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Treatment of Oral Conditions by 810 nm Diode Laser

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Abstract: Background: When laser light incident on biological tissue, it is either reflected from the surface of the tissue (e.g. the skin) or scattered inside the tissue or absorbed .The laser light will be absorbed by water, hemoglobin and melanin. Absorption is also highly dependent on wave-length of laser radiation. The absorbed light is converted into kinetic energy leading to laser effect that when appropriately applied can produce reaction ranging from incision, vaporization to coagulation. **Aim of the study:** To evaluate the efficiency of diode Laser 810 ± 20nm in treatment of oral lesions. **Methods:** 6 patients (2 females and 4 males) with different oral lesions were treated in the hospital of specialized surgeries by the use of diode laser 810 nm, the lesions were: Apthous, Lichen planus, Pyogenic granuloma, Second stage of implant. **Results:** The result of the study depended mainly on the clinical observation during operation and in the follow up period. The results show that there was no pain, no bleeding, and no infection while the edema and necrosis at the operation site are present. **Conclusion:** Laser can be used to perform haemostatic surgery, decrease rate of infection and reduce post operative discomfort.

Keywords: laser in dentistry, laser oral surgary

Introduction

The term thermal interaction stands for a large group of interaction types. In photothermal interaction thermal effects have their origin in bulk absorption occurring in molecular vibration-rotation bands followed by nonradiation decay, transferring the photon energy to kinetic energy to the surrounding molecules (Aratal, et al. 2003).

Thermal interactions are largely wavelength dependent because the amount of heat generation in the tissue is determined by the extent of preferential absorption of the beam attributable to wavelength and target specificity. (Hsin et al. 2005)

Thermal effects can be induced by either continues wave (cw) or pulsed laser radiation. Temperature is certainly the governing parameter of all thermal laser tissue interactions. Therefore the temperature raise originates from the transfer of light photon energy into kinetic energy. In other word, the thermal effects have their origin in bulk absorption of laser light. In biological tissue, absorption is mainly due to the presence of free water molecules, proteins, pigments and other macromolecules. (Ik ateriua and G.Borisona, 20004).

An important aspect is that the target molecules have a similar energy level structure as the laser wavelength. The absorption coefficient strongly depends on the wavelength of the incident laser radiation. Heat generation is determined by laser parameters and optical tissue properties primarily like irradiance, exposure time, and the absorption coefficient which is the function of the laser wavelength. For thermal decomposition in tissues, it is important to minimize thermal damage to the adjacent structure to have the less possible necrosis. Thermal damage to adjacent tissue can be kept minimal if the wavelength that is selected is strongly absorbed by the tissue (Hsin et al. 2005).

Heat effects depend on the type of tissue and temperature achieved inside the tissue. Assuming a body temperature of 37°C no measurable effects can be observed. When temperature is raised to 42-50 °C hyperthermia will result. If the hyperthermia lasts for several minutes a significant percentage of tissue will already undergo necrosis. Beyond 50°C a measurable reduction in enzyme activity and cell immobility is observed. At 60°C denaturation of proteins and collagen occur that lead to coagulation of tissue and necrosis of cells. This coagulation phenomenon is the basis of most of the surgical application of lasers. At 80°C the membrane permeability is increased and tissue dehydration is observed. Further increasing the temperature results in superheating of tissue. So at 100°C, water molecules in most tissue start to vaporize. The vaporized heat has an advantage, that the vapor generated carries away the excess heat and help to prevent further increase in the temperature to the adjacent tissue. If all water molecules have been vaporized and laser exposure continuous, then at 150° C, carbonization takes place, which is observed by blackening of tissue and escaping of smoke, finally, at 300°C, melting can occur. Carbonization can occur with any type of laser if sufficient power density and exposure duration are provided (Hsin et al. 2005).

The location and spatial of each thermal effect depend on the locally achieved temperature during and after laser exposure. The proportion of laser light that is absorbed, scatter, transmitted, or reflected by tissue is wavelength dependent. For example, for the visible and near infrared lasers, virtually no absorption occur in biological molecules unless chromophores like hemoglobin. pigment, and melanin are present. (Ik ateriua and G.Borisona 20004)

Material and Methods

Eight different lesions from 6 patients were treated as shown in Table (1):-

- Pyogenic granuloma.
- The second stage of implant in which we exposed the implant and in this sample we had 2 variants, either we remove only soft tissue which is the gum or both soft tissue and sometime bone to expose the implant.
- Lichen planus.
- Apthous.

Table (1): Types of the lesions:

The lesion types	Patient no.	Lesion no.
Pyogenic granuloma	2	2
implant	2	4
Licken planus	1	1
Apthous	1	1

Table (2): Laser dose parameter according to the lesions:

Lesion	Mode	Power -W-	Exposure time -sec-	Power density -W/mm^2-
Pyogenic granuloma	Contact	5	180	10^{-3}
2nd stage of implant	Contact	Bone-8 Soft tissue-5	240	$2x10^{-3}$ 10^{-3}
Licken planus	Non contact	5	180	$2xl0^{-3}$
Apthous	Contact	5	60	$2.5xl0^{-3}$

The surgical diode laser system consists of three main components:

1. The main enclosure or in other word the housing which include all the optics, micro processor based control electronics and power supplies.
2. Foot switch to activate the radiation when it is set at the ready mode.
3. Optical libers for delivering the radiation to the tissue.

Two types of modes are used in treatments of lesions:

a. contact mode: which is used in the treatment of:

1. Pyogenic granuloma.
2. Implant.
3. Apthous.

b. Non contact mode:which is used in the treatment of Lichen planus.

According to the power there are two groups:

a. 5 W-group: which is used in the treatment of soft tissue lesion.
b. 8 W-group: which is used in the removal of bone during 2 second stage of implant (implant exposure).

Results

The results of this study depend mainly on the clinical observation inspection, patient compliant during operations and in the follow up appointments.

Table (3): Clinical observations and evaluations of results

Clinical sign and symptom	Symptom
Pain	Negative
bleeding	Negative
Edema	Positive (mild)
Infection	Negative
Necrosis of the operation site	Positive (mild)

Pain

Due to the fact that all the patients in this study were anesthetized during the surgical operation by local infiltration of the anesthesia; containing adrenalin at concentration at 1:80000 therefore there were no pain during the surgical operation.

Bleeding

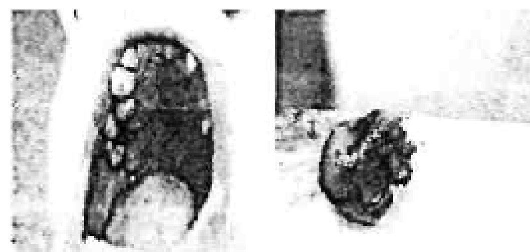
During the surgical operation there was no bleeding which gave clear surgical field. This was very useful especially in the treatment of lichen planus and in the second stage of implant procedure in order to expose the implant. Also no bleeding followed the operation.

Edema

There was mild edema extra orally 2 days after the surgery, and then it subsided gradually.

Infection

There was no infection in all the patients treated, although all the patients covered with antibiotic post surgery. The antibiotic used was Amoxicillin cap. 500mg, 3 times daily for five days. Necrosis of the operation site: One day following the operation the intra oral examination showed dark-brown necrotic tissue, friable with red inflamed line around the edges. After five days, the observation revealed that the sloughed tissue was completely changed to white color and was easily removed by gauze after 10 days. The inspection of the operated site showed complete healing as in Figure (1).



Pre operative Post operative

Fig. (1) The inception of the operated site

Discussion

Photothermal effect with tissue is the basic concept of Surgical Diode Laser (810-820 nm). In this process, the radiant light is absorbed by the tissue and transformed to heat energy changing tissue structure. Laser light within (810-20 nm) was converted to thermal energy on contact with tissue, causing laser tissue interaction, that when appropriately applied, can produce reaction ranging from incision, vaporization to coagulation (McDaniel DH.1990).

This wavelength has affinity for melanin or dark pigments, and is strongly absorbed by the blood hemoglobin, which contributes to their thermal effect. Therefore, this type of laser is more effective when the energy applied in the presence of pigments (McDaniel DH.1990). This is the reason of homeostasis which occurs with this wavelength. Through the heating of elements, and by direct sealing of small blood vessels, by desiccation and contraction of the vessel wall. In the preliminary study, Surgical Diode Laser creates a wound that can be characterized as thermal injery. The fiber was kept in steady motion and in contact mode that was used directly over the target tissue. The heated tip of the optical fiber was used as a knife to create thermal effects. So keeping the fiber in one spot will gradually heat a growing mass of tissue in that spot and will produce a laser wound, the depth of penetration of the laser wound made by a contact probe will vary with the power used and duration of exposure time (Frank Schwarz, 2003). Equation (1) shows that the longer the laser exposure time to tissue, the greater is the energy, and the thermal effect, which represents in the laser crater (Frank Schwarz, 2001), since the power is constant. Therefore, when the energy varies, the energy density will vary too.

$$Ed = E / Area \qquad (1)$$

Again, here the area was constant and the energy was variable, so the energy density increase as the energy increased. In comparison between the two laser groups of power dose parameters, in 8 W and 5W with different pulse intervals and pulse durations, it is obvious that, a laser pulse of long duration and a thermal relaxation time causes more penetration than of short pulse duration and long pulse interval. The reason for that is related to the fact that the energy deposited with less thermal relaxation time and therefore has more penetration depth that is directly proportional to the total time of exposure (Miserendino L J., and Pick M. 1995).

Moreover, the rate at which heat energy is dissipated in the tissue will also have influence, the extent of thermal damage to the surrounding tissue. The time required for diffusion of heat or thermal relaxation time (T_{therm}) for a given type of tissue is related to its composition and vascularity. T_{therm} is defined as the time required for specific tissue to cool down to 37% of its original value. Therefore, the extent of tissue damage will be both power-and-time dependent (Moss. S. L., and Hendricks. K. M. 1985). Changing from contact mode to non-contact mode will create larger spot size and will result in a lower power density across the area of the beam, thus causing the superficial layer to be vaporized (Macer C. 1996).

From all above it is obvious that the amount of laser light energy absorbed into tissue depends on factors that include wavelength of the radiant energy from the laser, spot size, power, pulse duration, thermal relaxation time and the composition of the target tissue. In addition, to laser type, the way the light is absorbed in tissue and the manner in which the light is applied, all affect the surgical outcome. In surgical practice, the collateral damage is dependent on the target tissue composition such as: water content, vascularity, volume of radiated tissue, and tissue surface. Furthermore, radiated energy and length of radiation are important factors in this process (Pick R M., and Powell G.L.1993).

For a non-contact mode, 5W laser dose parameters allowed good haemostatic and vaporization effect, through the heating of elements, and by direct sealing of small blood vessels, by desiccation and contraction of the vessel wall. It displayed greater haemostatic capability also it is concluded that non-contact surgery reduces the potential of contamination of the wound by thermal destruction of bacteria that explained the lack of infection (Pratesi R. Sachhi C A. 1980)

For various white lesion ablations, studies showed that the CO_2 laser is the most applicable laser because of its ability to ablate tissue rapidly in the defocused mode with minimal underlying tissue damage. Also, at lower power (3 to 4)W and in the highly defocused mode, the CO_2 laser allows the tissue to blister and causes certain lesions to separate at the basement membrane, allowing the clinician to laser peel the lesion away (Leo and Robert 1995).

Also from the studies, the CO_2 laser can also be used to remove granulation tissue. It should be used in the focused or near focused mode, and power settings should from 1-2 W when working in areas of larger openings or better accessibility. Higher power settings can be used but, again, with caution. Other wavelength such as Argon or Nd:YAG may prove to be more practical for this application (Aratal et al., 2003).

For coagulation of bleeding areas, coagulation of soft tissue graft donor sites, or other small, oral bleeding areas, CO_2 lasers can be effective. For active bleeding sites. Argon. Nd:YAG and Ho:YAG are the lasers to be chosen in non bleeding areas, to prevent subsequent bleeding, not all lasers are applicable.

Conclusions

Laser is able to perform haemostatic surgery by sealing blood vessels result in a clean, dry, and sealed wound. Laser is also able to decrease the rate of infection following surgery. In addition, laser seal the lymphatic vessels at the time of surgery which decreases the swelling and edema. Another advantage of using lasers is the possibility of cauterizing and sealing nerve ending which reduces post operative discomfort such as pain sensation. Also the char layer acts as a bandage and permit a traumatic healing.

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الخلاصة حالات مرضيه في الفم تعود الى ستة مرضى (اثنان اناث،اربعه ذكور) تمت معالجتها بواسطة دايود ليزر في مستشفى الجراحات التخصصيه/ دائرة مدينة الطب .اعتمدت نتيجة هذه الدراسه على الملاحظات السريريه اثناء العمليه وخلال فترة المتابعة وكانت النتائج هو عدم وجود الم بعد العلاج ونزف والتهاب في مكان العمليه. في حين كان هناك تورم مابعد العمليه وتقرح عند مكان العمليه.