CASE REPORT

Temperature variations and the histological impact of diode laser irradiation on oral soft tissue at two different application modes

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Padmanabhan AK, Paramashiviah R, Prabhuji MLV. Temperature variations and the histological impact of diode laser irradiation on oral soft tissue at two different application modes. Dentist Case Rep. 2018;2(3):48-51.

ABSTRACT

INTRODUCTION: The superior properties of diode lasers such as sterilization, coagulation and ease of use has made revolutionary improvement in treatment aspects in dentistry. The light energy emitted by the laser is absorbed by tissues which gets converted to heat and may cause undesirable tissue damages in the periodontium. A threshold temperature increase of 7°C is considered as the highest biologically acceptable temperature increase to avoid periodontal damage. Thus, this questions the utility of laser in the wide array of surgical periodontal therapies such as excision, grafting and regenerative procedures.

MATERIALS AND METHODS: In this study, the temperature variations while using 810 nm diode laser for cutting and biostimulation of soft tissues in operculectomy and gingivectomy procedures were investigated with an infrared thermometer. Temperature was recorded before, during and after the procedure in a thermally controlled environment.

RESULTS: There was an increase in temperature at the site of diode laser application when used for cutting with an average increase of 4°C. On histological examination of the biopsied specimens where laser incision was performed, signs of thermal damage such as hyperpigmentation, hyalinization and vacuolization were assessed. Biostimulated tissue did not show any signs of thermal damage on histological analysis.

CONCLUSION: In accordance with the results of the study, although there was a temperature increase and thermal injury to the tissues, laser irradiation did not induce a temperature change high enough to cause irreversible damage to the soft tissues. The histological observations such as coagulation of capillaries and hyalinization could be an indication that laser may not be ideal for harvesting grafts as it causes disruption of the vascularity. Laser also distorts histology, mimics dysplasia and hence interferes with diagnosis of the pathologist during biopsy.

Key Words: *Diode laser; infrared thermometer; operculectomy; gingivectomy; thermal damage; histological analysis*

Use of lasers in dentistry has made significant progress which has led to an explosion of research in photobiomedicine. When the dental laser light falls on tissues, it is absorbed by the tissues and gets converted to heat. The thermal effects of this heat depend in large parts on tissue composition (i.e. The amount of water, organic and inorganic components in the tissue) and the time interval that the beam is focused on the target tissue (1,2). The longer the duration of exposure, the higher the temperature which in turn may lead to alterations in the structure and composition. These changes may range from denaturation to vaporization and even carbonization (1,3,4).

Among the three types of laser-tissue interactions namely photothermal, photochemical and photoionizing, the most studied is photothermal interaction. During surgical procedures, a threshold temperature increase of 7-11°C is considered the highest biologically

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Received: November 21, 2018, Accepted: December 18, 2018, Published: December 26, 2018

acceptable temperature increase to avoid any irreversible periodontal damage (5,6).

The thermal variation in biological tissues under laser irradiation is an important investigation for the establishment of safe parameters before any clinical application. Thus the question arises about the safety of utilizing lasers for a wide array of surgical periodontal therapies such as excision, grafting, and regenerative procedures.

There have been several techniques employed to measure the temperature variations on the human body such as a conventional mercury-based thermometer, digital thermometer, thermal camera, infrared thermometer etc.

Amongst them, Infrared (IR) thermometer is the most recent and a feasible option. It is fast becoming a staple item in health care operations and has revolutionized routine care procedures by dramatically reducing the lag time associated with temperature determination in diagnosis thereby increasing efficiency.

An infrared thermometer records temperature from a portion of the thermal radiation sometimes called "black body radiation" emitted by the object being measured. They are also called as "Laser Thermometers", Non-Contact Thermometers", or "Temperature Guns", as a laser beam is used to aim the thermometer and it aids in the measurement of temperature from a distance (7).

Information on the appropriate usage of the laser is not well documented in the literature and hence that is the focus of our study. The objective of the present case report was to analyze the temperature variations and the histological signs of thermal damage of laser irradiation on oral soft tissues at two different application modes i.e. cutting and biostimulatory with an Infrared Thermometer.

MATERIALS AND METHODS

Two female patients aged 24 and 22 years requiring operculectomy and gingivectomy procedures respectively reported to the OPD and were included in the study. Both a verbal and written informed consent was obtained from each of the patients prior to the procedure.

A diode laser unit (810 nm) was used for the treatment procedures. The temperature variations were assessed with an IR thermometer.

CASE 1

A 24-year-old female patient with a chief complaint of pain in the lower left posterior region was diagnosed with pericoronitis. Local anesthesia was achieved with lignocaine 2%. Baseline superficial temperature at the site was measured as 31.8°C (Figure 1a) in a thermally controlled environment (at 23°C room temperature). The patient was then subjected to operculectomy procedure with Diode laser diode laser at a power setting of 3-4 W in continuous wave mode. The temperature was then measured during and after the procedure with the IR thermometer (Figure 1b). The excised tissue was collected and placed in 20% formalin solution and sent for histological examination.

Figure 1a) *Baseline temperature at the operculectomy site measured with IR thermometer*

Figure 1b) *Temperature increase measured with and IR thermometer during laser excision*

CASE 2

A 22-year-old female patient with a chief complaint of excessive gingival display in the maxillary anterior region was diagnosed with gingival enlargement confined to the maxillary left lateral incisor region.

After local anesthesia was achieved, Baseline superficial temperature at the site was recorded as 32.6°C (Figure 2a) in a thermally controlled environment (at 23°C room temperature).

The hyperplastic tissue to be excised was subjected to Low-Level Laser Therapy (LLLT) at 100 mW, continuous wave mode for 60 seconds with a maximum energy distribution of 6 J/square centimeter of the tissue.

The temperature was then measured during and after the procedure with the IR thermometer (Figure 2b). The irradiated tissue was then excised with a scalpel no 15 and sent for histological analysis.

RESULTS

The temperature increase noted when the diode laser was used for excision was between 4-5°C. The extent of thermal damage was noted

from the width of the damaged tissue adjacent to incision stained positively for H/E (Figure 3). There was no significant temperature change when low-level laser therapy was performed (Figure 4).

Figure 2a) *Baseline temperature at the gingivectomy site measured with IR thermometer*

Figure 2b) *No temperature change recorded during biostimulation procedure*

HISTOLOGICAL ANALYSIS

The biopsied specimens of tissues excised with laser showed evidence of thermal damage such as hyperpigmentation, cellular derangement, carbonization, and hyalinization. Tissues subjected for LLLT did not show any signs of thermal damage on histological analysis (Figure 3).

QUALITY OF INCISION

The depth, width and the margins of the incision demonstrated in the histological section showed thermal damages within the biologically acceptable limits and no irreversible damage (Figure 3).

DISCUSSION

Laser irradiation has several effects on the oral tissues. In general, the effects resulting from the laser-tissue interaction are thermal and dependent on the optical characteristics of the light and thermal properties of the exposed tissue. Optical penetration of incident light within the tissue depends on local reflection, absorption, and scattering of light (8). Absorption and scattering are responsible for the conversion of electromagnetic light energy into thermal energy (9-14). The thermal variation in biological tissues under laser irradiation is an important investigation for the establishment of safe usage parameters before any clinical application. The temperature increase can cause different reactions, depending on specific tissue characteristics.

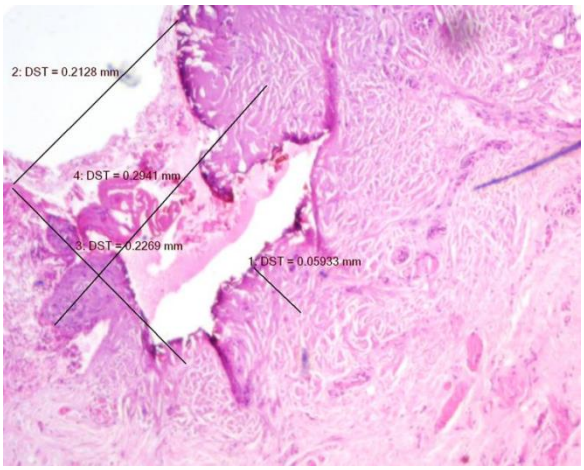

Figure 3) *Histological picture of the tissue that was excised with diode laser showing hyperpigmentation, cellular derangement, carbonization, and hyalinization. The extent of damage is measured as the width of the tissue adjacent to incision stained positively for H/E*

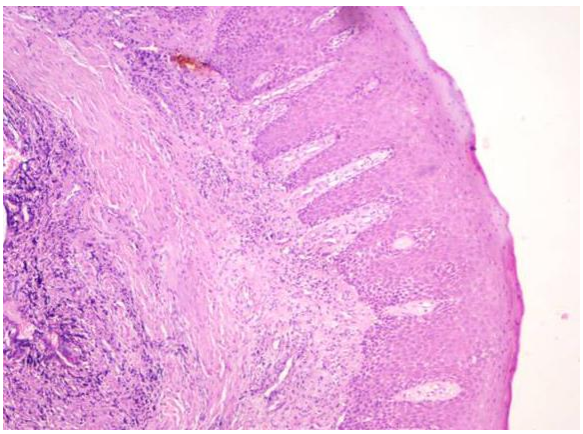

Figure 4) *Histological picture of the tissue that was subjected to biostimulation showing no signs of thermal damage*

The purpose of this study was to determine the temperature variations and the histological impact of the temperature increase on oral soft tissues. The evaluation of soft tissue thermal variation under laser irradiation is a complex task. Several factors can contribute to the heat

generated in tissues. Some of them such as tissue characteristics cannot be controlled. On the other hand, the laser parameters used for irradiation can easily be altered. Moreover, the thermal conductivity of the tissue and its thermal dissipation are dependent on the water and pigment concentration (chromophores) and the blood circulatory conditions (8). In order to decrease the bias due to age or gender differences, the patients recruited for the study were age and sex matched.

The use of Infrared thermometers is quite simple and the accuracy for assessing temperature is high compared to the conventional methods. As opposed to the prior temperature measuring device namely conventional mercury thermometers, an IR thermometer is a sophisticated optical electronic assembly with precision designed and assembled components requiring exacting specifications for its proper operation.

Infrared thermometers are characterized by specifications including accuracy and angular coverage. Simpler instruments may have a measurement error of about ± 2°C or ± 4°F.

Carla Raquel Fontana in 2004 evaluated the temperature variation induced by a diode laser in periodontal repair and showed that laser did not induce a temperature variation high enough to cause thermal irreversible damage to the periodontal tissues (8).

S Shahi studied the Thermal Changes in Dental Soft Tissue under 810 nm Low-Level Diode Laser Radiation which also revealed no damage to tissues (15).

The results of this study are concurrent with the results of previous studies performed on diode laser interaction on oral tissues. The key finding was the dysplasia like alteration in the histology of the tissues at the margins of excision. This may create confusion for the pathologist during routine biopsies.

CONCLUSION

The laser is one of the effective treatment options available with minimal complications and has been widely discussed in the literature. In accordance with the observations of the present case report, it could be concluded that although there was temperature increase and thermal injury to the tissues, laser irradiation did not induce a temperature change high enough to cause irreversible damage to the soft tissues.

The histological observations such as coagulation of capillaries and hyalinization could be an indication that laser may not be ideal for harvesting grafts as it causes disruption of the vascularity.

The laser also distorts histology, leading to a false diagnosis in the biopsy report.

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