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## Efficacy of laser hair removal according to skin type

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#### Abstract

This review article deals with hair removal by laser, for long-term results and has become the leading therapy choice. With the increase in demand, the regulation of these treatments has increased. for them, in the present study, the relation between skin color and the type of lasers are used when treating it. The wavelength of the lasers used to destroy the hair follicles it's in the range of 600 to 1100 nm, and the possibility of complications harmful to the skin decreases by increasing the accuracy of the laser energy delivery to the hair follicles. therefore, the lasers technology used for this purpose are specierfic and the most appropriate types of lasers to be used is the Pulsed Diode for skin phototypes light brown, brown, and black, Nd:Yag for brown and black skin, Alexandrite for plane white, white, cream white, and light brown skin and Ruby for plane white, white and cream white skins, which are a little more particular when it comes to heating the melanin that helps to eliminate the hair follicles. There is no harmful technology, but it is more important to understand the skin and also understand the technology behind a laser, so it is known how this skin can respond and what to do with the laser. If it is financially feasible, it will be easy to deal with all types of skins in terms of color by using different types of lasers according to the type of cases.

# **Chapter one**

### 1-1. Introduction

The term laser is an abbreviation of "light amplification through stimulated radiation emission" <sup>[1].</sup> Laser are currently used in multiple fields such as cd use electronics and precise distance measurement especially space object dimensions and in communications laser also used to remove hair.<sup>[2]</sup>

During recent years, both men and women have begun to resort to laser treatments aimed at removing hair from several areas of the body. Whether these areas are visible or hidden: the chest, back, legs, underarms, face, upper thighs, and other areas. ..... laser therapy prevents the regrowth of melanin cells in the skin layers and hair follicles<sup>.[3]</sup>

The laser beams injure the melanin cells, absorb and break up hair follicles, and delay or stop the growth of new hair in the area exposed to the radiation<sup>.[4][5]</sup>

Lasers used in hair reduction aim to disable effective hair growth by destroying hair bulbs, and the mechanism of laser-tissue interaction and the ability of lasers to damage hair follicles has been widely studied <sup>[6]</sup> Sometimes, a laser hair removal procedure is called "permanent hair removal", although this term is not an exact term in all cases. The treatment does not guarantee that hair will not grow again at all. Most of the treatments help to significantly reduce the amount of hair that grows.

This treatment is performed for cosmetic purposes only, and often reduces the need to use other hair removal methods such as: waxing, shaving, and other costly treatments that waste time. In our modern era, there are several methods used for hair removal, whether by laser or other modern methods aimed at injuring the hair root and preventing its growth again, such as the use of infrared and other methods.

There is a need for a pre-session with the doctor before performing the laser treatment, where the dermatologist agrees with the patient on the areas that will be subjected to treatment, according to the type of skin, color, hair color and thickness, in addition to the desires of the person himself. the color and type of skin have an effect on laser hair removal the hair strand increases and the skin tone lighter, the laser hair removal is better and the damage to the skin is less and the hair is also.<sup>[5][6]</sup>Several types of lasers, which are based on the light treatment, are available for hair removal and they are effective for different types of skins such as, ruby lasers (694 nm) for fair skin types, alexandrite lasers (755 nm) for lighter skin types, Nd:YAG (1064 nm) for darker skin types and diode lasers (800-810 nm) for all skin.

# **Chapter two**

## 2-1 History

The first laser was developed by Theodore H. Maiman a physicist, in Malibu in 1960, using a synthetic ruby cylinder. Then In 1963, Leon Goldman was the first to use the laser in dermatology, also known as the "father of lasers in medicine. After that Mester discovered the beneficial effects of low-energy red lasers on hair growth in rats in 1966 <sup>[11].</sup> The first laser-assisted hair removal device was cleared in 1995, more than 15 laser systems have been approved by the Food and Drug Administration (FDA) to specifically target hair follicles <sup>[6]</sup>

### 2-2 Skin typing color for laser treatment

The Fitzpatrick skin typing method for predicting skin reactivity in photochemotherapy was developed in 1975 [12]. The Fitzpatrick scale is known as the human skin color classification and is used to estimate the response of various skin types to light exposure. A known method for dermatological research into human skin pigmentation is the Fitzpatrick scale. As presented in Table (1) <sup>[6,12].</sup>

| SPT | <b>Basic Skin Color</b> | <b>Response to Light Exposure</b> |
|-----|-------------------------|-----------------------------------|
| Ι   | pale white              | burns easily, do not tan          |
| Π   | White                   | burns easily, tan with difficulty |
| III | cream white             | May burn initially but tan easily |
| IV  | Light brown / Olive     | Hardly burn, tans easily          |
| V   | Brown                   | Usually do not burn, tan easily   |
| VI  | Black                   | Do not burn, become darker        |

Table (1): classification of Fitzpatrick's skin phototypes (SPT).

## 2-3 skin

The skin is the organ that covers the human body and the bodies of many other animals <sup>[7]</sup> .the main function of the human skin is to protect the body and it is one of the first lines of defense against germs, and the skin protects the body through its physical properties as it is almost completely resistant to wetness ,and prevents the depletion of fluids that flood the body's tissues. The skin is the largest organ of the human body<sup>[8][9]</sup>

The skin prevent bacteria and chemicals from entering most parts of the body ,and protects the tissues under neath it from harmful sunlight .

In addition, the skin helps to maintain the internal temperature of the body at normal levels, by the glands in the skin secreting sweat when the human is exposed to extreme heat, where the sweat evaporates, the body cools down, but when the cold thickens, the body retains the cold thickens, the body retains heat by narrowing the blood vessels in the skin, reducing as a result the blood passes to the surface of the body, thus losing less heat.

The skin is the largest organ in the human body, covering the entire surface of the body, The skin consists of three main layers, different in its anatomy and function, namely epidermis, dermis and a deeper layer called hypodermis<sup>.[10]</sup>



Figure (1): structure of the skin

The color of human skin varies in color grades from dark brown to light pink or white , and this pigmentation in color is the result of natural election (a process that favors a genetic trait of a gene to become more common in later generations ) the skin is used for humans by regulating the amount of UV rays penetrating the skin and controlling biochemical effects<sup>. [11]</sup>

## 2-4 Hair

Hair is protein growths that grow on the bodies of mammals, and it consists of some non-living cells and some components that are usually toxic and harmful to the body and are excreted in the form of hair that covers the bodies of mammals. <sup>[12]</sup>

In the general case, people are born with hair covering their head and eye eyebrows in a simple way. Hair appears in the human body after puberty in places other than the head such as the pubis, armpits and leg. In men, beard hair or facial hair, mustache and chest appear, and this hair depends on the proportion of the hormone androgen. Hair grows in most parts of the human body, there is head hair, and people care about it a lot. There is also facial hair, and interest in it differs between women and men. Hair has an active role in human life and changes constantly throughout human development.

Hair is derived from the layers of the epidermis of the skin and consists of two main parts: the follicle and the hair shaft. The follicle is the main unit in hair growth. The hair shaft is made up of the bark and epidermal cells. The hair follicle goes through a set of continuous growth and resting stages called the Hair growth cycle<sup>.[12][13]</sup>

## 2-5 Types of hair

1-Normal hair: It is in the middle between oily hair and dry hair, so it does not show much fat and does not show dryness clearly, that is, it is neither dry nor greasy.

2-Oily hair: It is the hair that shows grease or quickly loses its style.

3-Dry hair: It is the hair that dries out after washing it and loses its shine at the same time.

4-Mixed hair: It is hair characterized by excess fat on the scalp and lack of fat at the ends, greasy on the top and dry on the bottom, and this is the most difficult type of hair and needs careful care.

Hair color is the pigmentation of hair follicles due to two types of melanin: eumelanin and pheomelanin. Generally, if more melanin is present, the hair color will be darker. If it is less normal then (Eumelanin) is present, and the hair color is lighter. Melanin levels can vary over time and this causes a person's hair color to change, and it is possible for hair follicles to be of more than one color on the same person.



Figure (2): Anatomy of hair structure

## 2-6 Mechanism of hair removal by laser

Laser hair removal operations aim to treat hair growth, and to prevent it from returning again in areas of the body where a person does not want hair to grow, for cosmetic reasons, or for treatment of excess hair [14]

laser hair removal is used to reduce unwanted hair. Common treatment locations include legs, armpits, upper lip, chin and the bikini. However, it's possible to treat unwanted hair in nearly any area, except the eyelid or surrounding area. Skin with tattoos should not be treated either.

Hair color and skin type influence the success of laser hair removal. The basic principle is that the pigment of the hair, but not the pigment of the skin, should absorb the light. The laser should damage only the hair follicle while avoiding damage to the skin. Therefore, a contrast between hair and skin color — dark hair and light skin — results in the best outcomes.

The risk of damage to skin is greater when there is little contrast between hair and skin color, but advances in laser technology have made laser hair removal an option for people who have darker skin. Laser hair removal is less effective for hair colors that don't absorb light well: gray, red, blond and white. However, laser treatment options for light-colored hair continue to be developed,<sup>[14][15]</sup>

The laser beams injure the melanin cells, absorb and dissolve hair follicles, and delay or stop the growth of new hair in the area exposed to the radiation. Sometimes, a laser hair removal procedure is called "permanent hair removal," although this term is not strictly accurate in all cases. The treatment does not guarantee that hair will not grow again.

## LASER HAIR REMOVAL



Figure (3): laser hair removal

## 2-7 Type of laser removal hair

The five most common types of hair removal laser systems include the Ruby, Alexandrite, IPL, Diode, and Nd:YAG. Each laser system is different from the other. Some lasers are better for certain types of hair. Some lasers are safer for individuals with darker skin tones. And some laser systems perform better on specific areas of the body than other lasers .In this 2 part series on the different hair removal lasers, you will learn about the five top lasers for permanent hair reduction and learn the advantages and disadvantages of each system so you can choose the best laser hair removal in NYC for you<sup>.[16]</sup>

#### 1-ruby hair removal laser.

The Ruby hair removal laser was the first system developed for permanent hair reduction. This system uses a shorter wavelength of 694nm that targets melanin. This makes the ruby laser ideal for removing hair that is light and thin.<sup>[17]</sup>

#### 2-alexandrite hair removal lasers.

It is considered one of the best types of lasers for hair removal in clinics and it is the most used device in our region and it is effective and relatively safe, and it can also be used to remove facial hair, and it is recommended to use it for people with dark and brown skin the Alexandrite laser is the most popular system for laser hair removal. although newer machines have built in cooling devices to improve patient experience. The Alexandrite laser operates at a shorter wavelength of 755nm <sup>[18]</sup>

## 3-Diode laser hair removal.

"Diode laser" is a management of a laser treatment that aims to reduce unwanted hair, and because the wavelength of the diode laser is longer than other laser methods, effective results are obtained that vary according to the time of treatment even in darker skin tones. The diode laser has a wavelength of 810 nm. This wavelength goes deeper into the skin than the Alexandrite laser <sup>[19]</sup>

#### 4-Nd.YAG laser hair removal.

This type of laser has the longest wavelength, but there is less absorption of melanin, making it very safe on darker types of skin. Low melanin absorption ensures that high energy can be used safely and penetration is relatively lower, but more energy can be used Nd:YAG lasers emit at a wavelength of 1064 nm<sup>. [20]</sup> The penetration of this type of laser beam is much deeper for darker skin types compared to ruby and alexandrite lasers.

#### 5-ipl hair removal.

IPL laser hair removal does not utilize a true laser, but the equivalent in the form of Intense Pulsed Light (IPL.) Like lasers, IPL's initiate photothermolysis . pulsing thermal energy that is absorbed by melanin in the hair follicle.<sup>[20]</sup> The advantage of intense pulsed light is a customizable wavelength, energy level, and pulse duration the iPL hair removal devices apply very gentle pulses of light to the hair root.



Figure (4): type of laser removal

## 2-8 Benefit of laser hair removal

There are many benefits of laser hair removal, and this method is superior to other traditional methods despite its high cost. Among these benefits are <sup>[21] [22]</sup>

1.Efficiency: as the laser is considered one of the most efficient hair removal methods, and its effect lasts in the long term.

2.Speed: The laser permanently removes hair in a relatively short time, according to the area undergoing treatment.

3.Simple pain: removing hair with a laser is less painful than removing it with wax or thread, and the skin is treated with an anesthetic cream before treatment because it may lead to feeling By simple stinging with each pulse of the laser.

4.Skin smoothing: Removing unwanted hair with a laser softens the skin and increases its beauty, and the laser is safe for sensitive areas such as around the mouth and eyes.

5.Rarity of side effects: Side effects of removing unwanted hair Laser is rare and not permanent.

### 2-9 Damages of laser hair removal

The laser hair removal is a safe option, but it can cause some damages, including.<sup>[22]</sup>

Burns in the skin due to exposure to the heat released by the laser, especially on brown skin because it absorbs heat more.

Damage to eyes, so protect eyes during treatment. Skin redness and swelling around hair follicles after treatment for a few days. Feeling of pain, tingling and numbness in the areas treated with the laser. Peeling skin, bruising, especially on sensitive skin, usually fades soon after treatment. A change in the color of the skin to a purple color in the areas that were exposed to the laser, which is very rare.

# **Chapter three**

## **3-1** Discussion

Lasers are now used in various fields in our lives, especially in cosmic clinics in medicine, so many articles were focused on lasers and their application in this area, particularly in hair removal <sup>[23]</sup>In a research performed by Atta-Mobtte and Załęska (2016-2019) from Poland and the United Kingdom on citizens of different racial backgrounds (Asian 29, black 25, mixed 34 and white 127) using diode lasers of 805 nm wavelength, 2100 W minimum peak power and 15 to 400 ms pulse duration and 10 to 100 J/cm2 pulse energy density for all treatments. The outcome revealed that the incidence of sensitivity depended significantlyon ethnicity. The incidence of statistically hyperpigmentation is statistically significantly dependent on race,

as well as the rate of burns was statistically strongly dependent on ethnicity, while race did not have a major effect on the prevalence of erythema, as shown in Table (2).

| Ethnicity                      | Types of Side Effects |          |                   |         |  |
|--------------------------------|-----------------------|----------|-------------------|---------|--|
|                                | Sensitivity           | Erythema | Hyperpigmentation | Burns   |  |
| Asian                          | 5                     | 2        | 3                 | 3       |  |
| (n=29)                         | 17.24%                | 6.90%    | 10.34%            | 10.34%  |  |
| Black                          | 12                    | 0        | 7                 | 9       |  |
| (n=25)                         | 48.00%                | 0.00%    | 28.00%            | 36.00%  |  |
| Mixed                          | 17                    | 4        | 11                | 10      |  |
| (n=34)                         | 50.00%                | 11.76%   | 32.35%            | 29.41%  |  |
| White                          | 30                    | 15       | 0                 | 13      |  |
| (n=127)                        | 23.62%                | 11.81%   | 0.00%             | 10.24%  |  |
| Significance of<br>differences | P=0.002               | NS       | P<0.001           | P=0.001 |  |

Table (2): The occurrence of side effects and ethnicity

The study also showed that following the diode laser hair removal treatment, the side effects occurred in the pubic region. The groups of Black and Mixed-race respondents had several side effects much more often compared to the White and Asian survey groups, Sensitivity, erythema, and burns were observed as side effects. Erythema alone did not 8have a statistical correlation with ethnicity among all the side effects observed, however, it was not observed in the black participant population, and hyperpigmentation was not found among white participants <sup>[6].</sup>

This phenomenon maybe refers to the long wavelength of diode laser that decreases the melanin absorption in the dermis of the skin by that the diode needs more flounce to heat the tissue and destroy of the hair follicle well.

while this high energy is not affected the black citizens with skin type IV to VI as it observed in the Atta-Mobtte and Załęska study, tabulated in the Table (2), the diode lasers are considered as a more suitable and safer type of lasers for hair removing in darker skin persons, as well as, this type of lasers have a temporary effect on the other types of skin such sensitivity, erythema, hyperpigmentation, and burning <sup>[24]</sup>

Mustafa et al. (2014) they used Alexandrite laser (755nm) and Diode laser (810nm) withirradiation power (1000mW) and a beam diameter of (5mm) was used in the model for hair removal in medium and dark skin. The result was that, in both samples, the ratio of photons transmitted through the laser diode was not equal to the ratio of photons transmitted through the alexandrite laser skin layers. This finding shows that the number of photons transmitted from both laser sources through dark and medium skin varied. With depth, the rate of fluency declined quickly within the skin. Although the decrease in the rate of fluency was more significant after a depth of 0.2 mm, a rapid decrease in the rate of fluency in the epidermis and dermis layer was observed for both laser sources, the amount of radiation transmission was measured for both laser sources in dark and medium skin with differing skin layer depths. The transmission ratio of the diode laser to the dark skin dermis was approximately 4% more than that of the alexandrite laser for the same skin type. The results of Mustafa et al. (2014) showed that the diode laser was better than the alexandrite laser because the short-wavelength alexandrite laser would require a higher fluence rate to achieve the same dose-effect due to the high risk of thermal damage to the surrounding tissue, especially the epidermis, while the diode may penetrate deeper into the dermis layer <sup>[5].</sup>



Figure (5): Fluence of two types of laser; (A) Diode laser (810 nm) and (B) Alexandrite laser (755 nm) as a function of skin depth for both dark skin and medium skin.



Figure (6): variation of laser transmission ratio as a function of laser source and skin depth for two types of skin: (A) Dark skin and (B) Medium skin.

Jansy et al. (2018) used Nd:YAG laser (1064nm, fluence 40-50J/cm2, 5mm spot size) for darker-skinned Indian patients, including 40 women in the 18-35 age group, and 32 patients completed all treatment sessions. for 28 patients after the first treatment session, a strong hair reduction (50-75 %) was seen. Excellent hair reduction (>75%) was observed after 3 sessions for 10 patients and strong hair reduction for 18 patients. In 12 patients at month 6, excellent hair reduction was observed, and a good response was observed in 16 patients. The side effects were noted in the post-procedure erythema and perifollicular edema analysis (50%). The study findings support the safe and successfui use of four consecutive 1064 nm Nd:YAG long-pulse laser sessions for facial hirsutism in Indian patients with darker IV and V skin imaging with limited side effects. In terms of effectiveness, the shorter laser wavelength is usually considered more efficient because of the higher absorption value of melanin, which decreases with increases of wavelength. However, because of decreased dispersion and deeper penetration of laser light, the longer wavelength Nd:YAG laser is considered suitable for the treatment of patients with darker skin<sup>[15].</sup>

|                            | At 4 weeks | At 8 weeks | At 12 weeks | At 6th month |
|----------------------------|------------|------------|-------------|--------------|
| Excellent (>75% reduction) | -          | 2          | 10          | 12           |
| Good (50-75% reduction)    | 28         | 26         | 18          | 16           |
| Fair (25-50% reduction)    | 12         | 9          | 4           | 4            |
| Poor (< 25% reduction)     | -          | -          | -           | -            |
| Lost to follow up          | -          | 3          | 3+4         | Total-8      |

 Table 3: Percentage of hair reduction in the study population

A standard ruby laser mode (694nm) was used by Campos et al. (2000), emitting a (3ms) pulse length, 7-10mm spot sizes, and 20-70 J/cm2 fluence. A wide variety of body sites were used to treat 51 volunteers mean follow-up after the last treatment was 8.37 months. Sixty-three percent of the patients had sparse regrowth. The mean fluence used was 46.5 J/cm2 in patients who had sparse hair regrowth and 39.3 J/cm2 in patients who had mild hair regrowth, the most frequent transient pigment changes occurred in patients with type IV skin. The normalmode ruby laser, especially in fair-skinned individuals with dark hair, is an effective and secure method for long-term hair reduction. Higher fluences generate greater long-term effectiveness. Minimal and temporary adverse effects are adverse. A

powerful and secure hair removal process is the ruby laser. The 694-nm wavelength penetrates deeply into the dermis, where follicular melanin is by far the dominant chromophore. In the hair shaft, epithelium, and matrix cells, melanin laser light absorption causes thermal damage to the hair follicles <sup>[16].</sup>

Russe et al. (2019) they have done a Research between 2016 and 2019 to determine the long-term effectiveness and safety of the alexandrite laser (755 nm) for hair removal, using parameters dependent on skin type, hair color, thickness, and anatomical location. Fluences varied between 16 and 25 J/cm2 and were set for each patient. The physician assessments were conducted at two follow-up intervals. The first follow-up was assessed at least 1 year after the final treatment. The second follow-up was assessed at least 8 years after the final treatment. In the first and second follow-up, there were no further therapies. Besides, information was gathered by the physician about the shift in thickness and color of chronic hair, change in growth speed as well as side effects

of treatment, including hypopigmentation and hyperpigmentation, scaring, and the outbreak of herpes infection. Adverse events in the long-term were small. This study shows that the long-pulse alexandrite laser is in the mid-range of the melanin absorbing spectrum and is , therefore an excellent choice for targeting the hair follicle. the long-pulsed 755 nm alexandrite laser 10 a safe and efficient treatment for the removal of excessive body hair with lasting results and high patient satisfaction <sup>[17].</sup>

The alexandrite has been developed by the new Alma company in a new platform called Soprano platinum Ice which combines 3 wavelengths (755nm,810nm & 1064nm) Combination of three different wavelengths in a single handpiece was developed to target different tissue depth & anatomical structures within the hair follicle. This blend of Alexandrite 755nm, Diode 810nm & Nd:YAG 1064nm provides better results in fine hair reduction compared to conventional Diode laser. But needs to be used carefully in dark skin type patients <sup>[23][25].</sup>

# **Chapter four**

#### **4-1 Conclusion**

For hair removal or to reduce hair growth in unwanted places of the human body, laser have been used., there are different kinds of lasers available, but the selection of an ideal laser for ethnic skin has its limitations. It is very important to pick the right laser for the right type of skin. It is necessary to determine the skin type of the flounce, the pulse length and the laser type to be used before beginning the laser therapy<sup>.[26]</sup>

#### References

[1] S. G. Shaunak Ghosh 1, Effect of Laser on Skin, Jornal, 11(2015): 161-166.

[2] F. Mustafa and M. J. I. J. o. P. Jaafar, Comparison of wavelengthdependent penetration

depths of lasers in different types of skin in photodynamic therapy, 87(3) (2013): 203-209.

[3] C. Ash, M. Dubec, K. Donne and T. J. L. i. m. s. Bashford, Effect of wavelength and

beam width on penetration in light-tissue interaction using computational methods, 32(8)(2017): 1909-1918.

[4] Nanni CA, Alster TS, Optimizing treatment parameters for hair removal using a topical carbon-based solution and 1064-nm Q-switched neodymium: YAG laser energy. Arch Dermatol (1997) 133: 1546–9.

[5] Olsen EA, Methods of hair removal .J Am Acad Dermatol (1999) 40:143-55

[6] M. M. Thomas, N. N. J. J. o. C. Houreld and L. Therapy, The "in's and outs" of laser hair removal: a mini-review, 21(6) (2019): 316-322

[7] Chernosky ME. Clinical aspects of dry skin. J SocCosmet Chem 1976;27:365–76.3.

[8] Elias PM. Stratum corneum defensive functions: anintegrated view. J Invest Dermatol 2005;125(2):183–200.

[9] ildnauer RH, Bothwell JW, Douglass AB. Stratumcorneum biomechanical properties. I. Influence of relative humidity on normal and extracted humanstratum corneum. J Invest Dermatol 1971;56.

[10] hair removal: a mini-review, 21(6) (2019): 316-322. 8. Abel E, Embryology and anatomy of hair follicle. In:Olsen EA, ed. Disorders of Hair Growth: Diagnosis andTreatment. McGraw-Hill: New York, NY, 1994: 1–9.

[11] Lin TYD, Manuskiatti W, Dierickx C et al, Hair cycleaffects hair follicle destruction by ruby laser pulses.J Invest Dermatol (1998) 111: 107–13.

[12]. Hughes CL, Hirsutism. In: Olsen EA, ed. Disorders of HairGrowth: Diagnosis and Treatment. McGraw-Hill: NewYork, NY, 1994: 337–50. 14. Orth D, Appa Y. Glycerine: a natural ingredient formoisturizing skin. In: Loden M, Maibach H, editors.Dry skin and moisturizers. Boca Raton (FL): CRCPress; 2000. p. 214.

[14] Franbourg A et at(2003) Current research on ethnic hair .Jam Acad Dermator 48(6 Supp11):S115-119.

[15] Swift JA(1999)Human hair :biologically conspired to the owner's advantage. J Cosmet Sci 50:23-47.

[16] Wagner R.F., Tomich J.M., Grande D.J. Electrolysis and thermolysis for permanent hair removal. J Am Acad Dermatol 1985; 3: 441–9

[17].Boulnois J.L. Photophysical processes in recent medical laser development: a review. Lasers Med Sci 1986; 1: 47–66

[18].Raymond Button, "The Pros and Cons of Laser Hair Removal", Retrieved 2018-5-24. Edited.

[19].Arshi Ahmed (2017-12-12), "Side Effects Of Laser Hair Removal Treatment That You Should Definitely know".Retrieved 2018-5-24.

[20] S. D. Gan and E. M. J. D. S. Graber, Laser hair removal: a review, 39(6) (2013): 823-

838.

[21] B. R. J. I. J. o. D. Eapen, Venereology, and Leprology, Agent-based model of laser hair

removal: A treatment optimization and patient education tool, 75(4) (2009): 383

[22]."Laser Hair Removal History - Serenity Rejuvenation Center". Serenity Rejuvenation Cent. Archived from the original on 2017-08-31. Retrieved 2017-05-08.

[23] R. J. J. D. D. Pillai, Laser hair removal on skin of color, 4(1) (2019):

[24] R. Jansy, N. Manickam, M. Kandasamy, K. Gopalan and D. J. I. I. J. C. E. D. Revathi, Efficacy of long-pulsed Nd:YAG laser in the treatment of hirsutism, 4(2) (2018): 85-89.

[25] V. B. Campos, C. C. Dierickx, W. A. Farinelli, T. Y. D. Lin, W. Manuskiatti, R. R. J. L. i. S. Anderson, M. T. O. J. o. t. A. S. f. L. Medicine and Surgery, Ruby laser hair removal: Evaluation of long-term efficacy and side effects, 26(2) (2000): 177-185.

[26] E. Russe, M. Purschke, M. Herold, F. H. Sakamoto, G.
Wechselberger, K. J. L. i. s. Russe-Wilflingseder and medicine,
Evaluation of safety and efficacy of laser hair removal with the longpulsed 755 nm wavelength laser: a two-center study study with 948 patients, 52(1)(2020): 77-838