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Thermal Effects of Laser Assisted Endodontic Treatment on The External Root Surface of Deciduous Teeth (in *vitro* study)

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Abstract

The aim of this study was to determine the possible temperature increase on root surface of deciduous human teeth after intra-root canal laser irradiation with different chopped modes to clarify the thermal safety of these modes. fifteen freshly extracted unrestorable deciduous molars were used. Immediately after extraction, teeth cleaned, root canal perpetrated, laser irradiation was done in mesial root using dual wavelengths 980/810 nm InGaAs diode laser (using a 200 µm fiber, 800mW output power. Room temperature were raised in the laboratory to 37C to simulate body temperature, for each tooth three chopped program were used successively: 25ms on 75ms off, 50ms on and 50ms off, and 75ms on 25ms off. Each round laser irradiated for 5 seconds then 10 seconds pause. At the very last second temperature was measured using infrared thermometer. This procedure for the three groups was repeated but with non-stop laser irradiation with no cooling intervals.

It was concluded that 30/70 ms layout can be used safely to assist root canal disinfection.

Keywords: *endodontic treatment, external root surface, laser*

Introduction

Successful endodontic treatment mandate elimination of bacteria in root canal system [1] . Its well known that all available irrigation solution are not optimized to eliminate all bacteria due to surface tension of liquids, which prevent these liquids to penetrate more than 100 µm in dental tissue[2] , whereas bacteria can do much more penetration in dentin which may reach ten folds of irrigation liquids depth [3]. Therefor additional disinfection protocol is needed to eliminate microbes in dentinal tubules to increase success rates of root canal treatment [4] .

The availability of diode laser in many dental clinics, the reasonable cost, and the quite rapid development of lasers technologies make them suitable aids to root canal disinfection [5]. Diode laser had been vigorously studied and it was concluded that using it in combination sodium hypochlorite and/ or oxygenated water would obtain a good outcome [6]. The effect of diode laser on microbes in dentin is either photothermal or photo-activate. The effect of the formal is relied on heat generation which in turn will kill bacteria, and the latter is required presence of special dye [7]. Beside photothermal effect cavitations generated by laser might assist in clearing smear layer and removing debris from dentin surface [8]. Diode lasers of wavelengths between 600 and 980 nm, had been applied to disinfect root canal system, with special interest to wavelengths above 810, due to their high absorption by water. The efficiency of laser in endodontics are relied on several factors such as: wavelength, intensity, laser mode, and proper access cavity [9]. The beneficial effect of laser photothermal of disinfection and cavitations of smear layer, may cause collateral damage to periodontal ligament and alveolar bone if the temperature on root surface increased more than 10 C for less than 60 seconds [10]. To prevent or decrease this harmful side effect, the laser parameters should be optimized to a

precise level that can perform efficient disinfection and in the same time insure periodontal ligament health. For this purpose, this study was designed to investigate the thermal changes on root surface during application of laser irradiation through root canal.

Materials and Method

This study was performed in the secondary health center of Al_Dywaniya, from January 2019 to June 2019. In this study 15 freshly extracted unrestorable deciduous molars were used. Immediately after extraction, teeth cleaned with normal saline, carries removed, proper access opening were done by high speed hand piece (W&H), root canal instrumentation of coronal 2/3 of the canal using rotary endomotor (Eighteeth, China) and rotary files (AF Fanta 0/6, China), followed by clearing root canal using normal saline then dry it with generic paper points. teeth were hold using artery forceps from the distal root to fixing them, laser irradiation was done in mesial root using dual wavelengths 980/810 nm InGaAs diode laser (Quicklase, UK), using a 200 µm fiber, 800mW output power. Room temperature were raised in the laboratory to 37C to simulate body temperature, for each tooth three chopped program were used successively: 25ms on 75ms off, 50ms on and 50ms off, and 75ms on 25ms off. Between each cycle teeth were cooled and cleaned with normal saline and dried. Laser fiber were inserted to the end of prepared canal then irradiation started, fiber was moved during the irradiation with speed of 3mm per second to avoid hot spot, Each round laser irradiated for 5 seconds then 10 seconds pause for six times and the total time of active irradiation was 30 seconds [1] . The temperature on mesial root surface was measured at the last second of irradiation using infrared thermometer (generic) on the middle of the mesial aspect, the result was recorded. This procedure was performed for each tooth in the same manner. The exact procedure for each tooth for the same parameters were repeated but without pause intervals, 30 seconds of laser irradiation was given in the same speed of 3 mm per second, and the temperature was measured in the same spot of above-mentioned method, to clarify the effect of non-stop laser radiation on root surface temperature.

Statistical analysis was proceeded using SigmaPlot Version 12. mean and standard deviation for each Group (1–6).

To determine temperature differences between groups we used One Way Repeated Measures Analysis of Variance. Statistical significance was defined at $p < 0.05$. To isolate the group or groups that differ from the others we used all Pairwise Multiple Comparison Procedures (Holm-Sidak method). Comparison of groups of the same parameters was done using Paired T test.

Results and Discussions

Analysis data by one-way ANOVA revealed slight increase in root temperature in all groups (table 1), The Intermitted 70/30 groups showed the higher temperature raise (5C above the initial temperature), Intermitted 50/50 showed a lesser thermal change (~3C), and the Intermitted 30/70 revealed the least temperature raise (less than 1C as average).

Table 1. Analysis data by one-way ANOVA revealed slight increase in root temperature in all groups.

Treatment Name	N	Missing	Mean	Std Dev	SEM
Intermitted 70/30	15	0	42.000	2.803	0.724
Intermitted 50/50	15	0	39.767	1.770	0.457
Intermitted 30/70	15	0	37.093	0.139	0.0358

There was a statistically significant differences between these groups (table 2), thus post hoc test was performed to isolate group or groups that differ from the others.

Table 2. Statistically significant differences between groups.

Source of Variation	DF	SS	MS	F	P
Between Subjects	14	66.885	4.778		
Between Treatments	2	181.049	90.525	29.048	<0.001
Residual	28	87.257	3.116		
Total	44	335.192			

Post hoc analysis showed that Intermitted 70/30 had statistically significantly higher mean than Intermitted 30/70 (P= <0.001), and Intermitted 50/50 (P=0.002). lower mean was recorded in Intermitted 30/70 which was statistically significantly lower than other groups (P=<0.001) as shown in table 3.

Table 3. Statistically significantly lower than other groups

Comparisons for factor:				
Comparison	Diff of Means	t	P	P<0.050
Intermitted 70/30 vs. Intermitted 30/70	4.907	7.612	<0.001	Yes
Intermitted 50/50 vs. Intermitted 30/70	2.673	4.147	<0.001	Yes
Intermitted 70/30 vs. Intermitted 50/50	2.233	3.465	0.002	Yes

Data of non-stop irradiation showed higher means in all groups, both Nonstop 70/30 and 50/50 showed high temperature (table 4), which was exceeded the upper acceptable threshold of 7-10C [8, 11], on the opposite Nonstop 30/70 group showed slight increase within safe limits. One-way ANOVA analysis revealed as expected significant differences among groups (table 5), therefore post hoc test was done using Holm-Sidak method to isolate particular differences between groups (table 6), this test showed that both Nonstop 70/30 and Nonstop 50/50 had higher mean than Nonstop 30/70 (P=<0.001), also Nonstop 70/30 was higher than Nonstop 50/50 (P=<0.001).

Table 4. Data of non-stop irradiation showed higher means in all groups.

Treatment Name	N	Missing	Mean	Std Dev	SEM
Nonstop 70/30	15	0	58.053	1.743	0.450
Nonstop 50/50	15	0	47.847	2.093	0.540
Nonstop 30/70	15	0	37.387	0.344	0.0888

Table 5. One-way ANOVA analysis revealed as expected significant differences among groups.

Source of Variation	DF	SS	MS	F	P
Between Subjects	14	32.952	2.354		
Between Treatments	2	3203.494	1601.747	618.268	<0.001
Residual	28	72.540	2.591		
Total	44	3308.986			

Table 6. Holm-Sidak method to isolate particular differences between groups.

Comparisons for factor:				
Comparison P<0.050	Diff of Means	t	P	
70/30 vs. 30/70	20.667	35.164	<0.001	Yes
50/50 vs. 30/70	10.460	17.797	<0.001	Yes
70/30 vs. 50/50	10.207	17.366	<0.001	Yes

The aim of this study was to determine the possible temperature increase on root surface of deciduous human teeth after intra-root canal laser irradiation with different chopped modes to clarify the thermal safety of these modes.

It's important to mention that invitro circumstances are not always identical to vivo condition, thus the picture in real experiments may vary from this study results [11]. In this study teeth temperature were raised to 37C by increasing room temperature to simulate the human body temperature, to avoid fast temperature loss during previous studies when using room temperature [12]. Previous literatures had showed the safe threshold of root surface to be less than 10C to avoid periodontal and bone damage [11, 13], although many authors considered 7C increases to be the safe threshold in human body due to slower cooling in comparing to vitro studies[14, 15].

Under the condition of this study, it was observed that chopped intervals had intense influence on root surface temperature, and layout of both 70/30 and 50/50 ms on/off laser irradiated showed remarkable thermal raise which was exceed the safe threshold when it was used with non-stop mode, and in intermitted mode with cooling off intervals the raise was still within acceptable safe limits but both groups showed significantly higher temperature increase in comparing with 30/70 ms layout. It's important to mention that this study didn't examine the efficiency of laser on root canal disinfection, thus its not possible to give conclusion about the optimal laser layout, but we can conclude that 30/70ms layout can be used safely even if the laser used without cooling off periods, on the other hand its good to advice that laser layout of 70/30 and 50/50ms should use with precaution and always be used with cooling off period to avoid unintentional thermal raise which will exceed safe threshold in less than 30 seconds.

Financial Disclosure: There is no financial disclosure.

Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under Al-Diwaniyah secondary dental health center, Al-Diwaniyah, Iraq and all experiments were carried out in accordance with approved guidelines.

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