

A Survey of Applications of Laser in Dermatology – Medical Physics

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ABSTRACT: Skin is in the form of thin layer covering the muscles and muscular fibers of the body. It gives good shape for our body and is responsible for giving good complexion (colour) due to the presence of colouring pigment called melanin. Skin also protects our body from ultraviolet rays coming from the sun. It also allows the evaporation of water through the pores in it during summer thereby regulating the body temperature.

The term dermatology refers to diseases related to the skin. Now a day's skin diseases are common due to allergic reactions to drugs, insect bites and environmental pollution etc. These diseases related to skin can be cured by taking proper medicines of allopathy or herbal. But major skin disorders like tattoos (extra growth of skin), vascular skin lesion and hemangioma (tumour in blood vessels etc) cannot be rectified by oral medicinal therapy (or) laser treatment. Earlier only surgery was used to solve these types of major skin problems. With the advent of discovery of various types of laser which differ in power capacity and wave lengths coupled with optical fibers doctors can perform bloodless surgery in short duration on a specified area (pulse laser) with a minimum time for healing.

One of the major fields in which modern laser finds its applications is dermatology through photothermal and photochemical reactions. The present study briefly discusses about various interesting applications in the field of dermatology.

KEYWORDS: Melanin, chromophores, hemoglobin, photothermal, photochemical, stratum corneum, tissue, proteins, ablations, photolysis, skin lesion, portwine stain, telangiectases, pulse dye laser (PDL), corticosteroids, tattooing and cryosurgery, psoriasis, keloids, steroid pigmented lesions, photofacial, laser genesis therapy, varicose veins, spider veins, facial wrinkles.

I. INTRODUCTION

Let us first discuss about the sensitiveness of skin to electromagnetic radiation like light X-rays, lasers etc and their penetration reactions with the skin through a term known as skin optics.

Optical penetrations into skin is determined by a combination of absorption and scattering. The principal chromophores (absorbing molecules) for optical radiation in skin are water, melanin and hemoglobin. When absorption occurs, photon energy is transferred to chromophores. The excited chromophores can dissipate this energy in various ways including photochemical reaction, heat or re-emission of light.

Absorption depends on the concentration of chromophores present. Scattering occurs when the photon changes its direction of propagation. About 4-7% of light is reflected upon striking the skin surface because of the sudden change in the refractive index between air and stratum corneum (outer layer of endometrium). The remaining light penetrates into skin and can be either absorbed or scattered by molecules, particles and structures in the tissues.

Let us now discuss particularly about the interactions of laser with skin. Laser light can impose a tissue effect only when it is absorbed by chromophores. There are 3 basic effects. The majority of current laser applications in dermatology use photothermal effects.

Discussion:

Here we are going to discuss about 2 mechanisms of laser applications in dermatology. They are photothermal interactions and selective photolysis. The accumulation of denatured material rises exponentially with temperature and is proportional to time. At high temperatures the specially configured macromolecules necessary for life are shaken open, resulting in loss of function.

Most proteins are denatured above 60°C and DNA above 70°C, tissue water is vaporized. This process is known as photothermal reaction. One popular use of laser in dermatology is for precise tissue ablation (abnormal growth) called laser re-surfacing. Two main factors which influence laser vaporization are (1) penetration depth for laser radiation, which depends on wavelength (2) the rate of tissue vaporization, which depends on the amount and rate of laser energy absorption.

The term “selective photothermolysis” was coined to describe site-specific, thermally mediated injury of pigmented tissue targets by pulses of radiation. This technique relies on selective absorption of a brief optical pulse to generate and confine heat at certain pigmented target only.

Secondly we are going to discuss briefly about the various important application of laser in dermatology .

II.LASER FOR VASCULAR SKIN LESIONS

- **Mechanism of action:** Laser wavelengths absorbed by hemoglobin are used to treat cutaneous vascular lesion (neuron in blood vessels) such as
 1. Portwine stains
 2. Hemangioma
 3. Spider angioma
 4. Cherry angioma
 5. Venous lake

Telangiectasia of face and legs (localized collections of distended blood capillary vessels)

The basic objective in treating vascular lesion is to irreversibly damage abnormal blood vessels but spare normal skin tissue, argon and other continuous and quasi continuous visible-light lasers were first used to PWS.

Port-Wine stain:

Commonly known as PWS is a congenital malformation of dermal stains microvasculature present in 0.3 to 0.5% of new born and persists throughout life. Treatments of PWS have included skin grafting, ionizing radiation, cryosurgery, tattooing, dermabrasion and **laser treatments:**

The current standard treatments of PWS is with pulsed Dye laser (PDL) at a wavelength ranging from 585 to 600nm, 0.4 to 1.5 ms pulsed width and fluence (energy/level) of 3 to 10 J/cm² with 3-10mm large spot size allowing laser lesions (tumour) to be treated quickly side effects including bruising (purpura) last only 1-2 week and crusting, textural change and scarring are rarely seen. The addition of dynamic cooling increases the comfort and safety to the patients during treatment. Approximately 50 – 75 % lightening of PWS is achieved within two to three treatments with PDL therapy. Complete resolution of lesion can be achieved with repetitive laser treatments.

Hemangiomas are common ‘bergin’ proliferation of blood vessels occurring in up to 10% of all children by the age of one year. They typically undergo a rapid growth phase during the first year of life followed by complete or partial involution by age 12 years.

Hemangiomas have been treated with varying success using compression therapy, ionizing radiation, intra lesion or systemic corticosteroids, cryosurgery and various laser therapies. The treatment methods used depends upon on the age of patient site and lesions and stage of the disease. Early surgery is an option in some cases of pendunculated hemangiomas. Superficial hemangioma are generally treated with local corticosteroids, PDL or both. Larger lesion with a deeper component and alarming hemangiomas usually require the administration of systemic corticosteroids. In clinical practice, treatment with PDL appears to be effective and may be the treatment of choice for small hemangiomas.

Telangiectases are common dilated superficial blood vessels associated with ageing, chronic sun damage, scars, malformation, acne rosacea and other conditions. Dilated veins are also common in both sexes due to poor venous return from incompetent vein valves during pregnancy, prolonged standing or sitting and heredity.

Sclerotherapy which consists of local injection of substances that kill endothelial cells, lining blood vessels, remains as the gold standard of treatment for telangiectasias of the lower extremities. Facial telangiectasias are less responsive to sclerotherapy than those located on the leg and more prone to complications. Therefore, laser treatment in general has greater role for treating facial telangiectasias. With a 532nm KTP laser and laser pulse duration in the millisecond range, good to excellent results can be obtained on facial telangiectasia with minimal side effects. Based on theoretical considerations, longer wavelengths and longer pulse durations would be more appropriate for the treatment of almost all leg veins. Longer wavelengths are needed to penetrate deeper into skin. Longer pulse width produces less mechanical injury, with more uniform thermal damage of large vessels and not purpura (blood bleeding into skin from blood vessels).

Recent laser treatments for other vascular lesions:

1. Pigment lesions:

Q-switching lasers (QSL) have higher energy and are successfully used to eradicate a variety of pigmented lesions including freckles, birthmarks including blue naevi, congenital lanocyclic naevi and Becker's naevi. Short pulse laser systems are more effective since they confine energy to melanosomes containing tiny granules of melanin inside pigment cells. The results depend on depth of melanin and the colour of lesion.

2. Tattoos :

Q-switched laser can selectively destroy tattoo pigment without causing much damage to the surrounding skin. The altered pigment is then removed from the skin by scanning white blood cells and tissue macrophages. The choice of laser depends on the colour, depth and chemical nature of tattoo. 2- 10 setting treatment is required for complete cure.

3. Facial laser re-surfacing ,scars & sun damaged skin:

High energy pulse CO₂ laser and erbium YAG lasers have been successfully used in reducing and removing facial wrinkles, acne scars, and sun damaged skin, side effects like redness scarring & tenderness last for several weeks while new skin glows over the area & damaged skin has been removed by laser treatment. Vaporizing CO₂ laser, erbium YAG laser and PDT are used to eradicate hypertrophic scars and Keloids. Also PDL has been successfully used to reduce the side effects like redness thereby improving the texture and pliability of scars, CO₂ & PDL laser are also removes water by vaporization. CO₂ laser & XeCl excimers lasers are used to remove variety of skin lesions like skin cancers by vaporizations or in cutting modes.

4. Varicose vein removal:

Varicose vein removal through laser is a new effective and revolutionary way to treat this condition. It doesn't require laborious surgery but rather gentle intersection of needle. Here powerful burst of laser light is sent into the varicose vein via tiny laser catheter inside the fiber needle. The heat from impinging light causes the veins to seal and subsequently either end and for reabsorbed into the body. It requires a skilled doctor who has good experience in varicose vein removal. This treatment has been performed in Renaissance laser and vein clinic in U.S successfully. The treatment requires less than an hour depending upon severity of the problem and more than one treatment if required. Local anesthesia can also be given to the patients.

5. Spider vein treatment:

Unwanted veins on the hands, face, legs and body are called spider veins. They can cause a patient a lot of embarrassment. Many men and women suffering from spider veins has been recovered successfully by laser treatment. Advanced laser technology requires only 10-15 minutes treatment were laser targets the pigmentation in the vein, sending blast of laser energy to that pigment and obliterating the vein. During spider vein treatment the vein should close permanently and begins to fade away. Some spider veins disappear immediately from patients body following the laser treatment (or) sometimes it takes a months time to fade away. For complete and permanent remedy requires single to three setting of treatments.

Safety measures:

The following precautions are to be followed during the laser treatment.

1. Treatment should be carried out using trained personnel (specialists).
2. Eye protection of patients and clinical staff.
3. Warning notice outside the treatment room.
4. Use of Non- Reflective instruments.
5. Removal of inflammable material.

Side effects of laser treatments:

1. Temporary pain, redness, bruising ,blistering and crusting.
2. Pigment change (brown & white marks) which may be permanent.
3. Scarring.
4. Infection

III.CONCLUSION

From the discussion about the application of lasers in dermatology we can say that the laser treatment is an effective and efficient one consuming less time for treatment (operation)without blood loss and subsequent healing . Since the lasers are also available in different powers and wavelength so that one of them may suits for one treatment varying from surface to in depth parts of skin with minimum side effect.

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