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Assessment of Heat Elevation on the External Root Surface during Intra-Canal 980 nm Diode Laser Irradiation

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ABSTRACT

Background: Endodontic therapy has recently seen the development of new procedures that have the potential to improve success rates. The lasers in endodontic therapy have been improved by laser application.

Aims: The goal of this study was to evaluate the increase in the root's outer surface temperature with the usage of a 980 nm diode laser (DL).

Materials and methods: 30 premolars with an 8mm root canal length have been used in the present study. The teeth were randomly sorted into three groups (A), (B), and (C). Each group consisted of 10 teeth. Canal preparation was made then treated for 8 secs with a continuous mode 980 nm DL. The DL treatment began 1mm below the apex and progressed upward at a rate of 1mm per sec in a helical motion. The power of the DL was 1watt (w), 1.5w, and 2w for groups (A), (B), and (C), respectively. The temperature elevation of each tooth was recorded by a thermal coupler. The DL application was done at room temperature. The mean temperature changes for each tooth and for each group were recoded.

Results: The means of temperature elevation in Celsius degree were 2.85, 5.38, and 6.99 for groups (A), (B), and (C), respectively. The temperature rising due to using the 1 w 980 nm DL was significantly lower than the two other 980 nm DLs that used in present study.

Conclusions: The 1w 980 nm DL can be considered safe for root canal therapy since the thermal elevation was in an acceptable.

Key words: Diode laser, Root canal treatment, Temperature thermocopluar

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INTRODUCTION

Successful endodontic treatment relies heavily on the elimination of microorganisms (MO from the root canal system, which is generally performed via biomechanical root canal instruments. However, root canal microorganisms have been reduced by a range of methods, including instrumentation, irrigation regimens, and intracanal medicaments. Direct heat application has been demonstrated to be capable of killing microorganisms at varied power levels [1,2]. DL types have been demonstrated to be capable of killing bacteria via photo thermal interaction, which is the conversion of light energy to heat energy [3]. When Laser is used in root canal therapy, it may generate heat that the periodontium cannot tolerate and lead to serious damage. A temperature of 47 °C was already identified in a previous study as a dangerous condition for the periapical area due to apical constriction and limited dentin thickness. Therefore, the recommendation states that the temperature change of the tooth during root canal treatment assisted by LASER should not exceed 7 degrees from human temperature (37°C) [4,5]. The wavelength, power density, mode of irradiation, duration of exposure, and type of tissue all have an effect on the action of the laser on teeth [6]. The presence of air or water during irradiation has an effect on the heat transmission from the tooth to the surrounding tissue [7]. The near-infrared lasers (810 to 1340 nm) had a high affinity for water and hydroxyapatite, allowing them to enter the dentinal tubules to significant depths and be absorbed by bacterial pigments. Bacteria in deeper area are eliminated in this way [8,9]. To maintain the integrity of the tissues adjacent to the target tooth, working with

the laser device requires 5 minutes (min) of irradiation followed by 5 min of rest [5]. The goal of current study was to determine how much the temperature rise at the root's outer surface in apical areas using intracanal 980 nm DL irradiation.

MATERIAL AND METHODS

The sample of the present study consisted of thirty freshly extracted premolars. The extraction was for orthodontic purposes. Every premolar was evaluated to ensure that they had a single root canal with 8 mm length. All teeth were cleaned with distilled water and preserved in a 0.1% thymol solution. The thirty premolars were classified randomly into three groups (A), (B), and (C). Each group included 10 teeth. Each premolar according to the group was given labels: (A1-10), (B1-10), and (C1-10).

Access and preparation of the root canal of each premolar were made. A high-speed hand piece was used to gain access to the root canals. The root canal preparation was done by using the protaper endodontic rotary files (SX, S1, S2, and F1) and irrigation solutions (17% EDTA and 5.25% sodium hypochlorite). Finally, the canals were dried with paper tips.

The dentinal tubules of the prepared canals in all teeth were treated with 980 nm DL (Gigaa VELAS Lasers, China) using a 400 micrometer silica optical fiber as the delivery system (Figure 1a). The application of the LASER within the root canals was in the continuous wave (CW) mode, with helical motion from apical to coronal parts lasting 8 sec. A laser tip was inserted inside the root canal till 1 mm below the apex. The laser irradiation speed was 1 mm/s. The root canal length treated was 8 mm. The outer tooth surface was attached to a K thermocouple connected to an Arduino microcontroller using the 6675 interface to transfer the data to a computer (Figure 1b). The thermal coupler and the tooth were held by the operator's naked hand (Figure 1c) to ensure intimate contact between them and also to establish a baseline temperature of 34.06 ± 1.36 °C, which is considered near to human natural temperature. The power of the 980 nm DL was specific to each group, with 1w, 1.5w, and 2w being used for groups (A), (B), and (C), respectively. Descriptive and inferential analyses were conducted using the SPSS program.

RESULTS

The thermal coupler at the premolars' apical third portion was registered the mean of the heat elevation for every tooth from the base line temperature during application of the 980 nm DL for 8 secs (Table 1). At 1.0 w the minimum elevation was 1.75°C and the maximum was 4.75°C with mean temperature 2.85 ± 0.98°C., while at 1.5 w the minimum elevation was 3.00°C and the maximum was 8.25°C with mean temperature 5.38 ± 1.77 °C, finally, at 2.0 w the minimum elevation was 4.25°C and the maximum was 13.25°C with mean temperature 6.99 ± 2.58°C.

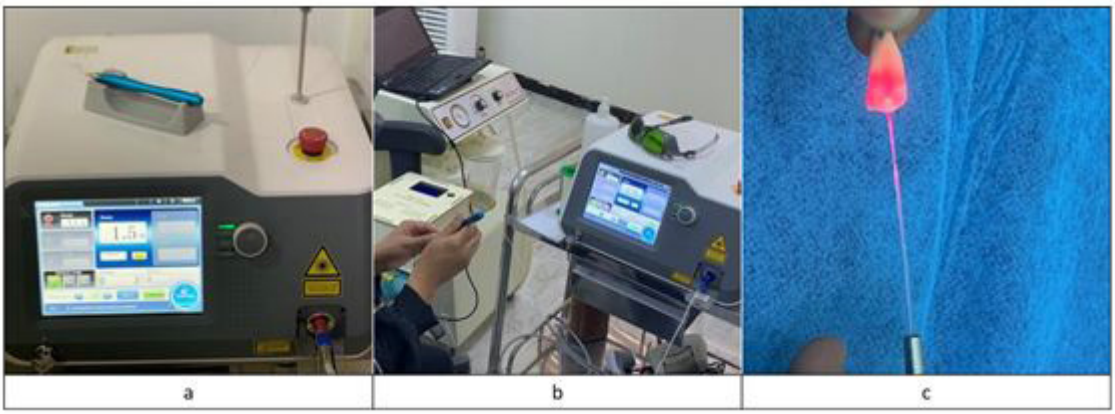

Figure 1: (1a) 980nm diode laser VELLAS II gigalaser. (1b) Arduino microcontroller using 6675 interface with transfer its data to the connected laptop. (1c) The thermal coupler held by operator naked hand.

Table 1: Descriptive analysis of heat elevation for each tooth due to the application of 1w, 1.5w, and 2w of 980nm DL. All measurements were in Celsius degrees.

Power of DL	The mean of heat elevation									
1 w	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10
Group A	2	2	2.25	4.75	3.75	3.5	3.5	1.75	2.25	2.75
1.5 w	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10
Group B	7.75	8.25	6.25	5.75	6	5	3	3.25	4.5	4
2 w	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
Group C	13.25	8.13	4.75	5.75	7.25	5.25	6	4.25	7.25	8

	Number	Mean ± SD (°C)	Minimum	Maximum
1 w	10	2.85 ± 0.98	1.75	4.75
1.5 w	10	5.38 ± 1.77	3	8.25
2 w	10	6.99 ± 2.58	4.25	13.25
Total	30	5.07 ± 2.52	1.75	13.25

Table 2: The correlation between the three study groups.

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	87	2	43.5	12.17	0.000*
Within Groups	96.52	27	3.58		
Total	183.52	29			

*significant level at p-value less than 0.05 by ANOVA test.

Table 3: Multiple comparisons between the three groups.

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
1 w	1.5 w	2.53	0.85	0.016*
	2 w	4.14	0.85	0.000*
1.5	1 w	2.53	0.85	0.016*
	2 w	1.61	0.85	0.156
2 w	1 w	4.14	0.85	0.000*
	1.5	1.61	0.85	0.156

*The mean difference is significant at the 0.05 level using Tukey post-hoc test

Significant correlation was found between the three groups (Table 2), further analysis was showed that significant difference was found between group (A) with both group (B) and (C) (Table 3).

DISCUSSION

The wavelength of 980 nm was the most widely utilized in dentistry [6]. As a consequence, since this wave is efficiently absorbed by colored proteins of bacteria but weakly absorbed by water and dental hydroxyapatite, it was chosen for this study [7]. This results in a higher laser irradiation penetration rate. The laser radiation can propagate, scatter, and transmit through the dentin because of the low absorption [8]. As a result, the temperature rises due to laser light absorption at deep depths, resulting in photothermal effects that are damaging to periodontal tissue [5]. As a consequence, the temperature goes up on the external surfaces of the root, generated by the application of a 980-nm diode laser in the canals of the root investigated in this work. The strategy employed in this study was adapted from Suchetan Pradhan's investigations to determine acceptable laser energy delivery levels in root canals [10]. In our study, however, the temperatures measurement was performed at the ambient room temperature of 34.06 °C (± 1.36) and used premolars teeth, the canals of root were extended to test temperature spikes in the worst-case scenario which is in accordance to Gutknecht et al 2005 [4].

In the current experiment, the tooth was gripped with two fingers (thumb and index) so that they made contact with the majority of the root's surface, leaving the thermocouple's attachment region free. The impact of cooling of circulation of blood in the ligament of periodontium and bone of jaw was duplicated by the elimination of energy by circulation of blood in the finger tissue, replicating the in vivo state. This is similar to protocol followed by Ramskold et al 1997. Several studies have found that increasing the temperature 10°Cover temperature of body for 1 minute causes irreparable damage to periodontal tissues and alveolar bone [4,9]. In our work, the use of 980nm diode laser at 1w and 1.5 w continuous mode didn't result in temperature rises more than 10 c. In this case, the mean maximum temperature increase was 6.99 degrees in 2w continuous mode. This is far less than Eriksson and Albrektsson's 1983 recommended threshold rise in temperature. The mean rise in temperature on the outer surface of root after laser irradiation in our result at 1w continuous mode was 2.85. Gutknecht et at 2005 found a rise of 5.2c at 0.6 to 1w in continuous mode in apical third of root at end of 10 sec cycle.

In present result the average temperature increase after application of 980nm diode laser at 2w continuous mode was 6.99c. Alfredo et al. (2008) discovered a 6.06-degree increase in temperature when using a laser with a continuous mode of 1.5 watts. At 1.5 w continuous mode, Gutknecht et al 2005 reported that the mean temperature rise was 8 c at the conclusion of a 10 sec cycle. According to Seraj et al. the temperature rises by more than 7°C at 1.5 w continuous mode [11].

At 1.5 W power, the rate of increase in temperature was 3.8 degrees Celsius, Zan et al observed that the maximum temperature rise was measured at 4 W output power with two resting times (0.5–25s) using Nd:YAG laser and potassium–titanyl–phosphate (KTP) laser, and the threshold value was exceeded at 1 and 2 W powers.. These differences, in our opinion, may be attributable to differences in irradiation method, laser application time, and measurement point count [12].

While a result, the study's maximum temperature was smaller than the critical value; one interpretation for this is that the delivery fiber is constantly running inside the root canal, as the temperature at the external root surface will increase if the fiber persists in the apical region [13].

According to De Costa Ribeiro et al. intervals among irradiations are required to prevent the cumulative effect of temperature rise. The chosen interval in this study was 8 seconds, and the irradiation was performed once for each canal during the irradiation [5].

sDuring this work, the peak temperature did not exceed 10°C when a thermocouple was employed with a 980-

nm diode laser power in a continuous wave. The used wattage (1, 1.5, and 2W) and selected time (8s) would be quite safe if we added in the body's cooling impact. It was anticipated that because of the cooling impact of circulation of blood and the lower heat conduction of the tissues surrounding the teeth than air, there would have been more safety around the tooth in the oral cavity. As a result, thermal energy dissipates more quickly [14].

CONCLUSION

The 1 w 980 nm DC can be considered safe for root canal therapy since the thermal elevation was in an acceptable range. However, further studies are required to evaluate the efficiency of treatment with DL, but it seemed harmless to surrounding periodontium and alveolar bone.

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