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ENDODONTICS AND THERMOVISION- TEMPERATURE CHANGES DURING PHOTO-ACTIVATED DISINFECTION IN ROOT CANALS. THERMOVISION DIAGNOSIS IN ENDODONTIC TREATMENT

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ABSTRACT:

Introduction: The application of thermovision in endodontics is an innovative method and has a great informative value, evidence proved, thanks to the use of last generation camera Flir A310 and a software ThermaCam Reporter 8.3 Pro. In the recent years a new method of root canal disinfection is introduced – photo-activated disinfection (PAD). Temperature increase have always been a concern during dental laser treatment.

Aim: The purpose of our study is to evaluate the temperature elevation on the outer root surface at extracted teeth and in periapical tissues when photodynamic therapy with 630-nm diode laser is used for root canal disinfection.

Materials and methods: For the laboratory study we used 72 single-rooted freshly extracted human teeth. They were divided into six groups depending on the power of the light source (220 mW, 360 mW and 500 mW) and the type of photosensitizer agent - Fotosan and Zn-phtalocianine.

In our clinical study participated 8 patients, who came in to our clinic with complaints of spontaneous pain or were with infected root canals and were referred for endodontic treatment. PAD was performed with a diode laser with wavelength of 630 nm using an endodontic handpiece with fiberoptic connector, allowing penetration to 4 mm from the apical stop, and movements of fibreoptic (200 μm) in apicalcoronal direction .

Results: The highest temperature value was detected at 500mW and 360mW. The average temperature increase recorded in our study at the external surface of the root canal did not exceed 10°C only at power setting of 220 mW during PAD with Zn-phtalocianine.

Conclusion: In conclusion, photo-activated disinfection of the root canal with Zn-phtalocianine and 630-nm diode laser using 200 μm fibreoptic tips at a power setting of 220 mW for 60 seconds induces a temperature increase which isn't sufficient to damage the neighbouring tissues. Based on this results we don't recommend root canal preparation over 02 or 04 taper when PAD will be performed.

Key words: Photo-activated disinfection, thermovision, endodontic treatment, temperature changes.

INTRODUCTION

Thermovision diagnostics is a modern approach used in contemporary medicine, which from two years now has been widely used in the dental medicine and presented at FDM-Sofia. A modern method for diagnosing of focal infections in the maxillofacial area by the means of thermovision diagnostics has been developed, thanks to a research project sponsored by the NSF. The application of thermovision in endodontics is an innovative method and has a great informative value, evidence proved, thanks to the use of last generation camera Flir A310 and a software ThermaCam Reporter 8.3 Pro (5).

The success of endodontic treatment depends on eliminating the infection in the root canals. The main cause of endodontic treatment failure is the presence of persistent microflora into the root canals, as well as the poor isolation of the operative field or the inadequate obturation of the tooth and the recontamination with this bacterial flora.(1, 2, 9) In the recent years a new method of root canal disinfection is introduced – photo-activated disinfection (PAD) .

Photothermal effects are influenced by wavelenght, power density, irradiation mode, duration of exposure, and dentine thickness. The temperature can rise 10 °C above body temperature for less than one minute without resulting in damage to periodontal tissue (10, 11). However, if the tissue temperature rises above 60°C, the blood flow is interrupted and bone necrosis is observed (4). To minimize thermal effects during endodontic laser treatment, the fiber end should be moved constantly in a circular motion. Our previous experience from main researches in this area led us into deeper exploration of this matter. (7, 8)

AIM

The purpose of our study was to evaluate the temperature elevation on root surface in vitro in extracted teeth and in periapical tissues in vivo when photodynamic therapy with 630-nm diode laser was used for root canal disinfection.

MATERIALS AND METHODS

Laboratory study

Root canal preparation

For the laboratory study we used 72 single-rooted freshly extracted human teeth . The teeth were cleaned from the organic material with a periodontal curette. The coronal parts of the teeth were removed and 15 mm of the root lenghts left. All canals were instrumented using crown-down technique using Kerr (K3) files (Maillefer Instruments SA, Switzerland) up to size 35 and taper 06. Following the each file operation all canals were irrigated with 1ml 5.25% NaOCl, then the smear layer was removed with 1 ml of 17% EDTA and with 10 ml of NaOCl . The root canals were dried with sterile paper points . After root canal preparation we performed PAD with Fotosan.

Photoactivated disinfection

Teeth were divided into six groups depending on the power of the light source (220 mW, 360 mW and 500 mW) and the type of photosensitizer agent. First (I) group- 12 teeth treated with PAD with Zn-phtalocianine at 220 mW power. Second (II) group- 12 teeth treated with PAD with Zn-phtalocianine at 360 mW power. Third (III) group- 12 teeth treated with PAD with Zn-phtalocianine at 500 mW power. Fourth (IV) group- 12 teeth treated with PAD with Fotosan at 220 mW power. Fifth (V) group- 12 teeth treated with PAD with Fotosan at 360 mW power. Sixth (VI) group- 12 teeth treated with PAD with Fotosan at 500 mW power. The required amount of Fotosan with low viscosity or Zn-phtalocianine is injected into the canal. A small size hand file is used to distribute the solution in the root canal. The irradiation is performed with a diode laser with wavelength of 630 nm using an endodontic handpiece with fiberoptic connector, allowing penetration to 4 mm from the apical stop, with parameters - 220 mW, 360 mW or 500 mW for 60 seconds and movements of fibreoptic (200 µm) in apicalcoronal direction .

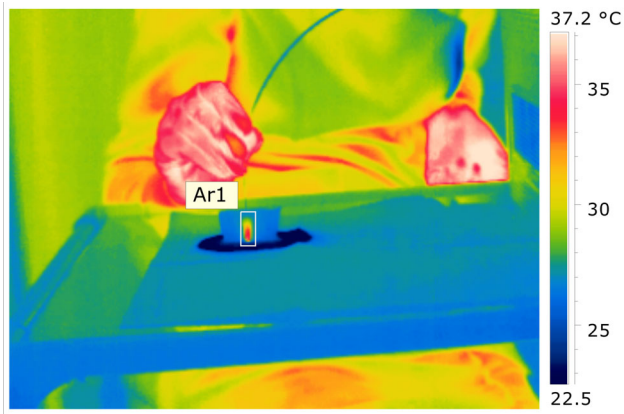
Clinical study

In our study took part 8 patients, who came in to our clinic with complaints of spontaneous pain, or were with infected root canals and were referred for endodontic treatment. For convenience of the study we selected incisors and premolar teeth. Each patient signed an informed consent. The root canal therapy was performed for each tooth which includes – preparation of access cavity, root canal preparation with crown down technique and irrigation with sodium hypochlorite (2,5%) and EDTA (17%) solution. Root canals were dried with paper points. After that we performed PAD with Fotosan - a photosensitizer, activated by laser beam with wavelength of 630 nm. The required amount Fotosan with low viscosity was injected into the canal. A small size hand file is used to distribute the solution in the root canal The irradiation was performed with a diode laser with wavelength of 630 nm using an endodontic handpiece with fiberoptic connector, allowing penetration to 4 mm from the apical stop, with parameters - 220 mW for 60 seconds and movements of fibreoptic in apicalcoronal direction. We measured the temperature on the outer root surface with thermovision camera.

Thermovision analysis

In both studies the objects were situated at 1,5 m distance from the camera lens, at room temperature of 22 degrees. The recordings with the camera were made in dynamics every 20 seconds for 1 minute total. Temperature changes were processed and analyzed with software ThermaCam Reporter 8.3 Pro (picture 1).

Picture 1. – Thermovision during PAD with Zn-phtalocianine



Statistical methods:

Descriptive statistics for tabular and graphical data presentation; test of Kolmogorov-Smirnov to verify the normality of the frequency distributions; t-test for comparison between the average of the two independent samples.

RESULTS

The received values of temperature rise during various manipulations are presented on figures 1 and 2. Figure 1 shows the results obtained at a laser power setting of 220 mW, 360 mW and 500 mW treated for 60 seconds with Fotosan. Figure 2 shows the results obtained at a laser power setting of 220 mW, 360 mW and 500 mW applied for 60 seconds with Zn-phtalocianine..

At a power setting of 220 mW during PAD with Fotosan the temperature rise varies between 6,1 °C and 21,8 °C . The respective average increase was 11,3 °C. At a power setting of 360 mW during PAD with Fotosan the temperature rise varies between 14,6 °C and 28,5 °C . The average increase was 22,2 °C. At a power setting of 500 mW the temperature rise varies between 19,6 °C and 44,9 °C . The average increase was 28 °C.

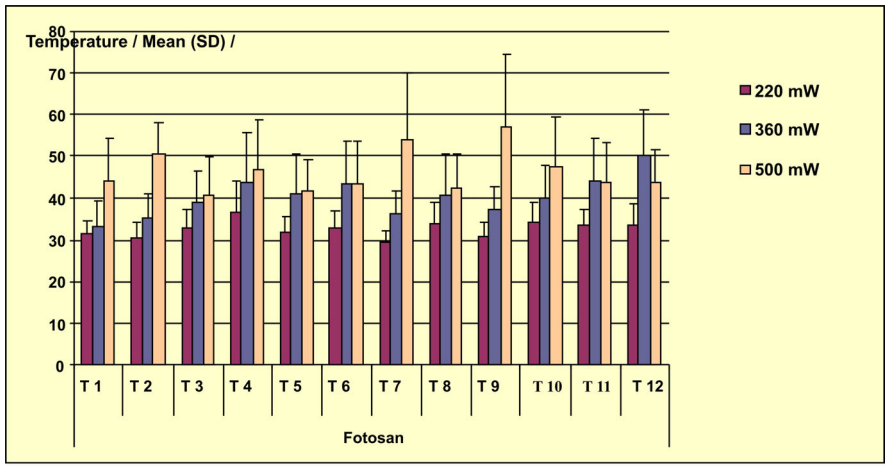


Figure 1. Temperature changes during PAD with Fotosan; T-tooth

At a power setting of 220 mW during PAD with Zn-phtalocianine the temperature varies between 6,1 °C and 21 °C . The average increase was 10 °C. At a power setting of 360 mW during PAD with Zn-phtalocianine the temperature rise varies between 6,8 °C and 18,5 °C . The average increase was 13,9 °C . At a power setting of 500 mW during PAD with Zn-phtalocianine the temperature rise varies between 19,9 °C and 39,7 °C . The average increase was 27,9 °C .

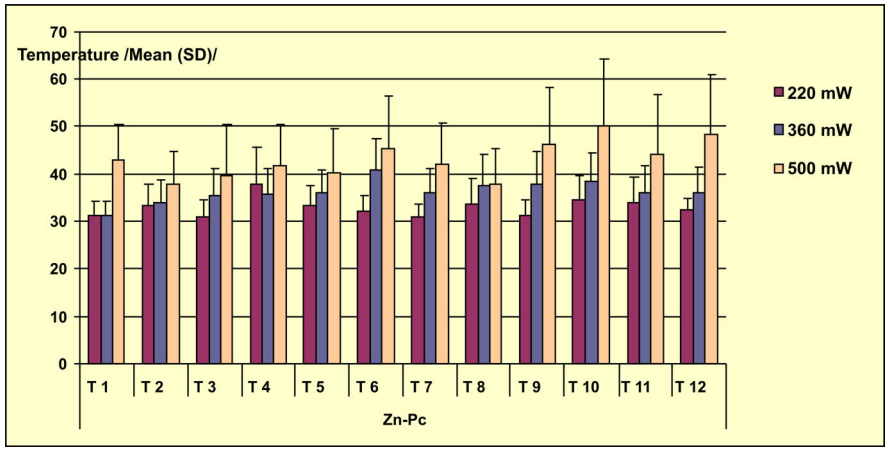


Figure 2. Temperature changes during PAD with Zn-phtalocianine; T-tooth

Only in the groups, treated with power settings of 360 mW with Fotosan and Zn-phtalocianine a statistically significant difference $p<0,01$ was observed (table 1).

Table 1. Statistical tests

Power	Photosensitizer	N	Mean	SD	t	df	p
220 mW	**Zn-Pc**	72	32,9	4,6	0,35	142	0,726
	Fotosan	72	32,7	4,5			
360 mW	**Zn-Pc**	72	36,3	5,6	-3,27	118	**0,001**
	Fotosan	72	40,4	9,1			
500 mW	**Zn-Pc**	72	43,0	10,3	-1,81	142	0,072
	Fotosan	72	46,3	11,4			

The results from the clinical study are presented on table 2. The received values of temperature rise during PAD in clinical cases is between 0,5 and 2,5 degrees C.

Table 2. Temperature changes during PAD with Fotosan at power settings of 220mW, clinical study

	Ar1.1	Ar1.2	Ar1.3	Ar1.4	Ar1.5	Ar1.6	
Case 1	36,3	37,1	37,5	37,4	37,4	37,6	1,3
Case 2	35,1	36,6	36,6	36,7	36,7	36,9	1,8
Case 3	36,1	37,1	36,6	37,3	36,8	37,4	1,3
Case 4	35,2	35,5	35,6	35,5	35,6	35,7	0,5
Case 5	35,9	37,4	37,5	37,5	37,6	37,6	1,7
Case 6	36,4	36,3	36,3	36,6	36,8	36,9	0,6
Case 7	35,3	37	37,4	37,6	37,7	37,8	2,5
Case 8	37,1	36,6	36,8	37,1	37,4	37,5	0,9
							Avg1,325

DISCUSSION

A number of studies into lethal photo-sensitisation have shown that Gram-positive and Gram-negative bacteria, fungi and viruses are all susceptible to being killed by photo-activated disinfection (PAD) (12, 14) . From these studies also became clear that some microorganisms need a longer irradiation time than others to be killed. Organised in biofilms, bacteria showed higher resistance to antimicrobial agents (3).

Temperature increase have always been a concern during laser dental treatment. For the periodontium and the surrounding bony tissues, the threshold for temperature increase is respectively 7°C and 10°C (5, 12). As lasers can produce high energy levels in a localised spot, they can also generate high increase in the temperature. In our study we apply PAD with a diode laser at different power settings - 220 mW, 360 mW and 500 mW and a long exposure time of 60 sec so that the photo-sensitiser could be sufficiently activated. We measured the temperature increase for each power with thermovision camera

The highest temperature value was detected at 500 mW and 360 mW. The average temperature increase recorded in our study at the external surface of the root canal did not exceed 10°C only at power setting of 220 mW during PAD with Zn-phtalocianine. The temperature rise is evaluated in teeth with different root thicknesses. The elevation of the temperature on the surface of the root depends on the thermal conductivity of the dentine and the cementum, but also on the thickness and the mass of these structures. We preferred to use teeth with different dentinal layer thicknesses in order to evaluate the presumed differences in temperature rise. Significant differences were recorded between the teeth with different wall thickness. In our study the teeth were instrumented up to size 35 and taper 06. This additionally thinner the dentin wall and does matter for a large increase in temperature during PAD.

For the clinical study we used power settings of 220 mW, which is the most appropriate for clinical application. We measured the temperature increase for each power with thermovision camera. The highest temperature value detected was 37,8 °C. The temperatures recorded in our study at the periapical structures did not exceed 10 °C. The respective average increase was 1,325 °C. In the clinical study the root canal preparation of the teeth did not exceed 02 taper. This provides sufficient thickness of the dentin walls and thus preventing a greater increase in the temperature during PAD. In clinical situation the periodontal ligament and the microcirculation has a great role for heat reduction on external root surface and periodontal tissues. The presence of photosensitizing solution in root canal during photo-activated disinfection may also be helpful to prevent the overheating on the external root surface. The fibre should be kept in constant motion, making a circular movement in and out of the root canal.

CONCLUSIONS

In conclusion, photo-activated disinfection of the root canal with Zn-phtalocianine and 630-nm diode laser using 200 μm fibreoptic tips at a power setting of 220 mW for 60 seconds, with continuous circular movement of about 2 mm/sec., induces a temperature increase on the external surface of the root canal, which does not exceed the critical 10 °C and is not sufficient to damage the neighbouring tissues (periodontal ligament and supporting alveolar bone) of the treated tooth. PAD at power settings of 360 mW and 500 mW with Zn-phtalocianine and with Fotosan at 220 mW, 360 mW and 500 mW induce a temperature increase on the external surface of the root canal, which exceeds the critical

10 °C and it its not safe for periodontal tissues.

Based on these results we don't recommend root canal preparation over 02 or 04 taper when PAD will be performed.

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