Thermal changes in the hard dental tissue at diode laser root canal treatment – clinical investigation

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Температурни промени в твърдите зъбни тъкани при вътреканално приложение на диоден лазер – клинично изследване

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Summary

Introduction

The laser coagulation at the apical part of the root canal after vital extirpation is a proper method of prevention of complications such as bleeding, pain, remaining vital pulp. The laser releases a large amount of energy that is transformed into heat and the hard dental tissues can be damaged.

Purpose

The aim of the present survey is to register the thermal changes that occur on the tooth surfaces during laser treatment of the root canal after vital extirpation (clinical investigation).

Methods and materials

An in vivo study with 30 single rooted teeth after pulp extirpation has been conducted. Root canals of all teeth have been prepared and have been dried. A diode laser system "DenLase" with wavelenght 810 nm and optic fiber with diameter 200μm has been used for the laser root canal treatment. The laser treatment has been conducted at impulse regimen with power 2 W at pulse length 1ms and pulse interval 1 ms, so the average power has been 1W. Temperature changes on the surface of the hard dental tissues and the apex of the tooth were captured with an infrared camera Flir T330.

Results

The registered temperature changes in the apex and the outer root surface were up to 3,3°C. The differences are due to the thickness of the root wall, the degree of bleeding in the root canal and the presence of lateral canals.

Conclusion

Temperature changes in the apex and outer root surface during laser treatment of the root canal using a diode laser are biocompatible.

Key words: *diode laser, root canal, thermal changes*

Резюме

Въведение

Лазерната коагулация в апикалната част на кореновия канал след витална екстирпация е метод за предотвратяване на усложнения като кървене, болка, остатъчна витална зъбна пулпа. Лазерът отделя голямо количество енергия, която се трансформира в топлина и може да доведе до термични увреждания на твърдите зъбни тъкани.

Цел

Целта на настоящето изследване е да регистрират температурните промени, които настъпват по зъбните повърхности по време на лазерно облъчване на кореновия канал след витална екстирпация (клинично изследване).

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Материали и методи

Проведено е in vivo проучване на 30 еднокоренови зъба след витална екстирпация на зъбната пулпа. Кореновите канали на всички зъби са препарирани и подсушени. За вътреканално облъчване е използван диоден лазер „DenLase" с дължина на вълната 810 nm и оптично влакно с диаметър 200 µm. Лазерното лечение е в импулсен режим с мощност 2 W при дължина на импулса 1ms и импулсен интервал 1 ms, така че средната мощност е била 1W. Температурните промени на повърхността на твърдите зъбни тъкани и в апекса са заснети с инфрачервена камера Flir T330.

Резултати

Регистрираните температурни промени по външната коренова повърхност и апекса на зъба са до 3,3 ° C. Разликите се дължат на дебелината на кореновата стена, степента на кървене в кореновия канал, наличието на странични канали.

Заключение

Температурните промени по външната коренова повърхност и в областта на апекса на зъба по време на вътреканално лазерно облъчване с диоден лазер са биопоносими.

Ключови думи: *диоден лазер, коренов канал, температурни промени*

Introduction

In practice, diode lasers are becoming more and more popular. They have good technical characteristics - they radiate over a wide range of electromagnetic radiation, have the ability to combine different resonance frequencies and wavelengths, ergonomic, long-lasting and affordable [1, 2, 3]. High-energy diode lasers are used in endodontics. [4, 5, 6, 7]. The diode laser coagulation is an effective method of pulpotomy [8, 9, 10, 11]. We investigated a new method for laser coagulations at apical part of the root canal after vital extirpation. Intracanal application of diode laser is possible after pre-conditioning of the root canal to ensure unobstructed movement of the optical fiber. The laser releases a large amount of energy that is transformed into heat and beside the apical coagulation the hard dental tissues can be damaged [6,7]. Change of temperature on the outer root surface and apex with 7 - 8°C does not lead to periodontal damage, but a temperature rise of more than 10°C can damage the surrounding bony structures [12].

The thermal effects of laser radiation in biological tissues depend on various factors: wavelength and tissue absorption, laser mode (tactile, impulse and Q-switching), energy or output power (single pulse / power W / cm2), active time (e.g., pulse duration), repetition rate (Hz), laser application method (contact / noncontact, focus / disfigured, and motion speed i.e. one point retention) the environment (blood, bone, hard dental tissues), coefficient absorption corresponding to the wavelength of the laser and thermal conductivity of exposed tissues [13, 14].

The temperature changes were detected with an infrared thermal camera. Infrared thermography proved to be a quite precise method for temperature registration in the maxillo-facial area. It has been proven to be effective in the focal diagnostics and can also be used in experimental studies for registering precise temperature changes during laser radiation [15].

Purpose

The aim of the present survey is to register the thermal changes that occur on the tooth surfaces during laser treatment of the root canal after vital extirpation (clinical investigation).

Methods and materials

An *in vivo* study with 30 single rooted teeth (11 central incisors, 6 lateral incisors and 13 canines) after pulp extirpation has been conducted. The infrared measurement of temperature changes can be easily done on frontal teeth because of the direct access to the hard dental tissue vestibularly. Root canals of all teeth have been prepared with a step-back technique with hand K-file. Apical stop is reached up to file number 35. The final irrigation has been made with distilled water and has been dried up with sterile paper points. The patients have signed an informed consent beforehand. A diode laser

system "DenLase" with wavelenght 810 nm and optic fiber with diameter 200µm has been used for the laser root canal treatment (fig 1a).

a

b

Fig. 1 *DenLase diode laser (a) and FLIR T330 infrared camera (b)*

The laser treatment has been conducted at an impulse regimen with power 2 W at pulse length 1ms and pulse interval 1 ms, so that the average power was 1W. The tip of the fiber optic was inserted into the root canal to the apical stop and was drawn about 1 mm backwards, and then the laser radiation was initiated. The fiber optic was withdrawn from apical to coronal with slow circular motion within 8 seconds (fig. 2).

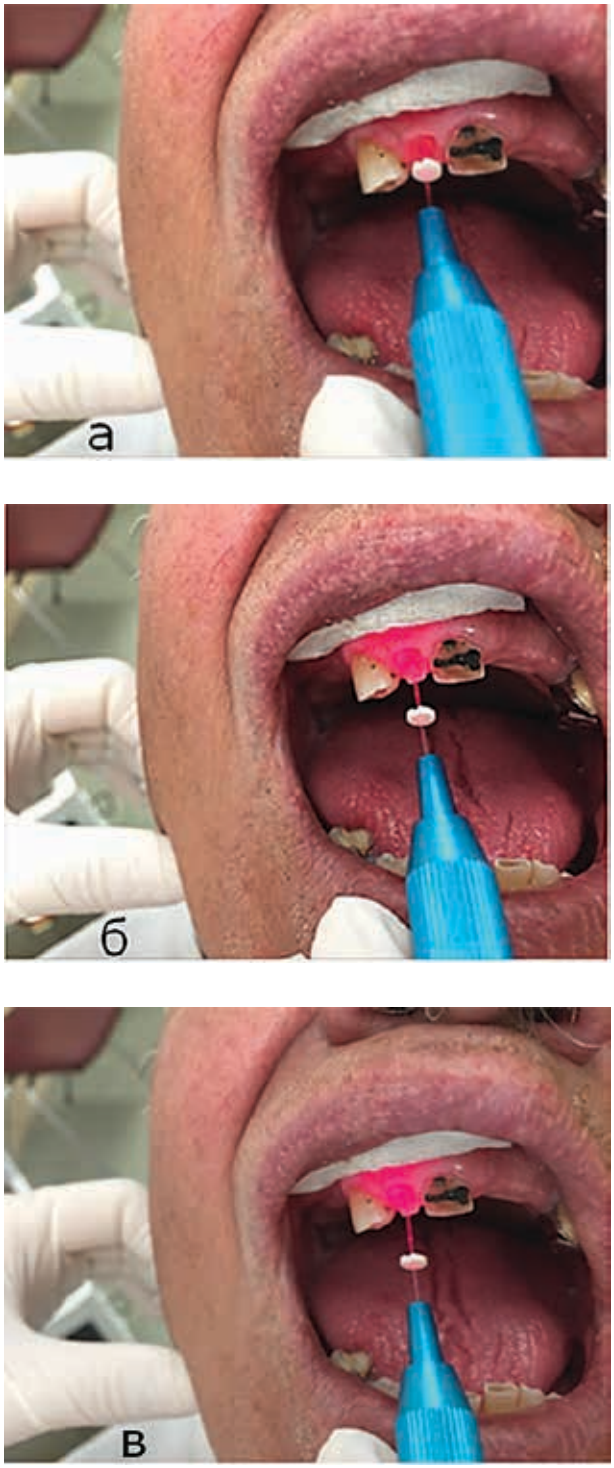

Fig. 2. *Laser treatment on tooth 12 – optic fiber was withdrawn from apical (а) to middle part (б) and coronal part (в) into the root canal*

The survey has been conducted in a thermally controlled environment without sources of heating or cooling – air conditioned room at 22°C. An infrared camera Flir T330 (fig. 1b) is fixed at a distance of 1.5 m from the investigated tooth. Temperature changes were captured with two thermal shots – in the beginning and in the end of the laser radiation (fig. 3).

Fig. 3. *Laser treatment on toot 23*

The captured thermal images have been processed with software product Flir Reporter Pro 9.

The results are statistically processed by a Paired Samples t-test, comparing two dependent groups in which the variable has a normal distribution. The accepted critical level of significance is $\alpha = 0.05$. The statistical data was processed with SPSS version 13.0 and IBM Statistics SPSS v. 19.

Results and discussion

The temperature changes in 30 single root teeth - 17 incisors and 13 canines - were captured and processed.

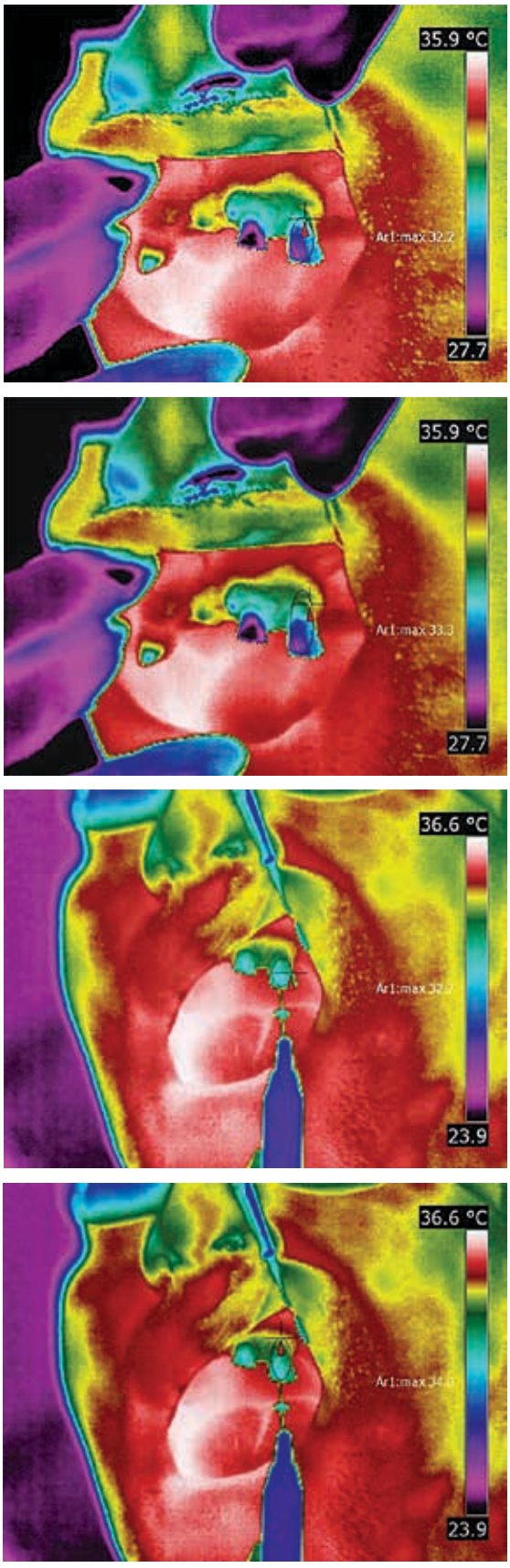

Fig. 4. *Thermal shots – in the beginning and in the end of the laser radiation on the tooth*

Table 1 *Temperature changes on the tooth surfaces in the beginning and in the end of the laser treatment*

t°C	Tooth 1	Tooth 2	Tooth 3	Tooth 4	Tooth 5	Tooth 6	Tooth 7	Tooth 8	Tooth 9	Tooth 10	Tooth 11	Tooth 12	Tooth 13	Tooth 14	Tooth 15
t° before	33.4	36.3	33.2	34.8	33.0	35.1	35.3	32.2	33.6	33.8	34.2	32.9	33.9	33.2	34.0
t° after	34.1	36.7	34.8	36.9	35.7	37.0	36.4	34.4	35.0	34.9	36.2	33.5	35.8	36.5	36.2
t° diff.	1.1	0.4	1.6	2.1	2.7	1.9	1.1	2.4	1.4	1.1	2.0	0.6	1.9	3.3	2.2

Table 2 *Temperature changes on the tooth surfaces in the beginning and in the end of the laser treatment*

t°C	Tooth 16	Tooth 17	Tooth 18	Tooth 19	Tooth 20	Tooth 21	Tooth 22	Tooth 23	Tooth 24	Tooth 25	Tooth 26	Tooth 27	Tooth 28	Tooth 29	Tooth 30
t° before	33.3	35.2	34.7	33.8	32.2	34.3	34.5	34.8	36.1	35.9	35.3	34.6	33.7	32.9	33.2
t° after	34.2	35.9	35.9	35.9	33.3	36.2	35.5	36.9	36.6	36.9	36.7	35.9	35.9	34.7	35.4
t° diff.	0.9	0.7	1.2	2.1	1.1	1.9	1.0	2.1	0.5	1.0	1.4	1.3	2.2	1.8	2.2

On fig. 4 a well visible temperature rise from 32.2°C to 33.3°C is seen in the first case and from 32.2 °C to 34.4°C in the second case.

The registered temperature changes in the apex and the outer root surface were up to 3,3°C (table 1 and 2).

Minimum temperature differences (diff.) were measured in 5 teeth (16.67% of cases) - the values of temperature changes are below 1°C. The maximum temperature difference is 3.3°C and is only measured in one case. In 24 cases (80%), temperature changes were between 1°C and 2.7°C.

Mean temperature values are shown in Table 3: Mean - arithmetic mean, SD - standard deviation, 95% CI - 95% confidence interval of the arithmetic mean, t - statistical criteria, df - degrees of freedom and P - level of statistical significance (table 4, fig. 5).

Table 3. *Mean temperature of the teeth examined*

Temperature	N	Mean	SD
t° before	30	34,18	0,99
t° after	30	35,81	0,92
t° diff.	30	-1,63	0,78

Table 4. *Comparative analysis with a Paired Samples t-test*

	Paired Differences		95% CI of the Difference		t	df	p
	Mean	SD					
t° before - t° after	-1,630	0,778	-1,920	-1,340	-11,479	29	<0,001

There was a significant difference in mean temperatures before and after ($p < 0.001$).

The differences are due to the thickness of the root wall, the degree of bleeding in the root canal, the presence of lateral canals. From our results we can see the direct dependence between the increase of temperature on the root surface and the thickness of the root walls. In teeth with more massive

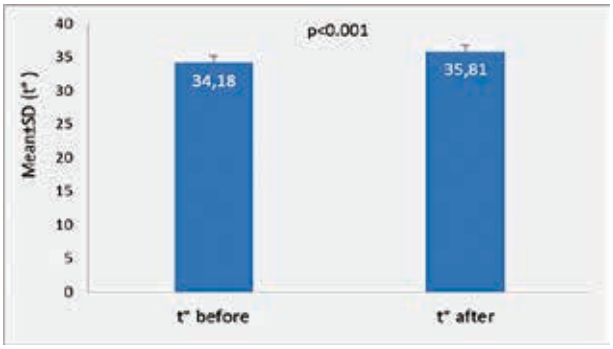

Fig. 5 *Average temperature changes*

roots (upper central incisors, canines), the change is smaller, while in teeth with thinner roots (lateral incisors) it is larger. The thickness of the root wall also depends on the degree of processing - with pre-injection, a lower volume of TTT remains and this leads to an increase in temperature [12, 16].

Our results are similar to those of A. Ribeiro and associates in 2007. They studied two workgroups using a 810 nm diode laser with a different power of 1.25 W and 2.5 W [12]. In another study on the application of the 810 nm wavelength diode laser, H. Gutknecht and colleagues studied the temperature changes on the root surface of 50 teeth after processing the channels of varying power - 0.6-1 W and 1-1.5 W - at steady mode and 1-1.5 W - for pulse mode with different interval settings. The temperature measured with NiCr-Ni sensors and thermometer T 202 did not rise above 7 ° C (close to our results), which is safe for periodontal tissues [16]. The results obtained by us and the registered biocompatible temperature changes on the outer root surface confirm the results of the A. Moritz and associates *in vitro* study of the effects of a diode laser having a wavelength of 810 nm in the root canals. The temperature changes are recorded with an infrared spectrometer [17]. In our study we used infrared thermography - the FLIR T330 thermal camera. Infrared Ther-

mography is a precise method for detecting the temperature in the facial area, in which one shot accurately records the temperature at all points of the subject under investigation [15]. Similar to our measurement of temperature changes *in vivo*, while working with a laser in conservative dentistry, in Bulgaria, Dogandzhiyska, Georgieva et al. [18, 19]

The thermal effects of laser radiation in biological tissues depend on various factors. It is important that the thickness of the fiber avoids contact with the root surface and thus does not contaminate and transfer the thermal effect onto the space of the periodontal tissues [13]. The movement of the fiber with a circular motion from the apex to the coronary, which is observed in our study, according to a number of authors, ensures that the laser covers the entire inner wall of the canal and thus diminishes and avoids the melting of the dentine and the transfer of the thermal effect on the periodontal tissues [13, 20].

Laser energy is absorbed in the surrounding tissues and the impulse mode of work is particularly appropriate because it allows for thermal relaxation of the target tissue (it has time to cool before the next irradiation) [21].

Conclusion

Temperature changes in the apex and outer root surface during laser treatment of the root canal using a diode laser 810 nm in impulse regimen (1 ms) with power 1 W for 8 s are biocompatible.

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