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Comparison of the root surface temperature rises following intracanal irradiation with 810nm and 940 nm diode lasers at varied power settings and a standardized environment- An in vitro study.

Medical Science

KEYWORDS : Root Canal, Disinfection, Diode Laser, Periodontium.

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ABSTRACT

This study was performed to determine the influence of diode laser wavelength on root surface temperature rise in a standardized environment.

A total of fifteen freshly extracted teeth were collected and biomechanical preparation was performed. Intracanal irradiation was performed with diode lasers (810nm & 940 nm) at different power settings (1.5W, 2W, 3W) with an exposure time of 20 seconds in a wet environment. The temperature rise at the external root surface was assessed using a thermocouple.

A significant rise of temperature was observed for both wavelengths and this temperature rise was above 10 degrees when irradiation was done for 20 seconds

Our study results demonstrate that irrespective of the wavelength of the diode laser (810nm/940 nm) used, the rise in temperature at the external root surface following intra-canal irradiation was similar.

Introduction:

The advent of laser technology in the 1960's has led to its path-breaking applications in the fields of ophthalmology, dentistry, engineering etc. The effect of lasers of different wavelength on dental tissues (enamel, dentin, gingiva, periodontal ligament, pulp and alveolar bone) has been observed and reported in several studies (Kim SJ et al 2013, Kivanc BH et al 2012, Viapiana R et al 2012)

The diode laser is one of the most commonly used dental lasers with wavelengths ranging from 810nm to 980nm. This laser has a semi-conductor crystal as the active medium and optic fibre as delivery system. Several fibre diameters are available which include 200 microns, 300 microns, 400 microns, 600 microns. Of these 200 micron fibres of varied lengths are used for root canal disinfection whereas the others are used for surgical soft tissue procedures.

The effect of the diode laser on dental hard tissues such as enamel and dentin is of a photo-thermal nature wherein there is a transformation of light energy into heat energy resulting in a rise of temperature.

This photo-thermal effect has been put to use in disinfection of the root canal after the biomechanical preparation step. Conventional methods of root canal disinfection involve use of chemical agents that have bactericidal activity such as sodium hypochlorite, chlorhexidine (Luddin N and Ahmed HM 2013). Some of the limitations of chemical method of disinfection of the root canal are lack of penetration into adjacent dentinal tubules and accessory canals.

Of late disinfection of the root canals, has been attempted with lasers. Amongst the various lasers available, diodes have been widely used due to their advantage in reaching the depth of the enlarged canals through the optic fibre delivery system.

Studies done by, Moritz A et al 1997 and de Souza EB et al 2008 have demonstrated complete disinfection of the root canal by diode laser irradiation in in-vitro microbial studies. One of the inadvertent side effects of root canal disinfection by laser irradiation is the temperature rise observed on the external root surface which can potentially damage the cementum and periodontal ligament fibers.

Studies have also evaluated the temperature rise on the root surface following intra canal irradiation with diode lasers of different wavelengths. Alfredo E et al 2008 evaluated the root surface temperature rise after intra canal irradiation with 980nm diode laser for 30 seconds with different power settings (1.5W, 3.0W, 5.0 W) in both dry and wet conditions and at cervical, middle and apical thirds. The authors concluded that 1.5W in continuous wave and pulsed modes and 3.0 W in pulsed modes for 20 seconds was a safe therapeutic modality for use in endodontic therapy.

da Fonseca A et al 2012, evaluated the root surface temperature change in mandibular incisors following intra canal irradiation with 810 nm diode laser at different power settings (1.5W, 2.0W, 2.5W, 3.0W, 3.5W, continuous wave mode). The authors reported that only 3.5 W continuous wave mode resulted in a temperature rise of more than 7 degrees (critical value assumed in the study). They recommended using a lesser wattage than 3 W for intra canal disinfection.

Hmud R, Kahler WA, Walsh LJ (2010), compared the temperature increase at external root surface following intra canal irradiation with 940 nm and 980 nm diode laser at different power settings in a wet environment. The authors reported a maximum temperature rise of only 4 degrees at the external root surface. However lasing in this study was done with rest periods or rinsing between 5 second exposures.

Among the diode lasers, the 810 nm diode laser is known to induce latent heat and higher heat transfer to the tissues as compared to the 940 and 980 nm wavelengths.

Therefore the objective of this study is to compare temperature rise at external root surface following intra canal irradiation with diode lasers of two different wavelengths (810nm and 940nm) at different power settings (1.5W, 2W, 3W, continuous wave) in a wet environment and standardized exposure time (20 seconds).

Materials and Methods:

A total of fifteen freshly extracted teeth were collected and thoroughly disinfected with saline and hydrogen peroxide. The teeth included a combination of incisors (maxilla and mandible), premolars and molars. Access opening was done and pulp de-

bridement was performed followed by biomechanical preparation till ISO 30 in all the canals. In multi-rooted teeth any one of the root canals was chosen to be included in the study. The teeth were embedded in dental stone with any one of the root surfaces exposed. Diode lasers with two different wavelengths 810nm- Picasso, (AMD, Tulsa, USA) and 940 nm- ezlase, (Biolase Inc) were used in the study (Figure 1 & 2).

The study parameters for both the lasers used were as follows:

a. 200 micron fiber tip.
b. Power settings of 1.5W, 2W, 3W in continuous wave mode.
c. Wet environment: simulated by wetting the teeth with water prior to each irradiation.
d. Exposure time of 20 seconds (Gutknecht N et al 2005).
e. Circular tip movement from apical to cervical third with incremental movement of 2mm for every 1 second.

Determination of temperature rise at external surface:

The baseline temperature of the root surface was recorded and the rise in the temperature was determined following irradiation at different power settings for 20 seconds using both wavelengths.

The temperature rise at the external root surface was assessed using a thermocouple that was held in contact with the external root surface. This thermocouple has a sensitivity range 0 - 200 degree and the temperature changes were recorded at the level of cervical, middle and apical third of the root surface. In between each measurement, the tooth was wetted with water to eliminate any latent heat buildup in the root which will falsify the second measurement.

In total, 45 temperature readings for each power setting were recorded for the 15 teeth [15×3 (cervical, middle and apical third)]. And a total of 135 recordings were made at the completion of the study. (45 recordings for each power setting into 3 power settings (1.5W, 2W, 3W).

Only one root surface was taken up for recording the temperature data as at the end of the study an attempt was made to co relate the temperature rise observed with the remaining dentin thickness in that part of the root surface. The remaining dentinal thickness was measured with a vernier calipers following sectioning on the side of the root on which the thermocouple was placed to determine the temperature change.

Results:

This study assessed the temperature changes at the external root surface following irradiation with diode laser of two different wavelengths at 1.5W, 2 W, 3W in a continuous wave mode for 20 seconds in a wet environment.

The mean temperature rise along with standard deviation for the 15 samples at different power settings for the 810nm and 940 nm wavelengths is summarized in Table 1.

Independent t test was done to assess the significance of difference in temperature rise between the groups (810nm vs 940nm). A statistically significant difference in temperature rise was observed in between group comparisons (810nm vs 940nm) l for 1.5W (cervical third and apical third [$p<0.05$]) and 3W cervical third [$p<0.05$]. (Table 2).

Tukey test was done to determine the significance of difference in temperature rise within the group for 810nm and 940 nm. No significant difference in mean temperature rise was observed for within group (cervical vs middle vs apical third levels; $p>0.05$) in all the situations. (Table 3). The mean temperature rise in each tooth (combination of temperature rise in cervical, middle and apical third values) following irradiation with 810nm, 940 nm are summarized in (Figure 3 & 4).

The summary of remaining dentinal thickness following biomechanical preparation in the root canal chosen for the study is provided in (Table 4).

Discussion:

Biomechanical preparation results in a smear layer containing dentinal debris and remnant bacteria. Root canal disinfection remains one of the key factors for successful endodontic therapy.

Dental lasers have been used in the field of endodontics not only for disinfection of the main root canal but also the adjacent dentinal tubules and accessory canals upto depths of 1 mm (Klinke T, Klimm W, Gutknecht N, 1997). This has been attributed to the penetrating ability of diode lasers that do not get absorbed in the dentin.

The widely accepted protocol of using a circular motion of the optic fiber tip from apical end of the canal in a coronal direction with increments of 2 mm for every one second has been used in this study (Abad- Gallegos M, 2009). In addition, the teeth were immersed in water to simulate a wet environment existing around the natural teeth in vivo.

The irradiation of the tooth root canals with diode laser results in conversion of light into heat energy (photo-thermal reaction). This gets transmitted through the dentin to external root surface where heat gets eventually diffused into the surrounding periodontal tissues. The possibility of thermal damage depends on the power setting, delivery mode (continuous wave/ pulsed mode), time duration and environment (wet/ dry).

The threshold value for temperature rise beyond which damage occurs has been determined to be 10 degrees above body temperature. This is based upon the studies by Albrektsson and Eriksson A, 1983, who demonstrated a temperature rise of 10 degrees above body temperature for 1-minute was sufficient to cause necrosis of the alveolar bone.

The present study was done to compare the temperature rise following use of diode lasers with two different wavelengths 810nm and 940 nm at different power settings in continuous wave mode with standardized exposure time and environment.

In this study, a temperature rise of above 10 degrees was observed following use of both the wavelengths, irrespective of the power setting/ portion of the root. This can be attributed to the exposure time of 20 seconds, continuous wave mode used for all settings, and less amount of dentinal substance remaining following bio-mechanical preparation. In addition, the natural heat diffusion effect through vascular perfusion was not available which a limitation of the design in this study.

In a study by Gutknecht N et al 2005, following intra-canal irradiation with 810 nm diode laser (1.0/1.5W, continuous wave mode), a temperature rise of only 8 degrees was observed at the end of the study. However in this study the exposure time was 10 seconds unlike in our study wherein the exposure time was 20 seconds. This may explain the observation of temperature rise exceeding 10 degrees in our study.

In our study, the temperature rise was found to be more in the middle and apical third as compared to cervical third. These results are in accordance with the observations in a similar study by Pradhan S and Karnik R, 2011.

Conclusion:

Our study results demonstrate that irrespective of the wavelength of the diode laser (810nm/940 nm), power settings used, the rise in temperature at the external root surface following intra-canal irradiation under standardized conditions was similar and above the acceptable limits. A reduction in the irradiation time or providing intervals between the irradiation / irrigation during intervals can contribute to root surface temperature rise remaining within acceptable biological limits.

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TABLE1: The mean temperature rise for the 15 samples at different power settings for 810 and 940nm wavelengths in cervical (C), middle (M), apical (AP) thirds of the root.

ROOT SEGMENT	POWER (WATTS)	GROUP	N	Mean (degrees Celsius)	Std. Deviation
C	1.5	810 nm	15	14.993	7.1351
		940 nm	15	9.740	3.1672
C	2	810 nm	15	12.500	4.5547
		940 nm	15	13.413	5.4117
C	3	810 nm	15	13.827	4.6700
		940 nm	15	19.213	8.5824
M	1.5	810 nm	15	13.360	5.0157
		940 nm	15	11.867	2.5595
M	2	810 nm	15	14.133	5.0611
		940 nm	15	13.480	3.8727
M	3	810 nm	15	18.087	7.2916
		940 nm	15	15.660	6.2671
AP	1.5	810 nm	15	12.607	4.2419
		940 nm	15	8.520	2.3103
AP	2	810 nm	15	9.833	4.3899
		940 nm	15	12.827	6.0991
AP	3	810 nm	15	16.047	5.6257
		940 nm	15	17.827	8.8282

TABLE 2:
Independent t test for testing significance of difference of means between 810 nm and 940 nm groups (Between group comparisons).

Category	t value	Sig (2 tailed) (p<0.05)	95% confidence of difference	
			Lower	Upper
C (1.5 W)	2.606	0.015	1.1245	9.3821
C (2 W)	0.500	0.621	-4.6544	2.8278
C (3 W)	2.135	0.042	-10.5544	-.2189
M (1.5 W)	1.027	0.313	-1.4849	4.4715
M (2 W)	0.397	0.694	-2.7172	4.0239
M (3 W)	0.978	0.337	-2.6586	7.5119
AP (1.5 W)	3.277	0.003	1.5320	6.6413
AP (2 W)	1.543	0.134	-6.9678	.9811
AP (3 W)	0.659	0.516	-7.3166	3.7566

TABLE 3: Tukey test for testing significance of difference of mean temperature rise within the group for 810 nm and 940 nm (comparison of means between cervical, middle and apical third)

Dependent Variable	(I) GROUP	(J) GROUP	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
810 nm, 1.5 W	C	M	1.6333	.706	-3.334	6.601
		AP	2.3867	.479	-2.581	7.354
	M	C	-1.6333	.706	-6.601	3.334
		AP	.7533	.928	-4.214	5.721
	AP	C	-2.3867	.479	-7.354	2.581
		M	-.7533	.928	-5.721	4.214
810nm, 2 W	C	M	-1.6333	.608	-5.783	2.516
		AP	2.6667	.273	-1.483	6.816
	M	C	1.6333	.608	-2.516	5.783
		AP	4.3000	.041	.151	8.449
	AP	C	-2.6667	.273	-6.816	1.483
		M	-4.3000	.041	-8.449	-.151
810nm, 3 W	C	M	-4.2600	.136	-9.549	1.029
		AP	-2.2200	.569	-7.509	3.069
	M	C	4.2600	.136	-1.029	9.549
		AP	2.0400	.620	-3.249	7.329
	AP	C	2.2200	.569	-3.069	7.509
		M	-2.0400	.620	-7.329	3.249
940nm, 1.5 W	C	M	-2.1267	.091	-4.525	.271
		AP	1.2200	.439	-1.178	3.618
	M	C	2.1267	.091	-.271	4.525
		AP	3.3467	.004	.949	5.745
	AP	C	-1.2200	.439	-3.618	1.178
		M	-3.3467	.004	-5.745	-.949
940nm, 2 W	C	M	-.0667	.999	-4.690	4.557
		AP	.5867	.949	-4.037	5.210
	M	C	.0667	.999	-4.557	4.690
		AP	.6533	.937	-3.970	5.277
	AP	C	-.5867	.949	-5.210	4.037
		M	-.6533	.937	-5.277	3.970
940nm, 3 W	C	M	3.5533	.448	-3.523	10.629
		AP	1.3867	.883	-5.689	8.463
	M	C	-3.5533	.448	-10.629	3.523
		AP	-2.1667	.739	-9.243	4.909
	AP	C	-1.3867	.883	-8.463	5.689
		M	2.1667	.739	-4.909	9.243

Table 4: Table summarizing remaining dentinal thickness following the biomechanical preparation in the root canal irradiated as a part of the study.

ROOT SEGMENT THICKNESS	MEAN THICKNESS (mm)	Std. Deviation
CERVICAL THIRD		
	3.200	.7270
MIDDLE THIRD		
	2.700	.7973
APICAL THIRD		
	1.867	.5499

Fig 1: Intra-canal irradiation using 810 nm diode laser (AMD, Picasso)



Fig 2: Intra-canal irradiation using 940 nm Diode laser (ezlase, Biolase Inc)



Fig 3: Bar graph representing the mean temperature rise in each tooth following intra-canal irradiation with 810 nm diode laser.

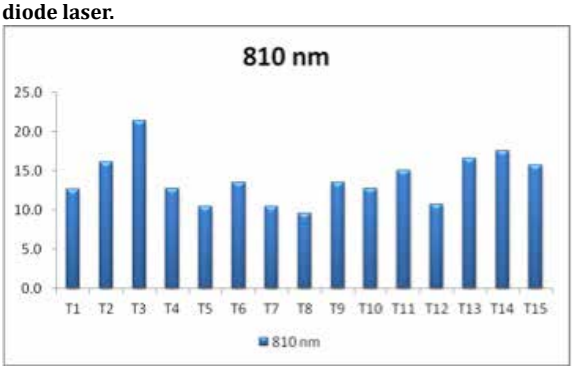
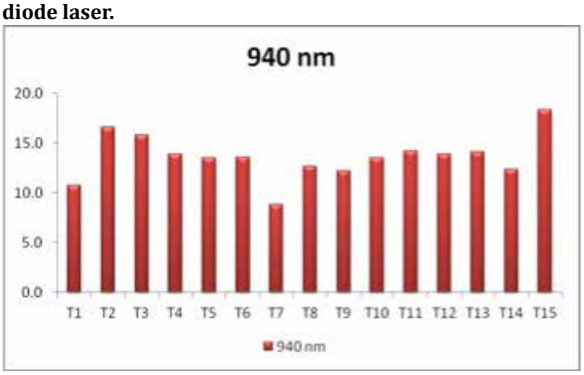


Fig 4: Bar graph representing the mean temperature rise in each tooth following intra-canal irradiation with 940 nm diode laser.



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