LASER THE LIGHT IN DERMATOLOGY, ADVANCEMENTS, AND LIMITATIONS - A REVIEW

Abstract

Laser technologies allow for correcting almost every skin condition. In dermatology, in recent years we have seen lasers evolving and their uses are also broadly expanding in a vast spectrum. It is used in many skin conditions from reversing the aging of the skin to treating skin conditions like pigmentation, scars, and vascular skin lesions, It is also seen for the use of permanent hair removal for unwanted hair in hirsutism and PCOD in girls, another quite common use is in tattoo removal. Since Laser is a noninvasive process it is seen that the use is very common and it's mostly for cosmetic use like skin rejuvenation to skin brightening and the demand is also markedly increasing. So far we have seen pretty low side effects and good silhouette yet we see many limitations along with advancements. In this review, the article brings out the principle, application, and advancements of Laser technology in dermatology along with an emphasis on their limitations.

Keywords: Dermatology, PCOD, Skin treatment, Light therapy

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I. INTRODUCTION

A laser is a device that amplifies light by stimulated radiation emission. By understanding the science underlying laser light, one may comprehend the impacts of laser light on the skin. A basic knowledge of the way lasers interact with tissue will help the doctor to select the best appropriate laser for a particular clinical scenario. [8]. Laser being a light therapy is a light having a single uniform wavelength hence it is monochromatic [3]. It is an electromagnetic radiation source that has the power to sever, coagulate, destroy, or reconfigure tissues. [3,4]. The article is classified into three sections overall, firstly The principles of the Laser, and then the uses and applications in various skin conditions followed by the advancements and limitations.

II. THE SCIENCE BEHIND THE LASER LIGHT THERAPY - UNDERSTANDING THE PRINCIPLE

As discussed before Laser light is a monochromatic light with a single wavelength[3] picturized in Figure 1. The skin interacts with the laser light in different ways, a better understanding of this interaction is crucial. There are four ways skin interacts i.e., reflection, scattering, absorption, and transmission[5] shown in Figure 2.

When the Laser beam hits the skin some of it will be reflected whereas some of it will go deeper and then be reflected, Depending upon the molecule it hits in the skin tissue like melanin, fat, and collagen, not all of it will be reflected some of it will be absorbed which decides the appropriate result, it depends on the energy as well as the wavelength of the light according to which the absorption happens. The light that is not absorbed and gets reflected back will exit the skin.

We can emphasize here that depending on the wavelength and the target molecule wide array of applications can be possible. Figure 3 shows the lights with different wavelengths and their corresponding penetrance in skin layers. There is very little light scattering in the epidermis, but a lot of light scattering in the dermis because of the high collagen fiber concentration there. [3].

Photothermolysis - Thermal Effect seen in Laser: A straightforward predictive model developed by R R. Anderson, J A Parrish, as well as other models like non-invasive laser microsurgery conducted by Madison RD, Macklis JD, and Frosch MP, serves to clarify the thermal consequences of laser interactions. In the context of laser-tissue interaction, the conversion of laser energy into heat leads to thermal coagulation, resulting in cell necrosis, the maintenance of homeostasis, sealing of nerve endings, and significant changes in the extracellular matrix, This mechanism is hamessed to selectively target skin pigments, including pigmented cells, blood vessels, and tattoo particles.

For a better insight, we should have a perceptive understanding of skin tissue chromophores. A Chromophore is a substance that can be exogenous, or introduced from outside the body, or endogenous in the tissues. Its absorption coefficient determines which wavelengths it can absorb [12]. Because of their large absorption peaks in light energy, the three primary chromophores in human skin – hemoglobin,water, and melanin – can all be targeted by both a range and a particular wavelength of light.[13]. When these chromophores absorb the light wavelength it causes the cutaneous target to heat and cause sectional and

desirable damage. There are many Lasers used in dermatology with an appropriate wavelength targeting a specific tissue chromophore which gives a desired clinical outcome which is discussed in the application of laser in a wide array of skin conditions.

III. THE LASER LIGHT USES

1. **Pigmented Lesions:** Most of the pigmented lesion involves melanin production seen in melanoma, Freckles, Lentigines Melasma, seborrhoeic keratoses, skin tags, moles, café au lait macules, etc. These pigmentary lesions can be corrected by targeting the pigment with the appropriate wavelength of light. The most common lasers used to target pigment are ruby, KTP, and Cooper vapor. It has been observed that the effective dermal penetration depth and the preferential absorption of melanin over hemoglobin are both explained by wavelengths between 630 and 1100nm.[13]. The therapeutic effects of treatment with a strong pulsed light source on melanocytes were assessed in a study by G. A. Moreno Arias J Ferrando[14]. A strong pulsed light source with the following specification was used to treat both superficial and deep melanocytic lesions: filters of 590,615, and 755 nm, Based on the results, it was determined that intense pulsed light is a useful treatment for superficial melanocytic lesion, but that repeated treatment sessions are necessary for those with deep component to improve. Two treatment sessions were administered to superficial lesions, and four to deep ones.

   The only effective way of tattoo ink removal is the guided selection of light therapy with the appropriate wavelength specified in the study done by M Haedersdal, N Bech-Thomsen, H C Wulf [15]. The background and design of the study was a fundamental idea of laser treatment of tattoos is that the wavelength must be well absorbed by the tattoo color. In this study, absorption by different tattoo colors was therefore measured in vivo by skin reflectance to establish optimal laser wavelengths for different tattoo colors.

2. **Vascular Lesion:** Vascular Malformations, Pyogenic Granulomas and Hemangiomas are the three main types of vascular lesion. [16]. Mostly with vascular malformation, we see middle-aged females with quite concerning veins in their legs because of normal aging causing wear and tear of valves. The regulation of backflow is lost which causes unwanted bulging veins. Noninvasive treatments most commonly seen are excision, and cryotherapy with a lot of complications. According to a study by M.P. Goldman and S. Eckhouse, leg veins with a diameter of 0.1 to 3mm can be safely and effectively treated with IPLS [17]. In a multicenter experiment with 369 lesions and 149 patients, a strong pulsed light that permeates the skin causes vessel necrosis. [17].

   The Pulsed Dye Laser treatment remains a notable approach, proven effective in addressing various vascular lesions. These lasers operate on the principle of converting light into heat and are termed ‘pulsed-dye’ due to their use of an organic dye solution to generate the laser effect. They have exhibited efficacy in treating a range of skin conditions, including rosacea, facial redness, port wine stains, hemangiomas, hypertrophic scars, keloids, and telangiectasis[18]. In a study conducted by R Ashinoff, R G Geronemus involving 10 children with capillary hemangiomas, treatment with the flashlamp-pumped pulsed dye laser resulted in a reduction in both the size and color intensity of the hemangiomas, with no adverse effects observed such as ulceration, hemorrhage, infection, or scarring,[19].

3. **IPL devices - The Most Customary Use in Hair Removal and Skin Rejuvenation:** The growing cosmetic industry has made everyone at ease with the use of FDA-approved IPL devices as domestic appliances with the comfort of in-home use. It has drawn the attention of many and use has been markedly increasing for the removal of unwanted body hair to correcting wrinkles, and spots. The device for hair removal at home has been proven safe and effective through a clinical experiment that revealed no major side effects. The trial's overall hair reduction was 78% at the one-month and 72% at the three-month follow-ups [20]. It has also has been shown that IPL can be utilized to treat dark skin types, providing positive results for all skin types.

IV. LIMITATIONS AND INDICATIONS OF THE LASER LIGHT

Although we have seen many uses and advancements in Laser therapy in recent years, yet there are quite limitations as well as indications one has to focus on. In broad terms, we do see burns, blisters, itching, rubor, and color which are temporarily seen, on the other scaring can be a long-term effect seen with Laser therapy

1. **Anti-inflammatory Drugs affecting Laser Therapy:** Many medications, including amiodarone, minocycline, warfarin, isotretinoin, aspirin, niacin, and vitamin E cause delayed healing, bleeding, scarring, increased bruising, hyperpigmentation, and localized chrysiasis after laser therapy, so a thorough assessment of the patient's profile is essential.[21],[22].

2. **Other Miscellaneous effects of Laser Therapy:** We see quite a few metabolic effects and other epidermal skin reactions with Laser therapy which are postulated precisely in the study, Evaluation of Laser Effects on the Human Body After Laser Therapy[22].

   Furthermore, since the laser has been made available to clinics and commercial business in addition to hospitals, where safety is a concern, appropriate use of the laser is essential. In these situations, the laser treatment provider's qualifications and the availability of consultations are critical. Without a strong background in this science, it has been observed that many doctors and nurses who opt to work with lasers are unable to conduct risk assessments on an operational basis on a daily basis.[23]. Numerous control methods, such as engineering, procedural, and administrative controls, have been established for risk management and must be adhered to. [23].

V. CONCLUSION

This review provides evidence-based insights into how lasers are effective, their application, and advancements in recent years with limitations and indications. It explores the diverse uses in skin conditions and the effect seen in them with light therapy. Overall it concludes, that good sets of protocols and a proper safety guide with the use of Lasers can promise a better delivery of clinical results along with a good safety profile and improved knowledge and management will contribute to better outcomes for individuals.

Light therapy has been a phenomenon in giving the best results so far with the proper skilled use by the operator and we may see new advancements along the way since it is a never-ending evolution we humans have to technologies.

VI. FIGURES AND TABLES

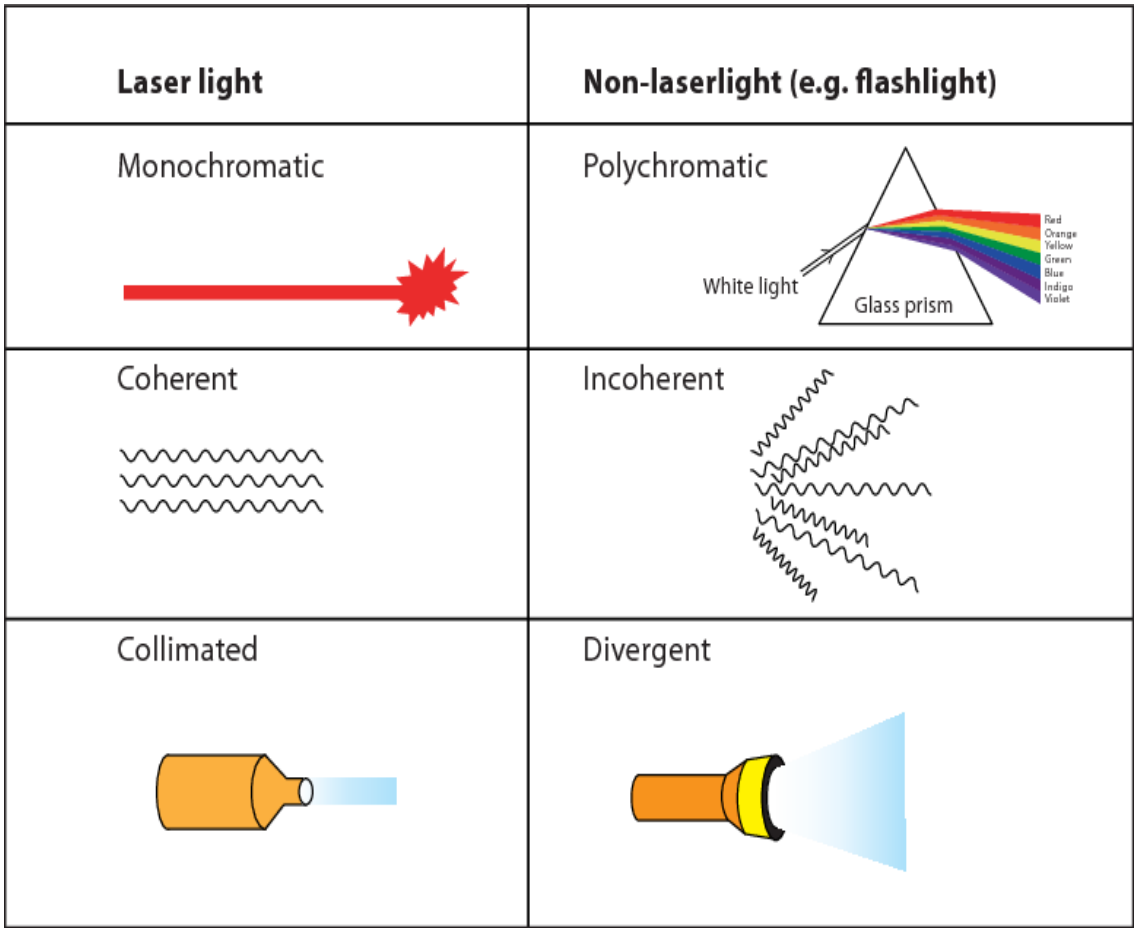

Figure 1: Laser the Monochromatic Light [6]

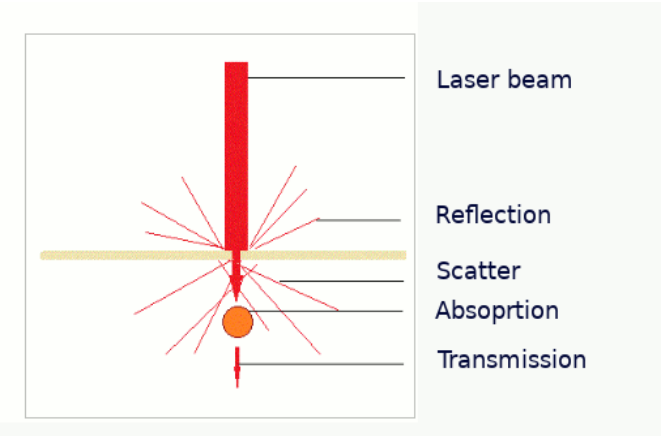

Figure 2: Skin and Laser Interaction [7]

- **Reflection:** There is always a degree of reflection of laser light from the epidermis.
- **Absorption:** Absorbed laser light may cause tissue coagulation or vaporization.

- **Scattering:** Most light entering the tissue is scattered by a complete interaction with water lipids and cellular membranes. Scattering is greater for short wavelengths of visible light.
- **Transmission:** The laser light is transmitted through tissues to their target.[5]

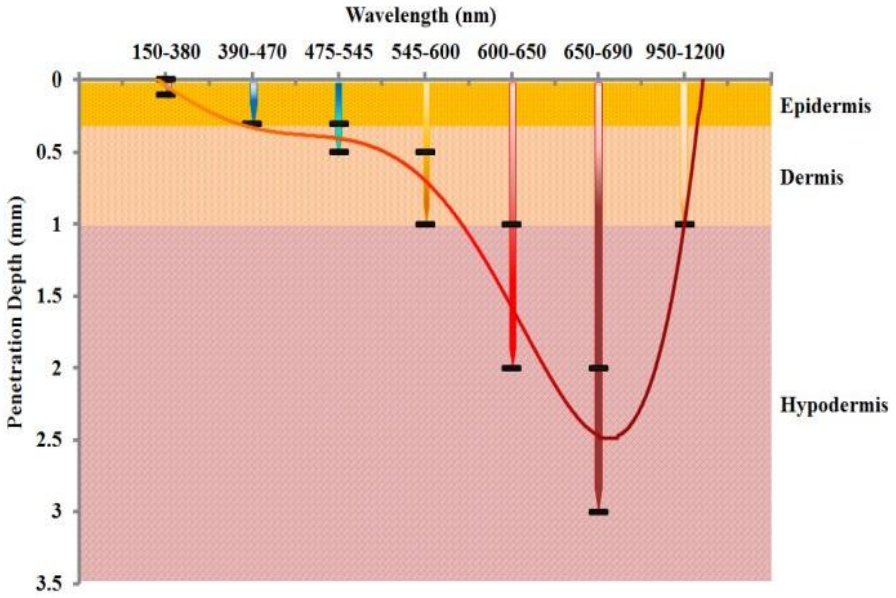

Figure 3: The lights with different wavelengths and their corresponding penetrance in skin layers. [9]

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