

Heat Generation by Diode Laser (1064-nm) on Dental Implants. (An in vitro study)

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الخلاصة

الأهداف: الهدف من هذه الدراسة هو تقييم التغيرات في درجة حرارة زرعة الأسنان عند استخدام ليزر ديود بواطيات مختلفة (ليزر فوكس 1064 نانومتر) وتعيين إعداد طاقة مقترح ليس له تأثير ضار على العظام المجاورة. **المواد وطرائق العمل:** تم استخدام غرسات التيتانيوم وبعدها 75 مع براغي الشفاء في هذه الدراسة. تم استخدام تقنية المزدوجة الحرارية لقياس مستوى درجة الحرارة المتولدة أثناء التعرض لليزر. تم تثبيت الغرسات في نموذج سفلي أكريليكي ثم تم وضعها في حمام مائي متحكم فيه عند 37 درجة مئوية. تم تسجيل الملاحظات الزمنية (إلى 47 درجة مئوية) بعد أن تغير كل واط أيضاً وقت إسقاط درجة الحرارة إلى 37 درجة مئوية. **النتائج:** ارتبط انخفاض الوقت اللازم للوصول إلى 47 درجة مئوية ارتباطاً مباشراً بزيادة الواطية، لذا فإن الوقت مرتبط عكسياً بالواط. انخفضت جميع مقاييس وقت التسجيل إلى 37 درجة مئوية مع عدم وجود فروق ذات دلالة إحصائية. **الاستنتاجات:** يمكن الاستنتاج أن استخدام ليزر ديود في 6 واط مع الموجة النبضية تنتج درجة حرارة عالية مع أقل وقت بينما استخدام 2 واط تحتاج إلى مزيد من الوقت لإنتاج نفس الحرارة.

ABSTRACT

Aims: The aim of this study was to assess temperature changes of dental implant body when using different wattage of diode laser (Fox laser 1064-nm) and set a proposed power setting that has no detrimental effect on adjacent bone. **Materials and Methods:** Seventy-five Titanium implants with healing screws were used in this study. Thermocouple technology was used to measure the temperature level generated in the dental implant body when being exposed to laser. The implants were fixed in an acrylic mandible model and then placed in a controlled water bath at 37 °C. Time to reach a temperature degree of 47 °C were recorded after each wattage as well as the dropping time of temperature to reach a degree of 37° C was recorded. **Results:** The decrease in time needed to reach 47 °C was directly related to an increase in wattage and as such the time is inversely related to wattage. All the recording time measures dropped to 37 °C with no significant differences. **Conclusion:** It can be concluded that using diode laser in at 6 wattages with pulsed wave settings produced high temperature with minimum time compared when using 2 wattage settings which needed more time to produce the same heat

Keywords: Dental implant, laser, Heat generation.

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INTRODUCTION

The use of endosseous implants in dentistry has increased dramatically over the last 20

years^(1,2). With dental implant therapy complications may occur which could either be prosthetic or biological complications or both. Suc-

cess has been demarcated recently ⁽³⁻⁵⁾. Peri-implantitis is the most common biological complication around dental implants. A current consensus report concluded that peri-implantitis is a bacterially induced inflammation of the supporting peri-implant tissues leading to non-reversible bone destruction ⁽⁶⁻⁸⁾. The incidence of peri-implantitis fluctuates from 11.3 to 47.1% after 8 years. ⁽⁹⁾ Numerous treatments have been recommended for peri-implantitis in the literature such as physical method plastic curettes, scaling, ultrasound. ⁽¹⁰⁾, local chemical antibiotics, antiseptic solutions. ⁽¹¹⁾ systemic methods, ⁽¹²⁾ or a combination of these. ^(13,14) The use of laser in the dental field has encouraged research for determining its effectiveness in the treatment of peri-implantitis. ^(15,16) The revolution for dental laser came in the middle of the 1990s. Many laser types with corresponding wavelengths, diode laser rapidly began establishing itself as a compact, competitively priced, and versatile accompaniment to the dentist's collection mostly used on soft tissue applications ⁽¹⁷⁾ Diode lasers can be used for numerous dental events which are frequently soft tissue procedures. ^(18,19) Diode lasers have been suggested for uncovering submerged implants. ^(20,21) decontaminating implant surfaces when treating peri-implantitis ⁽²²⁾ and, periodontal pocket therapy ⁽²³⁾. The thermal effect of

laser beams on implant surfaces is widely studied. These studies have revealed that thermal injury at the bone-implant site impedes the regenerative reaction of bone healing, hence reducing osseointegration leading to subsequent implant mobility. ⁽²⁴⁻²⁶⁾ It has been established that if bone is warmed up to a temperature of 47°C for one minute, bone necrosis, which obstructs the osseointegration of an implant, can occur. However, heating to temperatures lower than 47°C did not seem to affect the bone tissue at the microscopic level, but vascular injury, as evidenced by increased capillary leakage, could not be excluded at even lower temperatures. ⁽²⁷⁾ The aim of the current invitro study was to assess temperature changes of dental implant body when using different wattage settings of diode laser (Fox laser 1064-nm) and set a proposed power setting that has no detrimental effect on adjacent bone.

MATERIALS AND METHODS

This study was conducted at the department of Oral and Maxillofacial Surgery / College of Dentistry / University of Mosul. Dental implants with SLA surfaces were used in this study (3.3 *10 mm) (Leader, made in Italy). A motor system (NSK, made in Japan) was used for insertion of the dental implant (Figure 1).

Diode Laser (1064-nm) on Dental Implants

Diode laser (FOX Laser, ARC Laser GmbH, Germany) was used in pulse mode with a spot size of 600 μ (puls on 50 ms and puls off 100 ms (Figure 2). A Synthetic mandible model (Sawbones, Swedish-made) produced from solid foam was used as a model for implant insertion (Figure 3). A water bath with a thermostat-

ic temperature-control device maintaining the water temperature at 37°C (C.K type KI&BNT made in china) was used (Figure 3). Thermocouple electrodes (K-type made in china) were used to measure the temperature (Figure 3). An electronic timer was used to record reading in seconds ⁽²⁸⁾.



Figure (1): NSK motor system



Figure (2): Diode laser

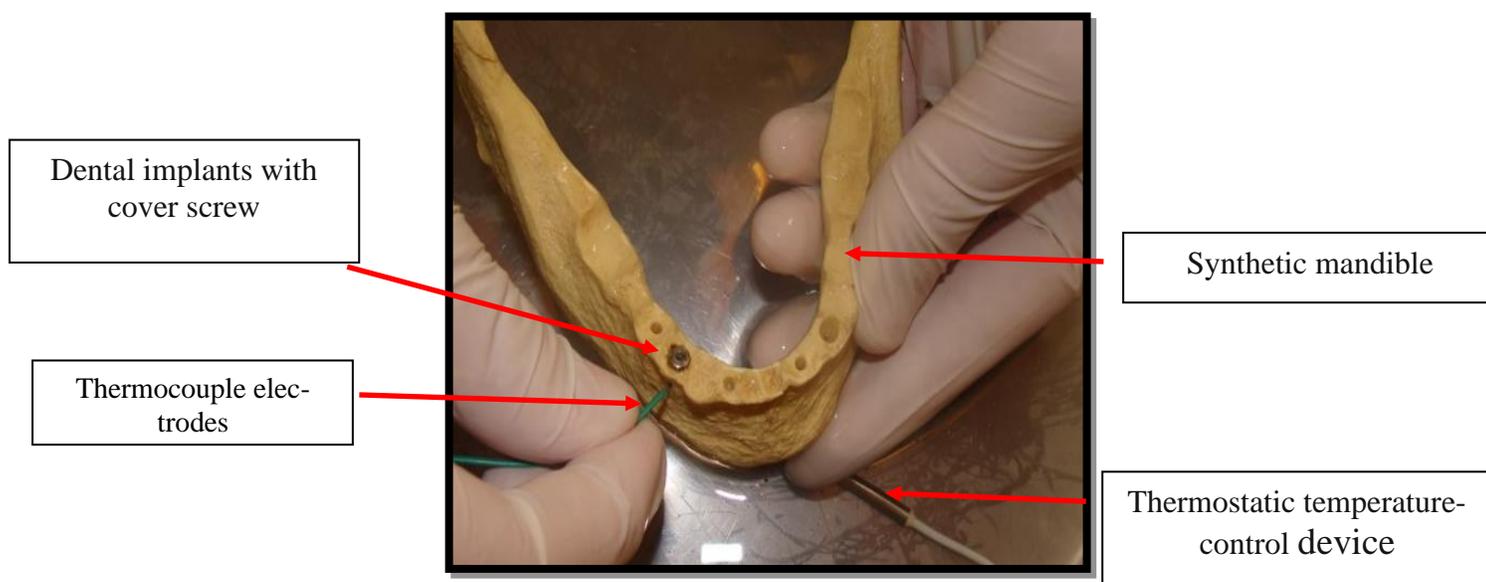


Figure (3): Method used.

Dental implants with an SLA surface with 3.3mm in diameter and 10 mm in length were inserted in the mandible model by using a mo-

tor system of dental implant preparation which began with an initial Linderman drill (2.2 mm) then a first drill (2.6 mm) followed by final

drill and finally by countersink. The drill speed was set up to 1062 RPM and torque kept at 50 n\cm and gear ratio stabilized at 1:32. After completion of implant insertion, the cover screw was placed in its position. The mandible model was immersed in the water bath with a thermostatic control mechanism keeping the water temperature at 37°C. Thermocouple electrode heads were attached to the exterior surface of the fixed implant at its cervical facets and the head of the thermocouple wires were insulated from water. The tip of the laser was positioned in non-contact mode two millimeters away from the center of the cover screw perpendicular to the implant long axis and then laser exposure was initiated following the protocol of safety. The dental implants were separated into five groups according to laser watt used (2,3,4,5,6 watts respectively) with each group of 15 dental implants making a total of 75 implants and 20 temperature readings in each group. An electronic timer was used to measure the time needed to reach 47 °C and the time needed to drop to 37°C after laser application.

Statistical analysis

Data were processed using the statistical analysis program (SPSS version 21 for Windows 10 Pro), Lenovo laptop, think pad L460. Mann-Whitney test was used for comparing between different powers and time during temperature rises to 47°C. The relation between the time and the powers used was assessed using Kruskal -Wallis for dropping of temperature to 37°C. The level of significance considered was set at $p < 0.05$.

RESULTS

The mean time required to raise the temperature to 47°C at 2 watts was (126) seconds, at 3 watts (93.2) seconds, at 4 watts (73.7) seconds, at 5 watts (68.4) seconds and at 6 watts was (61.6) seconds. The mean ranks and significance as calculated by the Kruskal-Wallis test for time in seconds needed to rise to 47°C disclosed a significant difference between groups. The results revealed in the Mann-Whitney test (Table2) showed a significant difference in time (seconds) to rise to 47°C between each reading.

Table (1): Mean ranks and p-value of Kruskal -Wallis test for temperature 47°C rise at different powers with mean time in second to reach 47 c.

Power in Watt	Meantime in second to reach 47°C c	Std. Deviation	Mean rank
2	126	2.4	1350
3	93.2	1.5	1050
4	73.7	0.77	750
5	68.4	1.4	450
6	61.6	0.85	150
p-value			0.00

Table (2): Mann-Whitney test for temperature 47 °C at different powers

Relation between Different power in watts	p-value
2-3	0.00
2-4	0.00
2-5	0.00
2-6	0.00
3-4	0.00
3-5	0.00
3-6	0.00
4-5	0.00
4-6	0.00
5-6	0.00

Statically significant at $p \leq 0.05$

Concerning the time that was needed to drop temperatures to 37°C at different powers, Kruskal -Wallis test results showed no significant difference between groups and as shown in (Table 3). The mean time needed for dropping of temperature to 37 °C at 2 watts was (59) seconds, at 3 watts (59.1) seconds, at 4 watts was (59.1)) seconds, at 5 watts (59.1)) seconds and at 6 watts was (58.9) seconds. Mann-

Whitney test results showed no significant differences regarding drop of temperature to 37°C when comparing between each reading with another and shown in (Table 4). As an overall observation, temperatures in the implant body increased as the power settings increased and the time to reach baseline temperature (37°C) showed no significant differences between all groups as shown in Figures (4,5).

Table (3): Mean ranks and p-value of Kruskal -Wallis test for temperature 37°C rise at different powers with mean time in second to reach 37 c.

Power in Watt	Meantime in second to reach 47°C c	Std. Deviation	Mean rank
2	59	0.9	742.92
3	59.1	0.91	769.89
4	59.1	0.9	774.35
5	59.1	0.93	731.60
6	58.9	0.9	733.73
p-value			0.565

Table (4): Mann-Whitney test for temperature 37 °C at different power

Relation between Different power in watts	p-value
2-3	0.414
2-4	0.340
2-5	0.734
2-6	0.772
3-4	0.133
3-5	0.248
3-6	0.383
4-5	0.197
4-6	0.228
5-6	0.960

Statically significant at $p \leq 0.005$

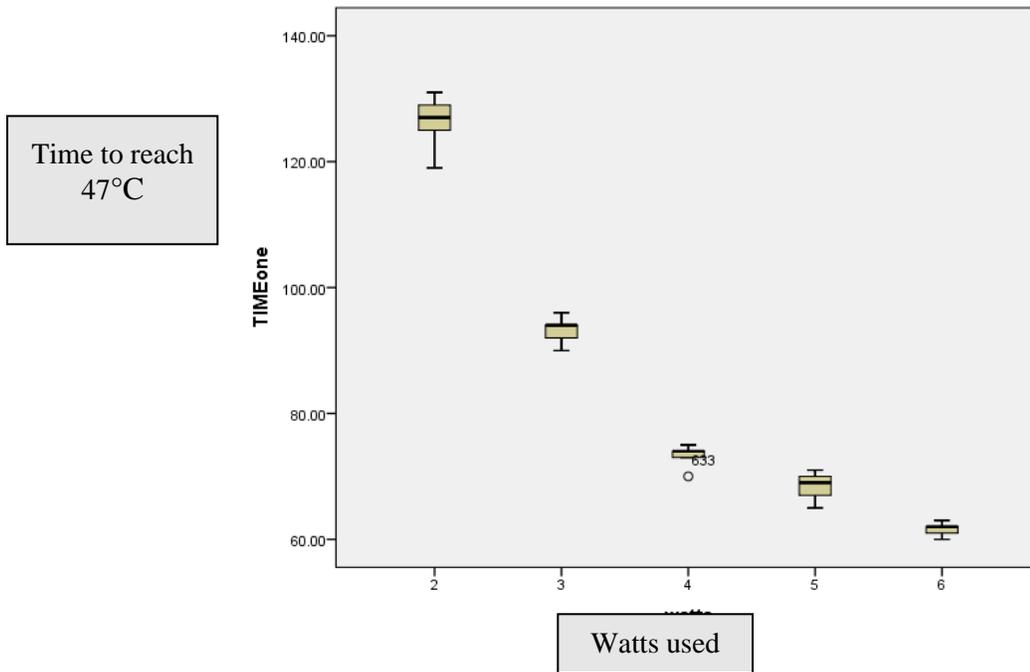


Figure (4): Relationship between watts used and time to reach 47°C

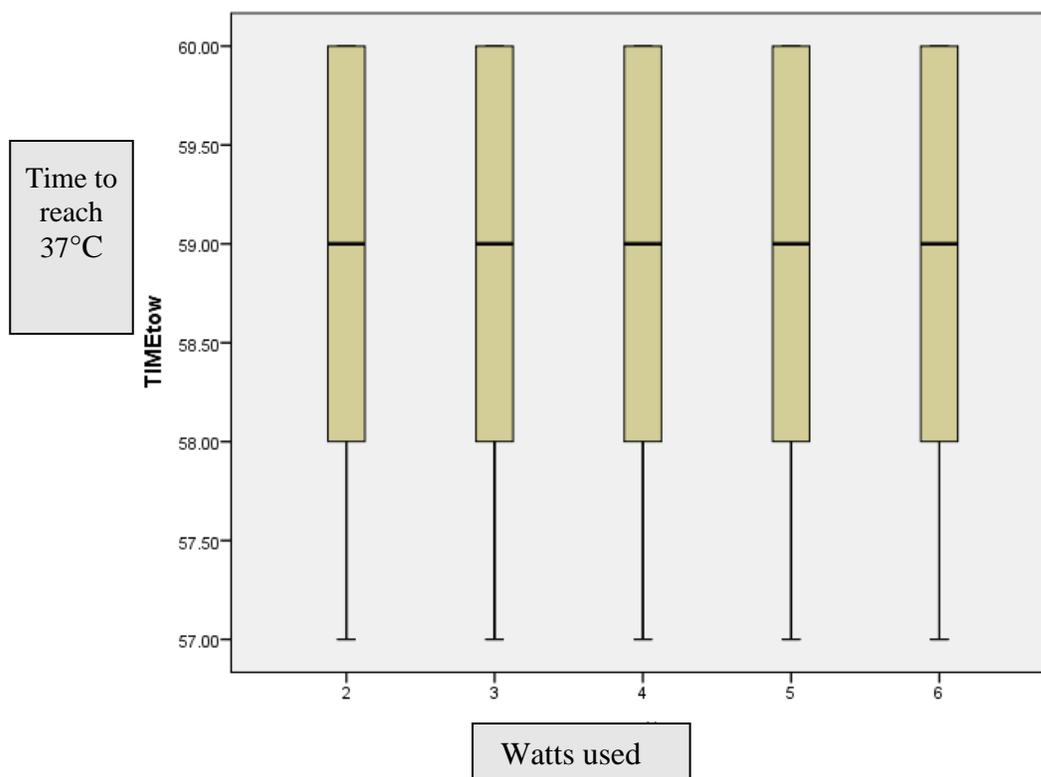


Figure (5): Relationship between watts used and time needed to drop to 37°C

DISCUSSION

The eradication of microorganisms by diode laser though established by numerous studies has some aspects when used for the treatment of peri-implant disease in that the laser beam may disturb the implants titanium surface ⁽²⁹⁻³¹⁾. Such a type of laser and with its power parameters should always be adjusted to avoid the negative changes that may affect the process of osseointegration. The present study inspected the heat generated after exposure to a pulsed diode laser in wave lengths 1064 in an in-vitro model. The results revealed that the exposure power of the laser should be adjusted carefully

to avoid any changing effects on the biological and mechanical levels of the implant. Such results may fluctuate if different bone models are used and if different types of implant systems are used due to differences in the reaction of the laser by the surface form ⁽³²⁾. In some studies, bone injury by heat induction was carried out in rabbits causing adverse effects on living bone when the temperature rised above 47°C for 60 s affecting the ability of bone to regenerate ^(27, 33, 34). The overheating at the bone-implant interface may cause bone death and compromise the bone's ability to stay alive as a differentiated tissue ⁽³⁵⁾. Temperatures be-

yond 50 C are widely believed to promote thermonecrosis⁽³⁶⁻³⁸⁾. It has been established that bone is more sensitive to temperature than formerly supposed, and it will withstand a threshold temperature ranging from 44°C to 47°C for only 1 minute without impaired bony regeneration. However, increasing the temperatures but lower than 47°C did not appear to affect the bone tissue at the microscopic level, but vascular harm did occur as evidenced by increased capillary leakage at even lower temperatures⁽²⁷⁾. The result of this study came parallel with the results of Matys, J., et al whom showed that the temperature on the implant interface increases as the laser power increased⁽³²⁾. Leja, C., et al showed that lower laser power settings and pulsed rather than continuous mode took longer to reach critical temperature⁽³⁹⁾. The main limitation of the current study was the lack of evidence of this type of laser on the surface topography of implant. However, there are studies in this field that can give us some clue on its effects. Particular care should be taken when using lasers in its different types for treatment of peri-implantitis such as Er: YAG, CO₂, Diode, Er,Cr:YSGG(Erbium, Chromium doped Yttrium Scandium Gallium Garnet) and Nd:YAG (Neodymium-Doped Yttrium Aluminium Garnet^(40, 41).

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