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Temperature changes induced by 1064 nm diode laser inside the tooth pulp during enamel etching

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Abstract: This study evaluated in vitro the amount of heat elevation inside the pulp chamber which is very critical for the vitality of pulp tissue during enamel etching by using diode laser (1064).Thirty-six freshly extracted single-rooted human teeth were selected. The teeth were divided into four groups of three each and irradiated by using diode laser (1064) on their enamel surfaces. In groups 1, 2 the enamel surfaces were irradiated with power (4.5,5)watt, Continuous wave. In groups 3,4 the Power(4.5,5)watt, pulse wave(pulse duration 50msec,pulse repetition 5pulse/sec)at time(10,15,20)sec for all groups. The temperature was monitored by means of a thermocouple positioned in the pulp chamber to assess pulpal temperature during and before enamel etching. Temperature measurements were repeated three times for every group after two hour standby period. Mean values were compared statistically with t-test to determine the significant difference among the tested groups at ($p<0.05$) level of significance. The highest temperature rises (18.66 ± 3.05)^{o}c occurred during enamel etching at power5watt, Continuous wave, time 20 sec for every test period. The least temperature increase (2.66 ± 0.57)^{o}c occurred during enamel etching at power5watt, Pulse wave, time 10sec for every test period. These results indicated that the choice of laser types (Continuous or Pulse) and irradiant time is important during enamel etching to avoid any thermal damage to the pulp.

Keywords: enamel etching, tooth pulp, diode laser, Temperature changes.

INTRODUCTION

Among the wide range of lasers now used in dentistry, diode lasers offer many advantages that make them quite popular among dentists. Their low cost, small size and ease of use in the oral cavity owing to fiber delivery are important features that favor their use in clinical practice and encourage new studies (1,2,4,7). Previous studies using diode lasers have demonstrated that the enamel surface of the teeth underwent melting and resolidification. These changes suggest an increase in the resistance of the enamel to acids, thus possibly playing an important role in the prevention of dental caries (12,13).

Thermal insulation to pulpal tissue is the major limiting factor to the use of any laser on dental hard tissues. It is essential that any thermal changes, which do occur, do not pose a risk to the vitality of the pulp. Parameters for thermal injury to dental pulp have been determined by in vivo studies, which have examined pulp pathology following exposure of pulps to various non-laser heat sources (3, 5, 6).This work has defined a 'critical' threshold for pulpal temperature rise of (5.5°C), above which an unacceptably high incidence of pulpal necrosis occurs. Below 5.5°C, reversible and mild pulpitis occur. Below (2.2°C), no histological changes are discernible (6, 8, 10).

The tissue interaction of infrared lasers is caused by thermal conduction and convection of heat. Therefore, one of the main concerns is the effect of infrared lasers on the pulpal tissue and the adjacent tissues (9, 11). Usually, continuous-wave lasers and pulsed lasers with pulse durations in the microsecond range generate considerable heat in the region of the pulp chamber during the irradiation process. This is because, during pulse duration, heat diffusion plays an important role in this type of thermal inducing laser-tissue interaction, especially when the interaction times are in excess of the thermal relaxation time for the dental hard tissue (14).

This study evaluated in vitro the amount of heat elevation inside the pulp chamber which is very critical for the vitality of pulp tissue during enamel etching by using diode laser (1064) .

Materials and Methods

Thirty-six freshly extracted single-rooted human teeth were selected. The teeth samples were extracted over two weeks prior to the study and cleaned free of saliva and debris like blood. The samples were also free of caries and had no visible fracture lines in enamel. The samples were stored in distilled water and the water was changed every day to avoid bacterial accumulation. Each of the samples was cleaned with liquid soap and washed under running water before exposing to laser radiation. The tooth sample was dried before laser treatment. The teeth were divided into four groups of three each and irradiated by using (diode laser 1064, Fox, Germany) (Figure4) on their enamel surfaces. In groups 1, 2 the enamel surfaces were irradiated with power (4.5,5)watt, Continuous wave. In groups3,4 the Power(4.5,5)watt, pulse wave(pulse duration 50msec,pulse repetition 5pulse/sec) at time(10,15,20)sec for all groups. The temperature was monitored by means of a China _Digital Multimeter thermocouple (Figure3) positioned in the pulp chamber to assess pulpal temperature during and before enamel etching. Temperature measurements were repeated three times for every group after two hour standby period.

Results and discussion

T-test Statistics for the means and standard deviation of the temperature rise in the pulp chambers occurred during enamel etching are shown in (Table1,2).The highest temperature rises(18.66±3.05)^{o}c occurred during enamel etching at power 5watt, Continuous wave, time(20sec) for every test period. The least temperature increase (2.66±0.57)^{o}c occurred during enamel etching at power5watt, Pulse wave, time 10sec for every test period. The increase in temperature for different exposure times and laser powers is shown in (Figure 1,2).It is seen that the temperature rise is less than the damage threshold (5.6)^{o}c of the pulp material during enamel etching by using diode laser (1064), Pulse wave ,but it can be concluded that is safe to use the lower power laser for enamel etching by using diode laser (1064), Continuous wave, even if the exposure time is longer .The results indicate that as the laser power increasing the safe level of exposure time reduces .However, the temperature values measured in this study cannot be directly applied for temperature changes in vivo. The reason is that the method accomplished in this study does not consider the heat conduction within the tooth during enamel etching due to the effect of blood circulation in the pulp chamber. A shortfall interfering with the results of this study is that this type of experiment cannot be conducted in vivo. Even an in vivo study on teeth undergoing root canal therapy would be less representative of the clinical situation than the present in vitro model because in a clinical study the thermocouple would not be totally enclosed into the dental tissues as it would be introduced through a coronal access cavity and there would be heat loss to the surrounding air introducing a potentially significant error (15,16).

The study results prescribe the safe power levels, exposure times and the effect of pulse length, pulse repetition time on the temperature rise in the pulp-chamber. Also, the results cannot be generalized because the teeth vary in thickness and thermal conductivity of enamel and dentin.

Conclusion

The following conclusion can be made from this study: Diode laser 1064 irradiation by choosing suitable (pulse and irradiant time)is effective to avoid any thermal damage to the pulp during enamel etching. The maximum values of temperature rise recorded evaluated in the study were not considered critical to pulp integrity1

Finally: I thanks Dr. Zaid Alshamaa for his help in this research.

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(Table1) T-Test Statistics for the Mean peak temperature rises (degrees Celsius) and standard deviations of the group (4.5watt) at time (10,15,20) sec

Time(sec)	Power(4.5watt)		t-value	df	Sig.(P-value)
	Continuous	Pulse			
	M±Sd ($T^{O}c$)	M±Sd ($T^{O}c$)			
10	6.33±0.57	4.33± 2.3	1.455	4	0.219
15	7.66±0.57	3.66±0.57	8.485	4	0.001
20	10.33±1.52	4.33±1.15	5.427	4	1.105

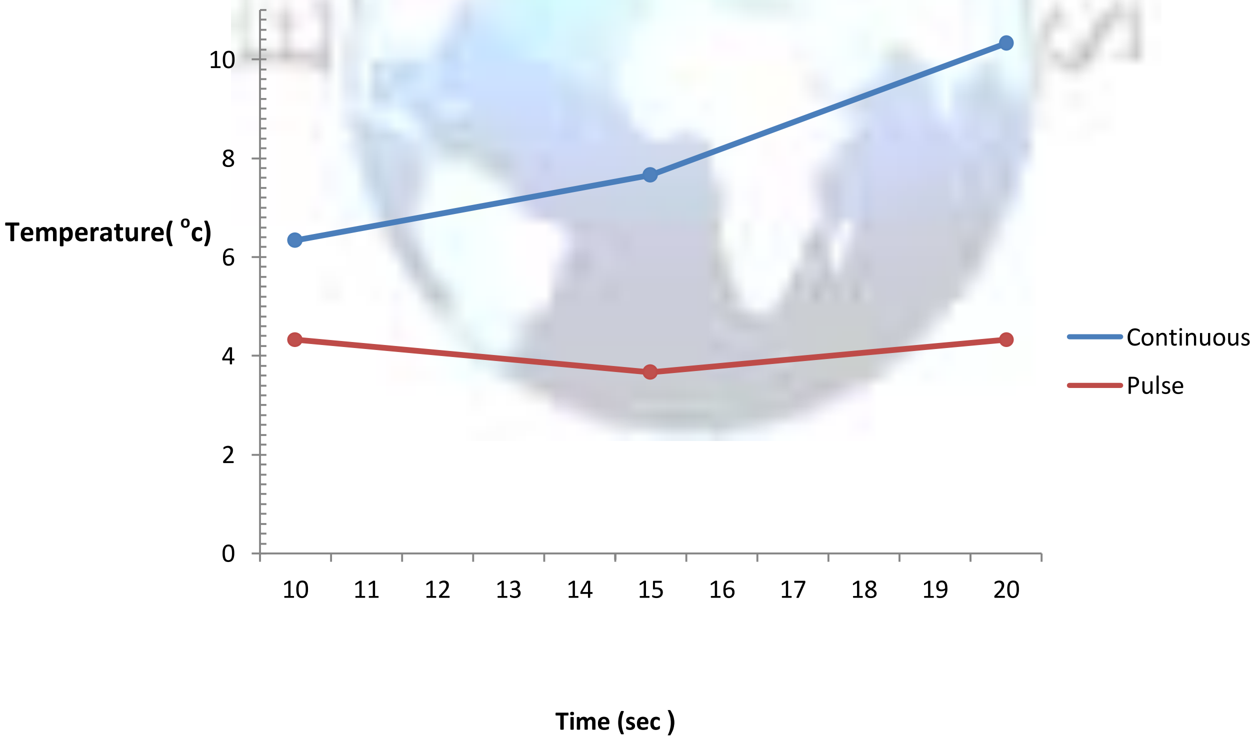

Figure (1): Mean temperature rise inside the pulp chamber during enamel etching of the group (4.5 watt) at time (10,15,20) sec

(Table 2): T-Test Statistics for the Mean peak temperature rises (degrees Celsius) and standard deviations of the group (5 watt) at time (10,15,20) sec

Time(sec)	Power(5watt)		t-value	df	Sig.(P-value)
	Continuous M±Sd(T^0c)	Pulse M±Sd(T^0c)			
10	11.33±1.15	2.66±0.57	11.628	4	0.000
15	15.66±3.05	3.00± 1.00	8.441	4	0.001
20	18.66±2.08	4.66±0.57	8.820	4	1.247

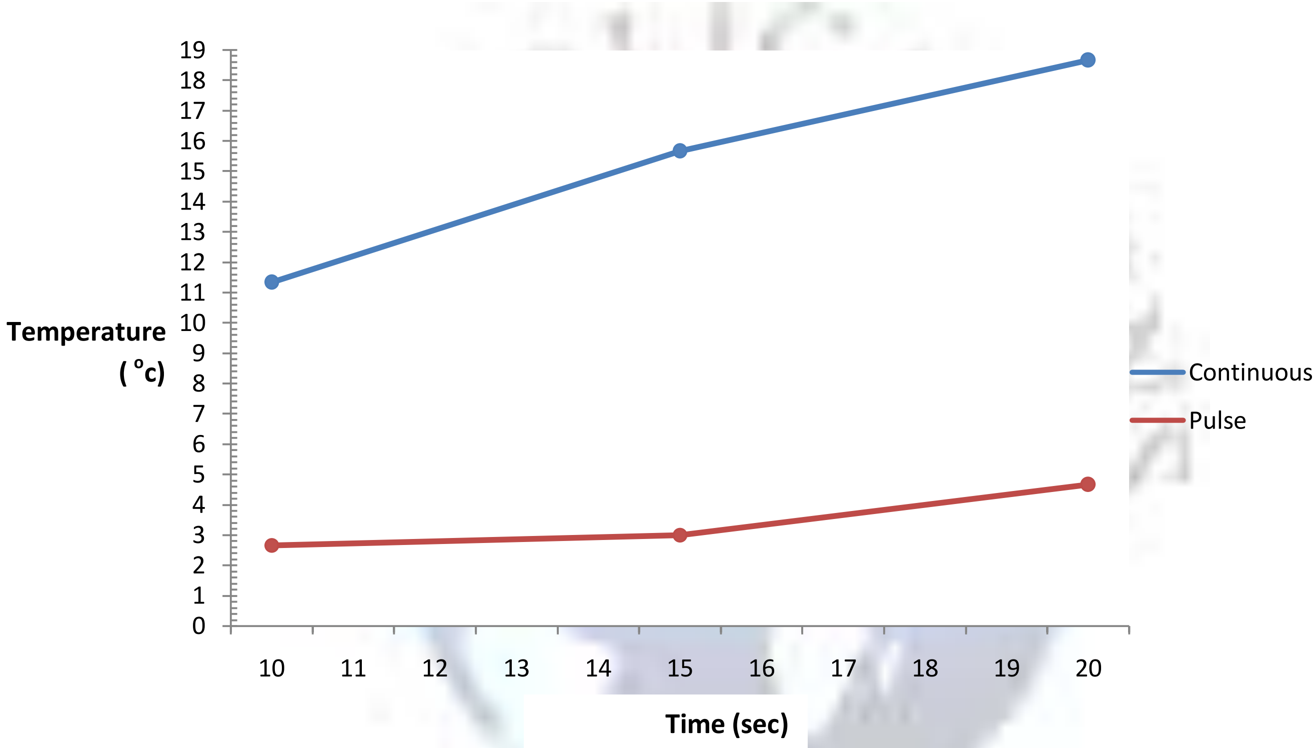

Figure (2): Mean temperature rise inside the pulp chamber during enamel etching of the group (5 watt) at time (10,15,20) sec

Figure (3): A China _Digital Multimeter thermocouple

Figure (4): Diode laser 1064, Fox, Germany