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RESEARCH ARTICLE

Determining of the Most Optimal Parameters of Monopolar High Frequency Diathermocoagulation in Endodontic Practice

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ABSTRACT

The main criterion for successful endodontic treatment is thorough cleaning of the root canal from microorganisms. Modern technologies are being developed to decontaminate the root canal system due to local temperature increase. High-frequency monopolar diathermocoagulation refers to one of these technologies.

Aim. To determine the optimal parameters of monopolar high-frequency diathermocoagulation providing a distinct antibacterial effect and which are safe for the surrounding tissues in endodontic dental treatment.

Materials and methods. Root canals of single-root removed teeth from the group of upper and lower jaw incisors (12 samples). The DC-35 MS device (2640 kHz, 1. 5 kOhm) was used to study various modes of high-frequency monopolar diathermocoagulation. 6 exposure modes were studied. To determine the heating degree of the tooth root surface, thermometry using a compact infrared radiation converter of the Seek Thermal imager was used, and a remote infrared thermometer Testo 830-T1 was used for temperature monitoring. After determining of the diathermocoagulation modes that are not able to cause significant heating of the surrounding tooth tissues, the antibacterial effect of diathermocoagulation in these modes was studied. To do this, we used clinical strains of optionally anaerobic bacteria obtained from the teeth root canals in pulpitis: Streptococcus sanguis, Streptococcus mutans, Enterococcus faecalis, Escherichia coli and yeast-like fungi Candida albicans.

Results. When performing diathermocoagulation of the root canal contents, the third, fourth and sixth modes of the device settings with the power given to the tissue within three seconds of energy in the range of 3.06 W to 5.4 W are safe for the tissues surrounding the tooth root. When treating root canals in the third and sixth modes, the power of diathermocoagulation is 5.4 W and 4.1 W. A multiple, significant decrease in microbial contamination of root canals by all kinds of pathogenic optional anaerobic microflora obtained from the teeth root canals in pulpitis was found.

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Introduction

Complications of dental caries account for more than a third of the total amount of dental diseases. In our country, these complications are still one of the main reasons for tooth extraction.

Various causes can lead to pulp inflammation. They are classified as infectious, mechanical, physical, and chemical. The most common cause of the onset and development of pulpitis is the effect of microbes in the carious cavity and their toxins. Timely endodontic treatment of teeth with pulpitis is the prevention of odontogenic inflammatory

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processes such as periodontitis, periostitis, osteomyelitis, abscess and phlegmon [*Ezzo P.I., Culter C.W., 2003*]. The high prevalence of caries complications allows us to consider endodontics as one of the most important areas of Russian dentistry.

The pulp of the tooth is a favorable environment for the development of microorganisms. [*Sirunyan L.S.*, 2012] Microbes enter the tooth cavity through deep carious cavities, damage to enamel and dentin that occur during dental injuries, exposed dentinal tubules during abrasion of hard tissues and erosion, periodontal pockets [*Murakami Y. et al., 2001*].

The main task of therapeutic measures is reduced to an antiseptic effect on the microflora and prevention of its entry outside the tooth root.

Improvement of endodontic dental treatment remains an urgent problem of modern dentistry. Despite the wide arsenal of drugs used in clinical practice, endodontic treatment is not always effective and often leads to the need for repeated treatment. It is known that with pulpitis, microbes penetrate into the root canals and their branches. Thorough cleaning of the canal from microorganisms is the main condition for successful treatment. In this regard, technologies are being developed that make it possible to disinfect the root canal system due to a local increase in temperature. These types of exposure include high-frequency diathermocoagulation. Diathermocoagulation is a particular manifestation of diathermy, which is understood as the conversion of high-frequency alternating current electrical energy in biological tissues into thermal energy. Previously, diathermy was used in physiotherapy to warm tissues. In this case, for therapeutic purposes, an alternating electric current of high frequency (1–2 MHz), low voltage (150–200 V) and high strength (2 A) was used.

In endodontic treatment of teeth, diathermocoagulation makes it possible to coagulate the contents of the root canal, stop bleeding, dry it and sterilize it for patency, which greatly facilitates further endodontic manipulations.

In the modern scientific literature there is information about the successful use of diathermocoagulation, including for apical therapy, for periodontitis and maxillary odontogenic sinusitis [*Mesaf T.*, 2007; *Shishkina O.E.*, 2008; *Semennikova N.V.*, 2010]. However, the authors themselves point out that diathermocoagulation is not widely used in endodontic practice, since this type of exposure is difficult to dose, and therefore complications may develop. Irrational use of the electrosurgical method can be complicated not only by prolonged pain syndrome, but also by gum necrosis and the development of osteomyelitis with sequestration of the alveoli.

Thus, despite its high efficiency, diathermocoagulation is not widely used in modern endodontic practice. This is due, on the one hand, to the fact that among electrosurgical instruments, bipolar diathermocoagulators are the most widespread, which cannot be used to process root canals due to the threat of periodontal overheating. On the other hand, even with the use of monopolar coagulators, the regimens for endodontic treatment are not always clearly prescribed, which can lead to overdose and the development of complications. This necessitates a theoretical substantiation and a comprehensive scientific study to study the effectiveness of the use of high-frequency monopolar diathermocoagulation in endodontic dental treatment.

The aim of the study is to determine the optimal parameters of monopolar high-frequency diathermocoagulation providing a distinct antibacterial effect in endodontic treatment of teeth and are safe for the surrounding tissues.

Material and Methods

To study various modes of high-frequency monopolar diathermocoagulation a DC-35 MS device was used. This device is a single-electrode monopole pulse diathermocoagulator where the optimal ratio of the frequency of the used alternating current (2640 kHz) and the output resistance (1.5 kOm) is selected.

The following exposure modes were studied:

First mode: pulse duration (effect) - 4 scale division, power-6 scale division.

This mode corresponds to the output power to the load - 13.1 W.

Second mode: pulse duration (effect) - 4 scale division, power-5 scale division. This mode corresponds to the output power to the load - 9 W.

Third mode: pulse duration (effect) – 4 scale division, power - 4 scale division. This mode corresponds to the output power to the load - 5.4 W.

Fourth mode: pulse duration (effect) - 4 scale division, power-3 scale division. This mode corresponds to the output power to the load - 3.06 W.

Fifth mode: pulse duration (effect) - 3 scale division, power - 5 scale division.

This mode corresponds to the output power to the load - 6.5 W.

Sixth mode: pulse duration (effect) - 3 scale division, power - 4 scale division.

This mode corresponds to the output power to the load - 4.1 W.

To determine heating degree of the tooth root surface during diathermocoagulation in various modes, thermometry was performed using a compact infrared radiation converter of the Seek Thermal imager. It provides visualization of thermal fields by showing the resulting image on the display of the Communicator to which it is connected. For temperature monitoring a remote infrared thermometer Testo 830-T1, designed for non-contact measuring of surface temperature, was used.

Root canals of single-root removed teeth from the group of upper and lower jaw incisors (12 samples) were expanded mechanically to the size of 0.25 and washed with an isotonic solution of sodium chloride.

For the experiment a prepared tooth was wrapped with gauze soaked in isotonic sodium chloride solution and fixed on a metal plate connected to a neutral socket (electrode) of the device DK – 35 MS via the capacitance 47 PF (picofarads), equivalent to the capacity between the machine tool and the frequency of 2.64 kHz. A metal root needle was used as an electrode inserted into the root canal before apical narrowing and closed the electrical circuit for 3 seconds, having previously configured the diathermocoagulator for one of the six studying modes of operation.

The temperature of the external surface of the root was recorded before diathermocoagulation, then the root canal was treated with a diathermocoagulator for 3 seconds while the maximum value of the root surface temperature obtained as a result of diathermocoagulation was recorded. Based on the comparison of the obtained values of the surface temperature of the tooth root in different modes of diathermocoagulation, we concluded that the use of a particular mode for the surrounding tissues of the tooth is safe.

After determining of the diathermocoagulation modes that are unable to cause significant heating of the surrounding tooth tissues, we began to study the antibacterial effect of diathermocoagulation in these modes.

To determine the antibacterial effectiveness of monopolar diathermocoagulation, we used clinical strains of optionally anaerobic bacteria obtained from the root canals of teeth in pulpitis, namely: Streptococcus sanguis, Streptococcus mutans, Enterococcus faecalis, Escherichea coli and yeast-like fungi Candida albicans.

A suspension of the studied strain was prepared in saline solution, which according to the optical turbidity standard contained 108 CFU/ml (colony-forming units per milliliter). The prepared suspension was inserted into the root canals of the removed teeth, 0.5 ml of suspension into each pre-mechanically processed root canal. To improve the adhesion of microorganisms, a 5-minute exposure of microbial suspension was performed in each root canal, pumping it into the canal using an endodontic file.

Before heat treatment of the root canal with the use of high-frequency diathermocoagulation, as well as after the end of thermal exposure, the material of the root canal contents was taken for microbiological analysis. For this purpose, a sorbing sterile paper pin, size 20, was placed in the root canal for 10 seconds, which was then transferred to sterile Petri dishes with nutrient media and drew cultures according to Gold method of Tsarev-Melnikov modification.

For the cultivation of streptococci, enterococci and Escherichia coli, 5% blood agar with the addition of gemin and menadion was used, and Saburo medium was used for Candida. Crops of anaerobic bacteria were placed in anaerostats with an oxygen-free gas mixture containing 80% nitrogen, 10% hydrogen, and 10% carbon dioxide. A palladium catalyst was used to reduce oxygen residues *[Hulsmann M et al.,* 2000*]*.

The results were recorded in 7 days of Petri dishes incubation in an anaerostat at a temperature of 37°C.

Quantitative accounting of control samples obtained before heat treatment of the root canal and experimental cultures obtained after heat treatment was performed using a binocular magnifying glass by counting the number of colonies of microorganisms cultivated on the Petri dish sites.

Research results were processed using variation statistics methods with the determination of the average value, its error, and the student's criterion for multiple comparisons, using Excel (MS Office) programs. Probable differences of R based on the number of the sample were determined. Statistically significant values of $P < 0.05$ were considered.

Results

The data on the temperature of the external surface of the examined teeth roots obtained using a compact infrared radiation converter of the Seek Thermal imager and obtained using a remote infrared thermometer Testo 830 - T1 completely coincided.

Before diathermocoagulation the surface temperature of the roots of the examined teeth was 25 + 0.5 ºC.

The results of the study of the surface temperature of the tooth root during diathermocoagulation in various modes are presented in table 1.

Table 1. Temperature of the external surface of the tooth root during diathermocoagulation of various modes

Diathermocoagulation mode	Power surface	Temperature of the tooth root
First	13.1 W	48+ 0.5 o S
Second	9 W	44+ 0.5 o S
Third	5.4 W	36+ 0.5 o S
Fourth	3.06 W	31+ 0.5 o S
Fifth	6.5 W	40+ 0.5 o S
Sixth	4.1 W	34+ 0.5 o S

As can be seen from the data presented in the table, during diathermocoagulation the temperature of the external surface of the tooth root depends on the electrical power of high-frequency radiation entering the tooth root canal under various settings of the diathermocoagulator. The higher the power, the higher the surface temperature of the tooth root. In the first, second and fifth setting modes, when the power is in the range of 6.5 W to 13.1 W, the temperature of the external surface of the tooth root can increase from 40+ 0.5 º C to 48+ 0.5 º C. This temperature exceeds the normal human body temperature of 36.6 º C and, therefore, can lead to overheating of the periodontal and other tissues surrounding the tooth.

In the third, fourth and sixth diathermocoagulator setting modes, when the power is within 3.06 W – 5.4 W, the temperature increase of the external surface of the tooth root is in the range from 31+ 0.5 º C to 36+ 0.5 o C. This temperature does not exceed the temperature of the human body and is safe for the surrounding tissues.

Thus, the third, fourth and sixth modes of the apparatus are safe and can't cause overheating of the surrounding root tissues when conducting diathermocoagulation content of root canals. In this case, the power of the energy given to the tissue for three seconds is in the range of 3.06 W to 5.4 W.

After determining of the diathermocoagulation modes that are unable to exert a thermal effect on the surrounding tissues of the tooth root, the antibacterial effectiveness of diathermocoagulation in these modes was studied. The results of the study are presented in table 2.

Table 2. Changes in microbial contamination of root canals during diathermocoagulation in various modes (lg CFU/ml)

Test strain of microorganisms	Control	Mode of diathermocoagulation		
		Third	Fourth	Sixth
Enterococcus faecalis	8±0.2	3.6±0.6*	7.6±0.6	4.9±0.5*
Streptococcus mutans	8±0.2	4.3±0.5*	6.3±0.3*	5±0.4*
Streptococcus sanguis	8±0.2	4.1±0.6*	7.4±0.7	5.2±0.5*
Escherichea coli	8±0.2	3.9±0.5*	5.9±0.5*	4.8±0.4*
Candida albicans	8±0.2	3.6±0.6*	5.0±0.4*	4.9±0.5*

Note:* - statistically significant decrease in microbial contamination ($p < 0.05$).

Discussion

The results obtained in the study of antibacterial effectiveness the use of high-frequency monopolar diathermocoagulation in the treatment chronic forms of pulpitis in a clinical setting are fully consistent with the results of experimental studies. Thus, as a result of the clinical and laboratory studies found that high frequency monopolar diathermocoagulation the contents of the root canals of the teeth in the treatment of chronic forms of pulpitis are not causes critical heating of the outer surface of the tooth root and has pronounced antibacterial effect against all representatives of pathogenic microflora obtained from the root canals of the teeth.

The results obtained data shown in the table indicate that the fourth mode of diathermocoagulation has an insufficient antibacterial effect. There was a significant decrease in bacterial contamination of root canals by such kinds of pathogenic microflora as Streptococcus mutans, Escherichea coli and Candida albicans when treating root canals in this mode. However, the change in the number of Enterococcus faecalis and Streptococcus sanguis wasn't statistically significant.

A multiple, significant decrease in microbial contamination of root canals by all kinds of pathogenic optional anaerobic microflora obtained from the teeth root canals in pulpitis was found when treating root canals in the third and sixth modes, when the power of diathermocoagulation is 5.4 W and 4.1 W respectively. At the same time, a more distinct antibacterial effect was observed in the subgroup where the third mode of diathermocoagulation was used, which is characterized by greater power and therefore greater heat generation than in the sixth mode.

Conclusions

Thus, based on the results of thermometry of the external surface of the teeth roots and experimental microbiological analysis of the effectiveness of root canal treatment using monopolar high-frequency diathermocoagulation in different modes, two optimal modes of the DC – 35MS device were established. The first recommended mode of diathermocoagulation for endodontic dental treatment using the DC-35MS device: pulse duration (effect) - 4 scale division, power – 4 scale division, exposure time 3 seconds, the mode corresponds to the output power to the load - 5.4 W. Second mode: pulse duration (effect) - 3 scale division, power - 4 scale division, exposure time 3 seconds, the mode corresponds to the output power to the load-4.1 W. In these modes, monopolar high-frequency diathermocoagulation has a distinct antibacterial effect and does not cause heating of the tissues surrounding the tooth root, which allows this method to be used for the treatment of teeth root canals in endodontic treatment.

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