laser if the patient and the practitioner do not wear eye protection during the procedure.

In some cases, infections may occur after laser treatment. Although it is more common after

ablative procedures because the barrier function of the skin is impaired, it can also occur after non-ablative treatments. The most common is bacterial infection, which in most cases is caused by *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* (46). Laser can also reactivate Herpes Simplex Virus (HSV), so for patients with history of herpes, preventive acyclovir therapy before the sessions is highly recommended (47).

Efficacy

When choosing the right laser and selecting the adequate wavelength and parameters that are suitable and individualized to each patient, diode laser hair removal is the most effective way

to reduce hair permanently on the selected areas. Most of the adverse effects and complications are preventable, if the practitioner is well trained, uses the adequate technique and parameters.

Also, successful treatment depends on the patient education, including being aware of taking medicine which may cause photosensitivity and taking the sun avoidance protocol seriously

(Table V). In this way, we can reach our goal to get a permanent hair reduction in the most effective and safest way.

	Suitable for				
Wavelength (nm)	hair removal	skin rejuvenation	pigmented lesions	vascular malformations	acne treatment
755	+		+		+
810	+		+		+
Combined laser: 810, 945,1060	+	+			+
1060	+	+		+	+

Table V. Summarizing the optimal wavelength for treating in different indications with diode laser.

Cost effectiveness

The faster and more efficiently a machine can handle the treatment, the more cost effective the treatment is. The applied technique, parameters, numbers of the clients, lifetime of the laser headpiece are all influencing the cost and benefits ratio. In terms of costs, the manufacturer must be considered. Purchasing a diode or an Alexandrite laser is much more expensive than an IPL machine that are commonly used in cosmetics. Using laser for hair removal is not only a more effective treatment, but also it is less painful than

IPL treatment. It is well known that comfort is a pivotal aspect for the costumers. Efficiency in the long run, convenience and selectivity tilt the balance in the direction of diode lasers in all respects. Due to a market analysis report in 2018, global laser hair removal market was valued at 587,56 million USD (48). The predictions show that 15,9% increasing is expected from 2019 to 2026, regarding to the safety offers by laser devices (Table VI).

Report Attribute	Details
Market size value in 2020	USD 1.76 billion
USD 1.76 billion	USD 1.87 billion
Growth Rate	CARG of 15.9% from 2019 to 2026
Base year for estimation	2018
Historical data	2015-2017
Forecast period	2019-2026

Table VI. *Laser hair removal market report scope (48).*

Discussion

Diode lasers can combine the advantages of other lasers by using different wavelengths. They can provide an effective solution for vascular malformations—e.g. hypertrophic malformations, pigmented lesions cherry angiomas, leg vein, telangiectasias, reticular vessels, and small vein hypertrophy (27, 28). It can be widely used as an antiaging non-invasive procedure, since it showed good results in skin rejuvenation and body contouring (5, 29). Marks, striae, hypertrophic and keloid scars, that cause a significant impact on quality of life, can be treated effectively with diode lasers (4). Diode lasers were also reported as effective method to remove melasma and solar lentigines (13, 20, 21, 49). In terms of facial rejuvenation, and treating scars or striae ablative treatments are still the most effective options however they may cause more severe and more frequent side effects (25). Nevertheless, diode lasers offer the most efficacious and safest procedure for permanent depilating, that makes it gold standard for permanent hair reduction (8, 38). It is very important to note that safety

could be only guaranteed when handled by well-trained professionals or medical practitioners to avoid adverse effects. After a trustful examination diode laser provide a convenient safe and effective method to treat variety of problems by using the adequate, effective, and safe laser parameters.

To conclude, the use of diode lasers not only provide an effective and safe solution for laser hair removal but can also deliver a solution to other aesthetic problems. This not only helps to solve physical and aesthetic problems but may also offer a solution to gain back self-confidence. Compared to its competitors, its field of application is constantly expanding, and we can achieve more efficient and convenient treatment in all respects. Based on the growing market of EBD procedures devices with wide fields of indication are more economical. In this sense investing to novel diode lasers with combined multiple wavelength handpieces may be financially rewarding for offices, since they can take advantage of its versatility.

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